How to succeed with your Modelling Approach using Enterprise Architect

About Meta-Models and Metamodeling



Part 1.5

Horst Kargl

SPARX SYSTEMS CENTRAL EUROPE

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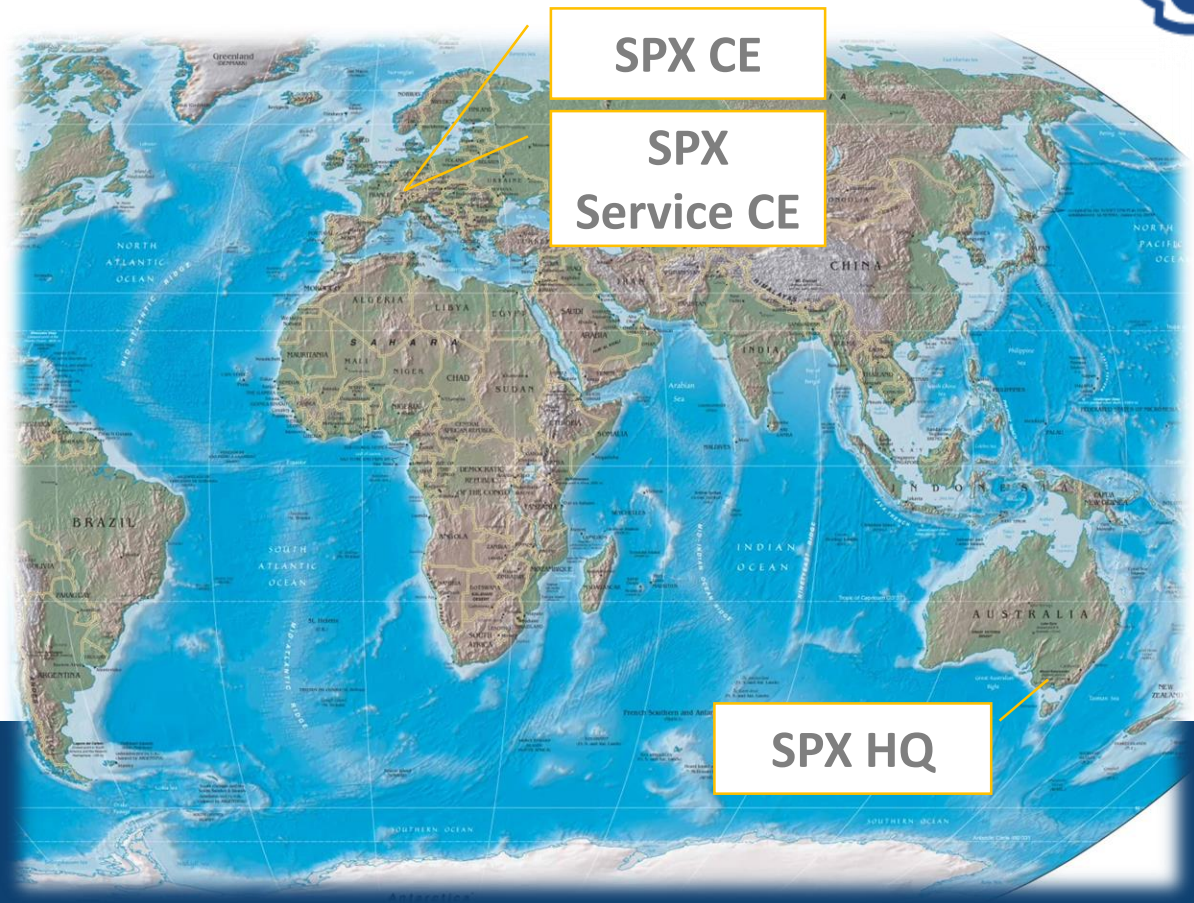
Who is **Sparx Systems** - Who is **Sparx Services**

- **Sparx Systems Central Europe** is a sister Company of Sparx Systems HQ.
  - Licenses, Training
- **Sparx Services Central Europe**
  - Consulting
  - Customizations



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Agenda

- Theory
  - Meta-Model
  - Model
  - Meta Meta-Model, etc.
- Praxis in EA
  - UML Profile
  - Meta Constraints
  - Additional Validation Possibilities
  - MDG Technology

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What is a Meta-Model?

- **Meta-Model**: is a Model about a Model.

- **Metamodeling**: is the process of creating such meta-models.



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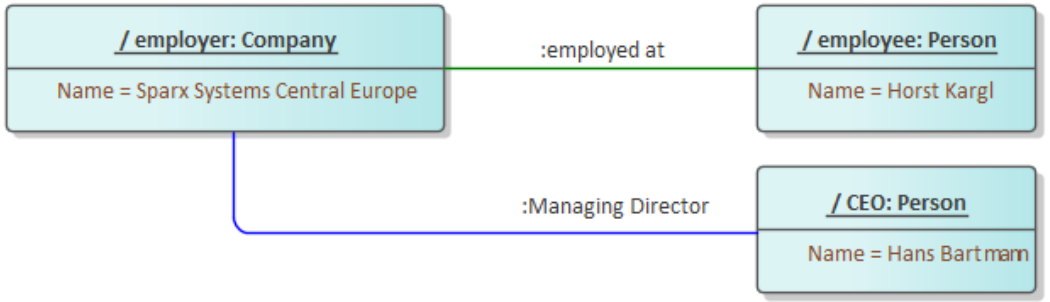
Meta-Model Example



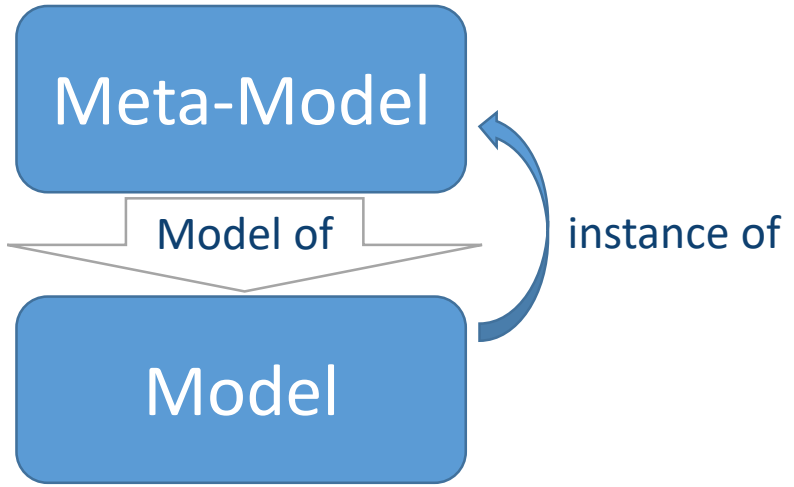
Metamodel

Model





Possible
Concrete Notation



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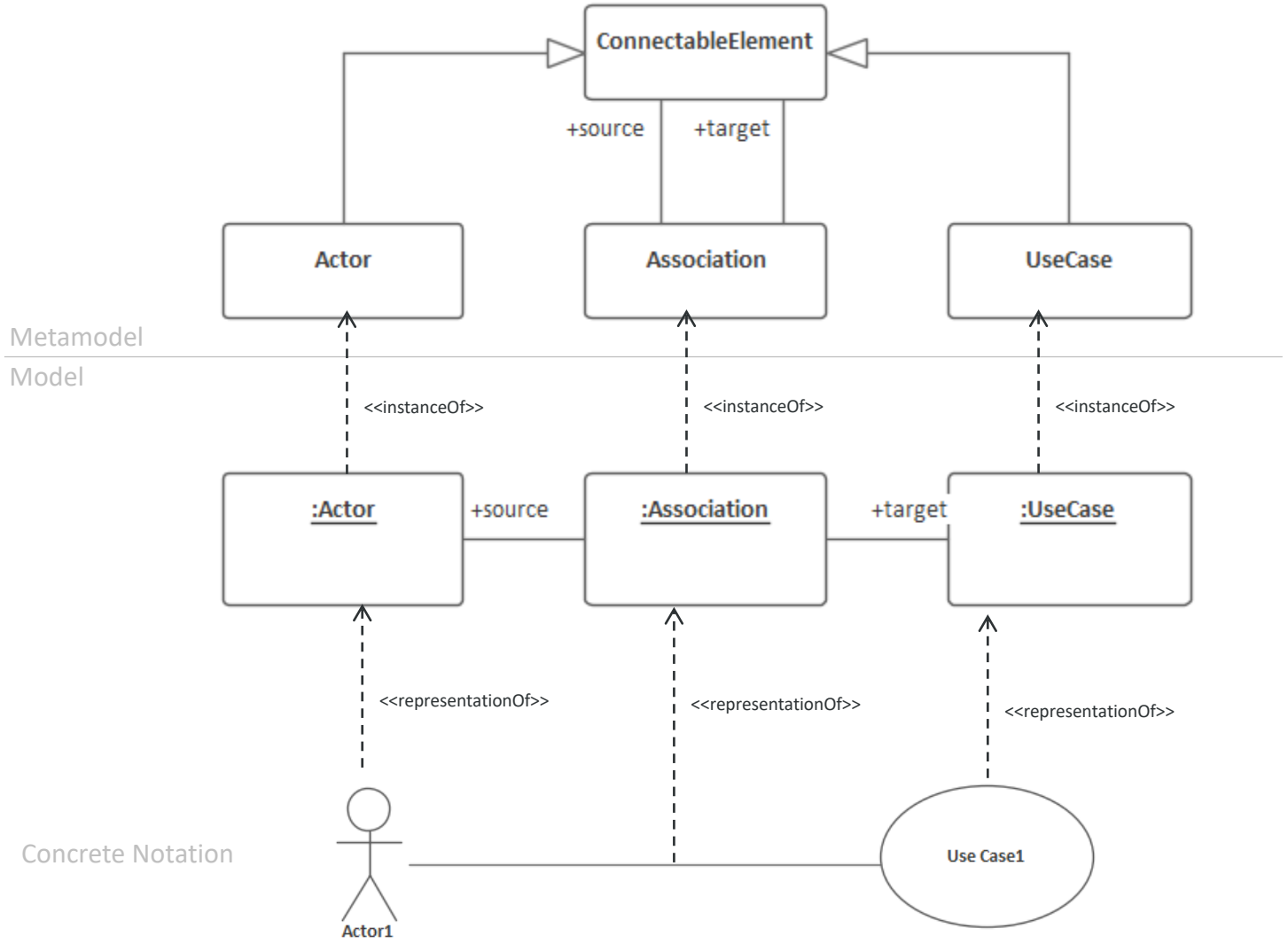
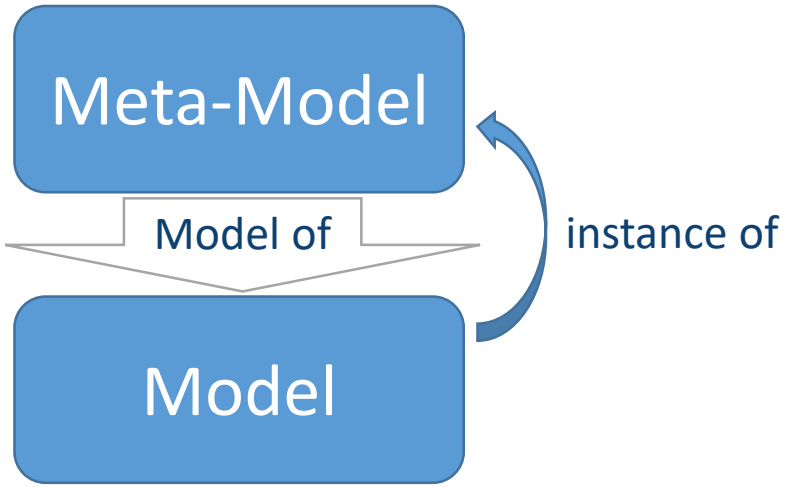
Meta-Model Example





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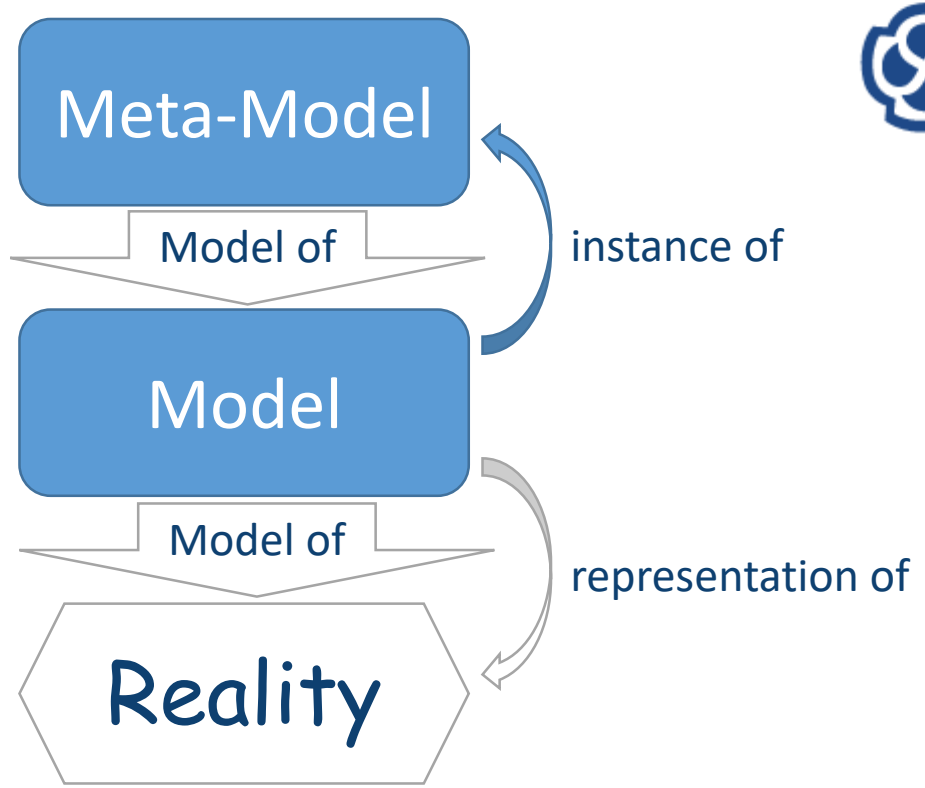
What is a Model?

- **Model**: A model is a simplified representation of a certain reality.
- **Modelling**: is the process and method of building models for a specific purpose.



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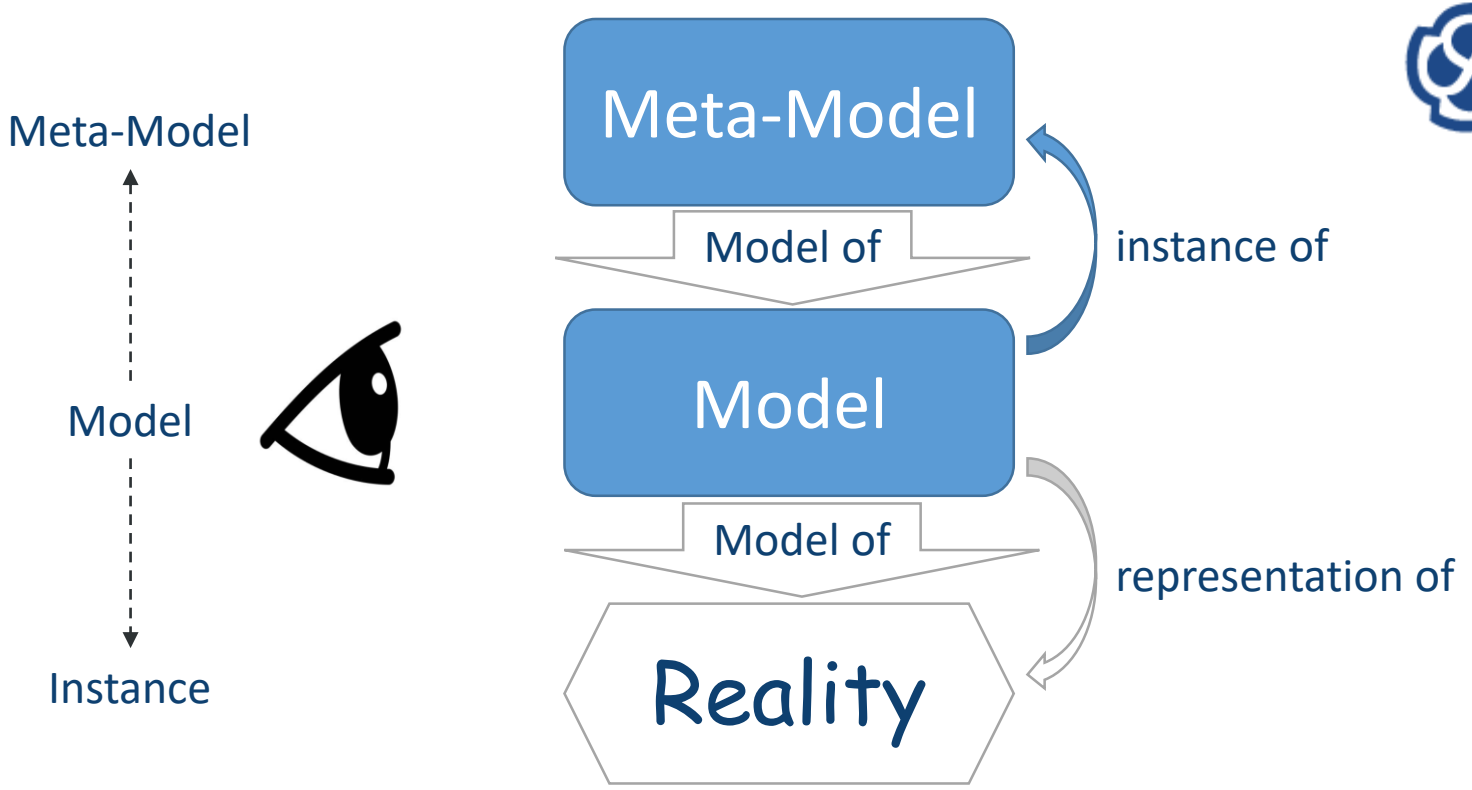
What is a Meta Meta-Model?



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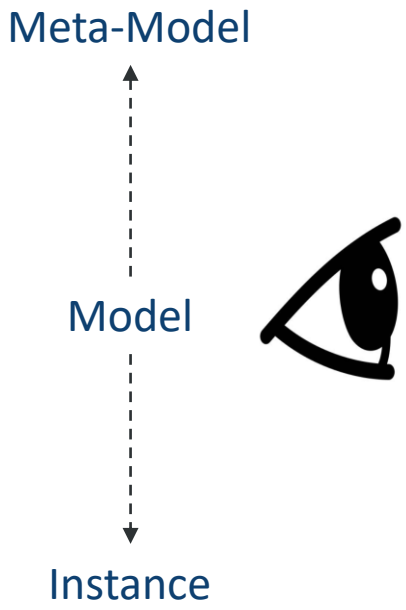

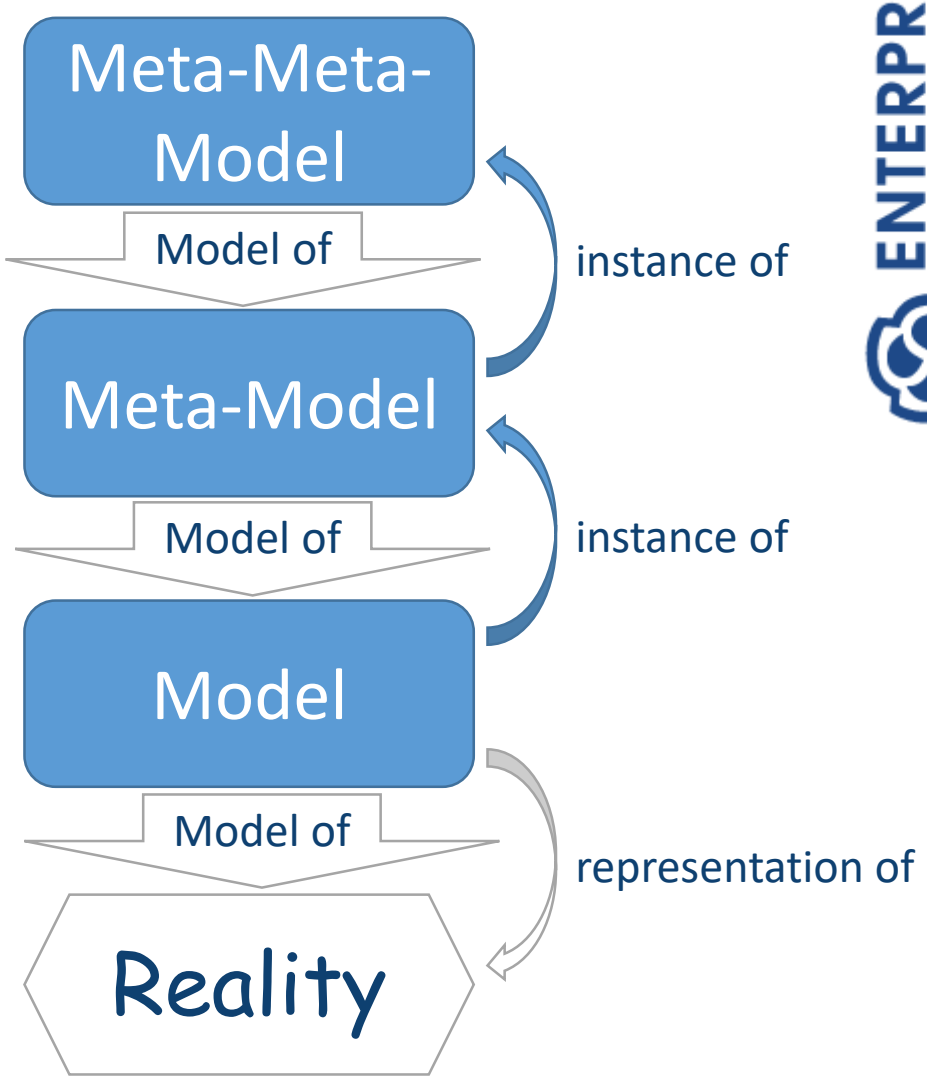

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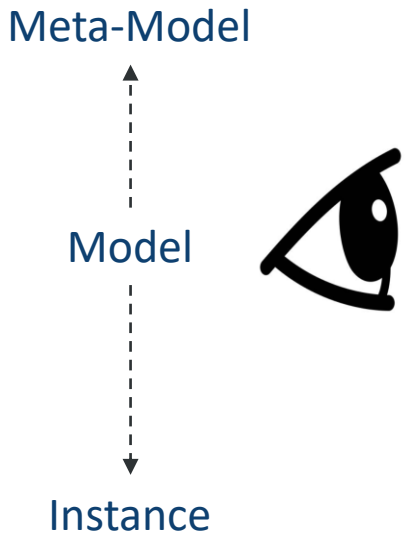
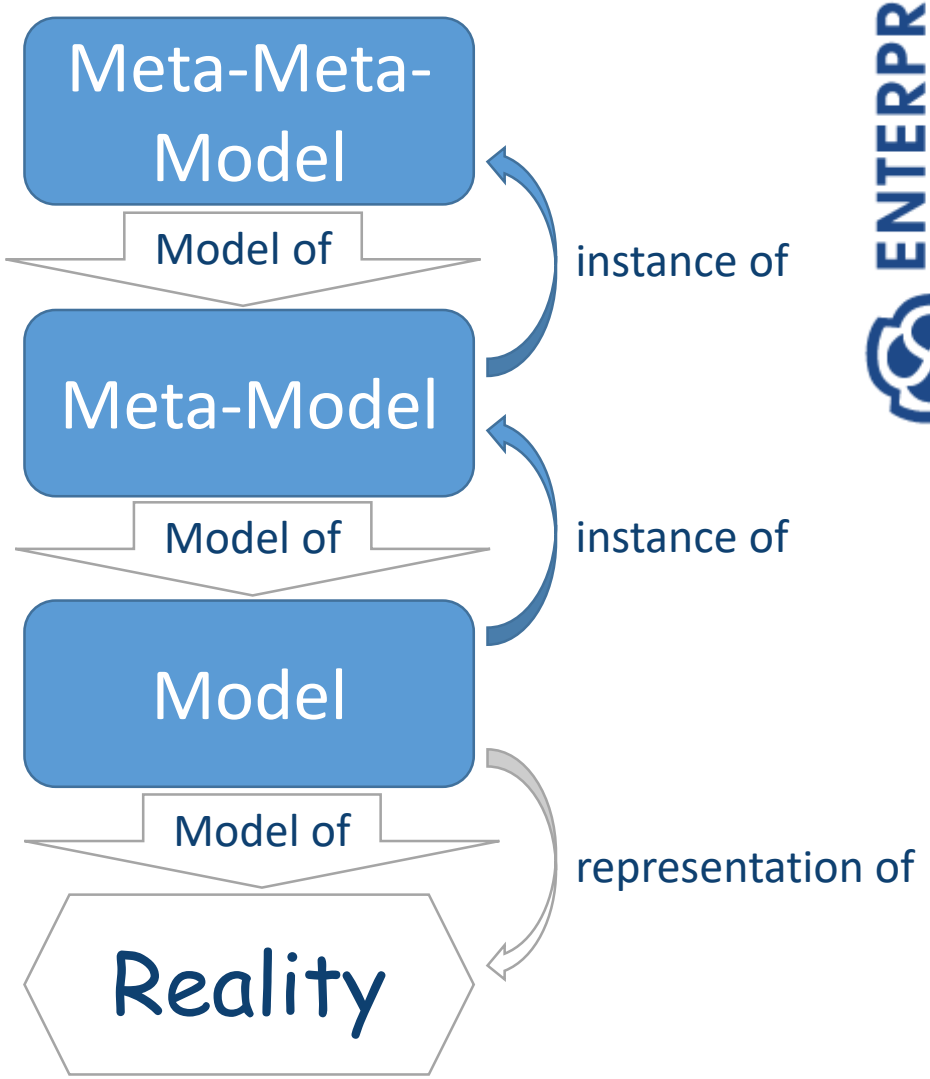
What is a Meta Meta-Model?





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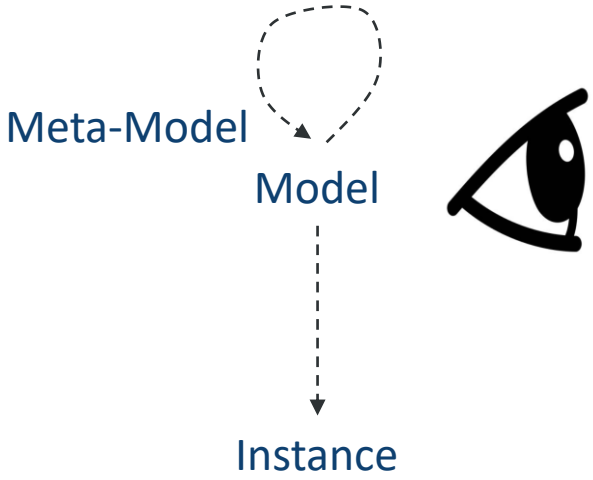
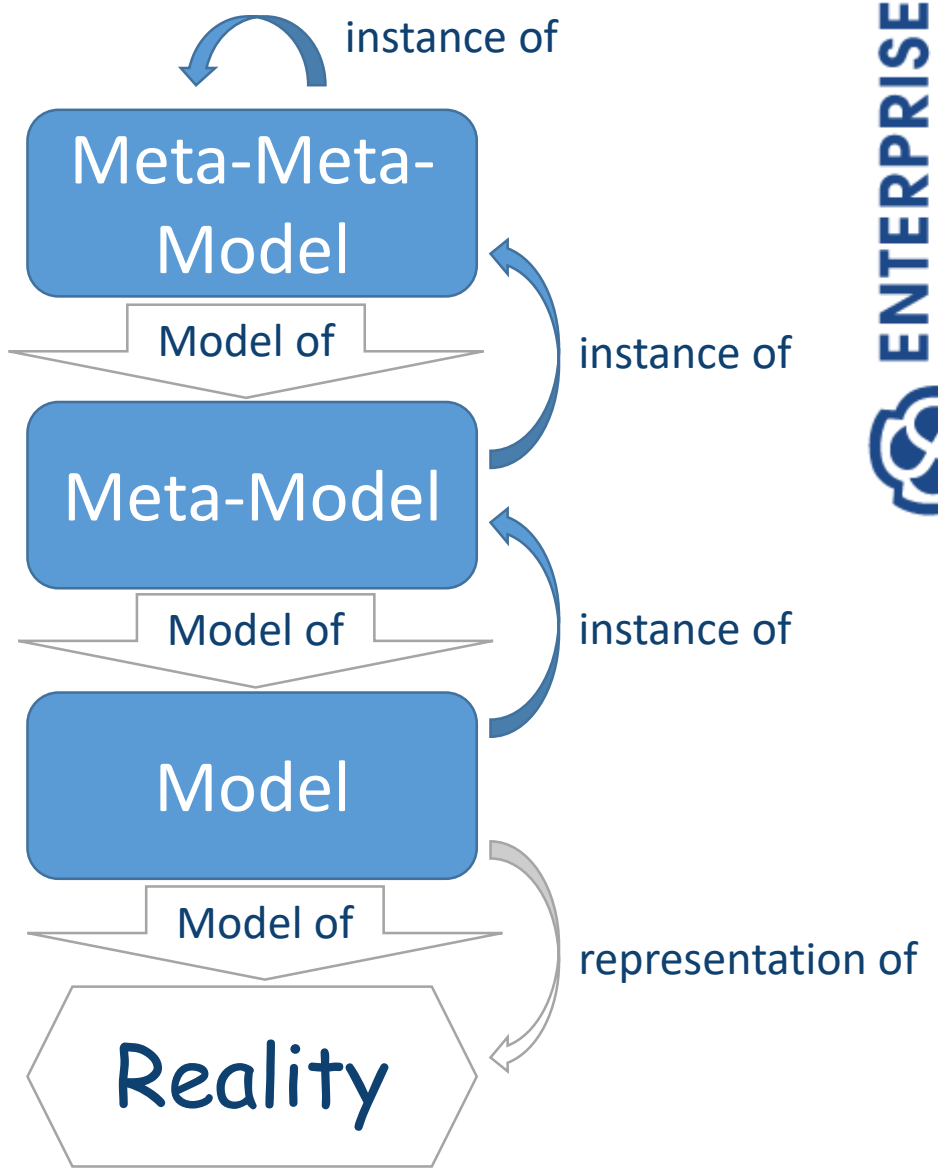
What is a Meta Meta-Model?





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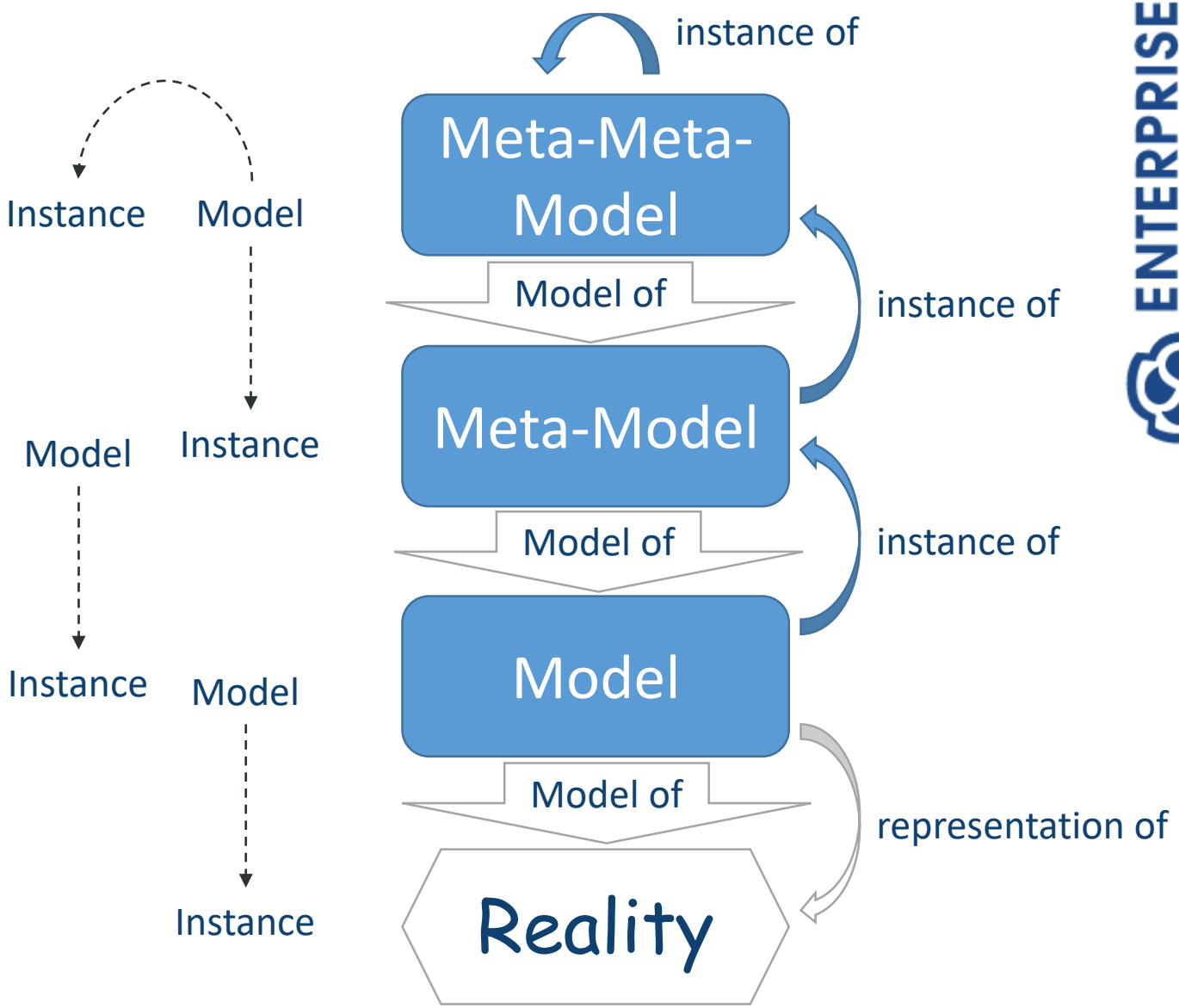
What is a Meta Meta-Model?



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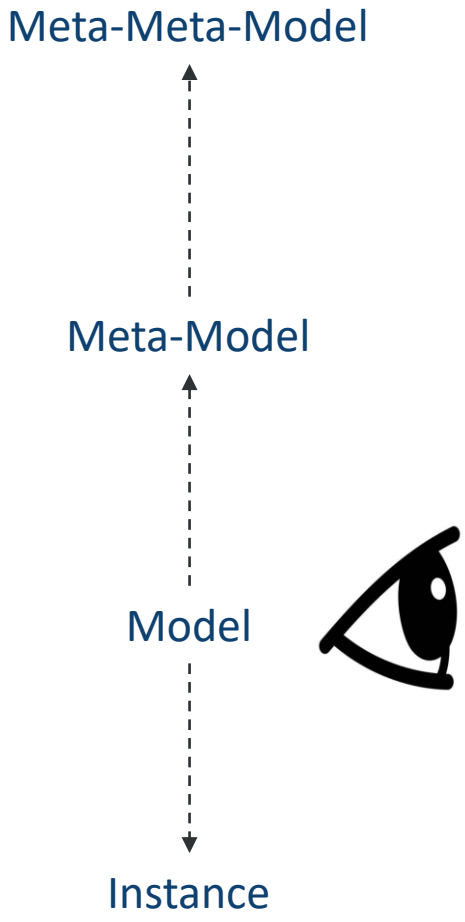
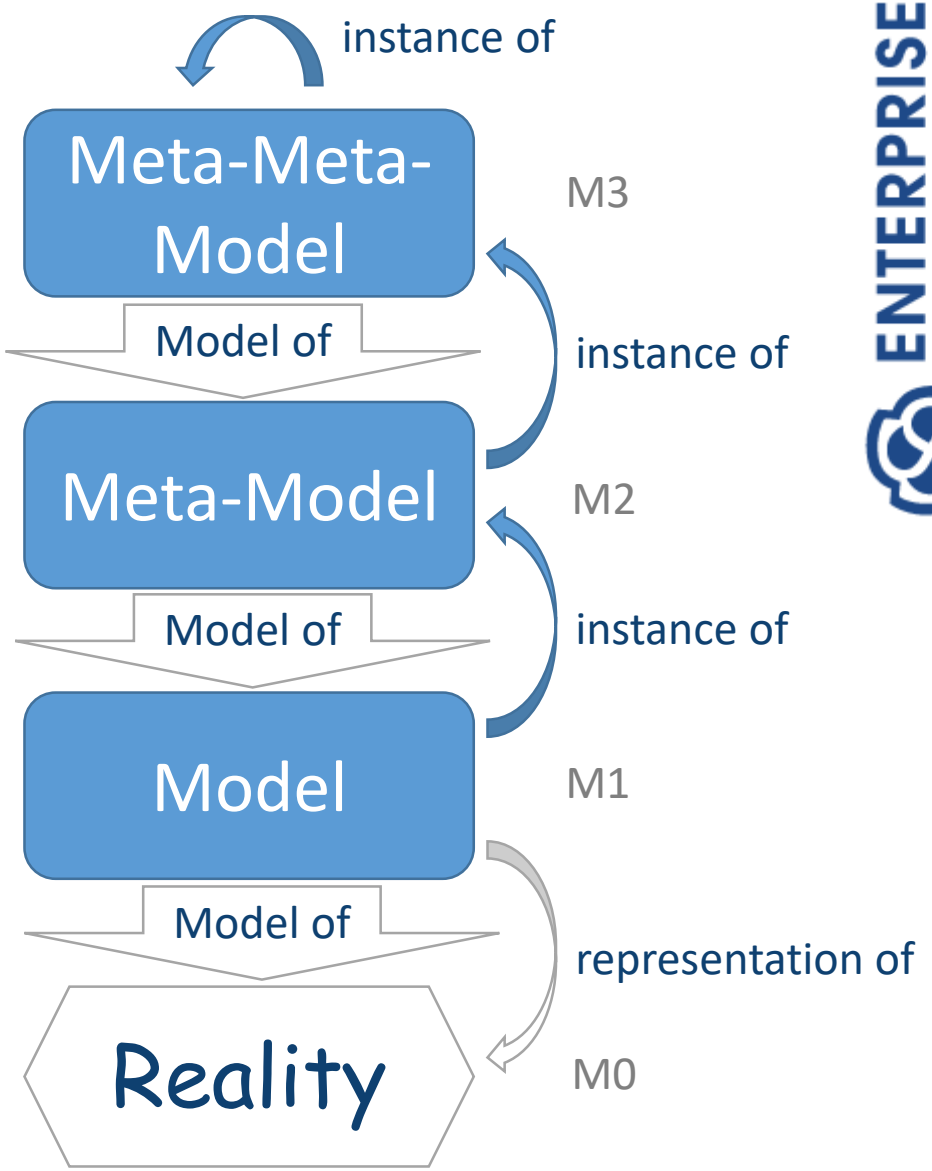
What is a Meta Meta-Model?

The Language Stack





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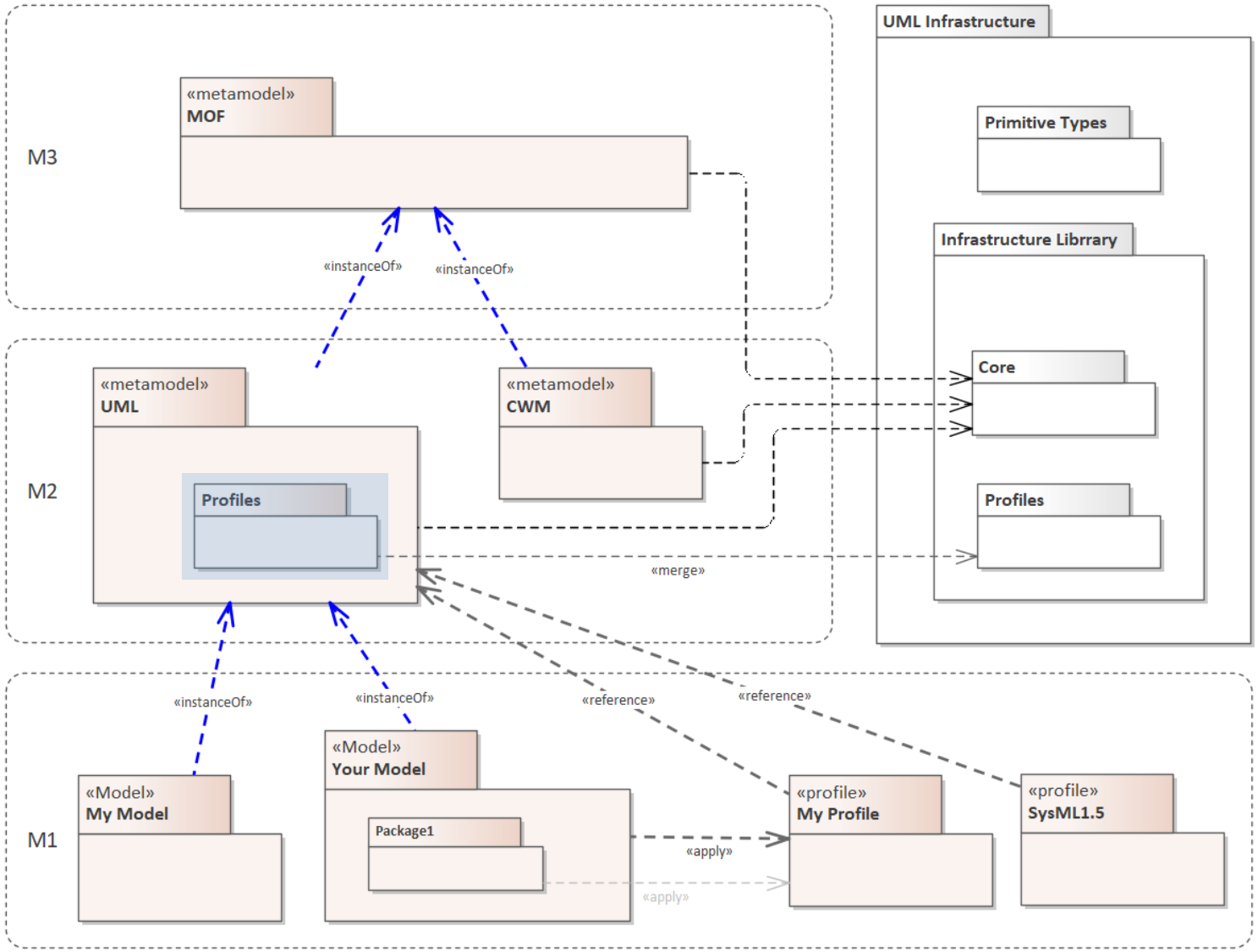
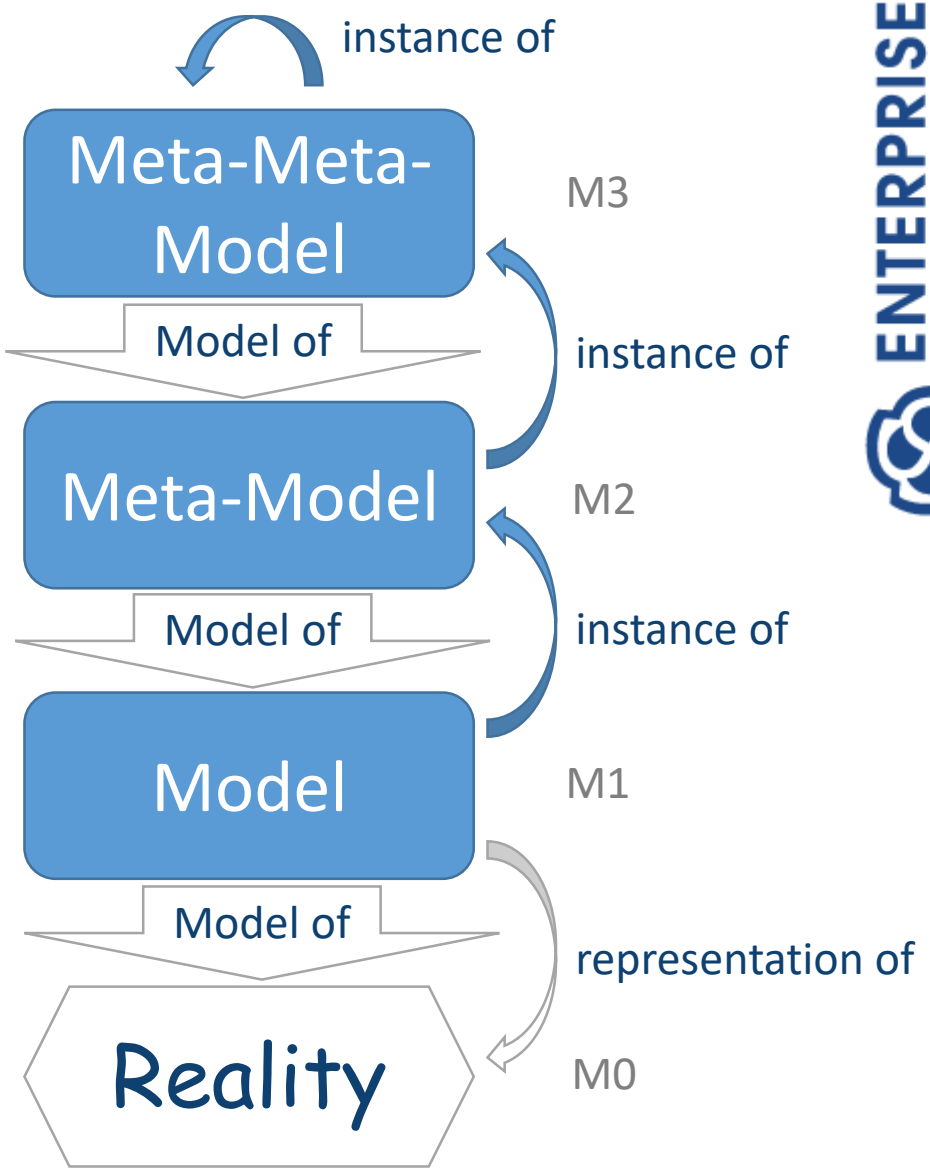
Language Stack

based on the Meta Object Facility





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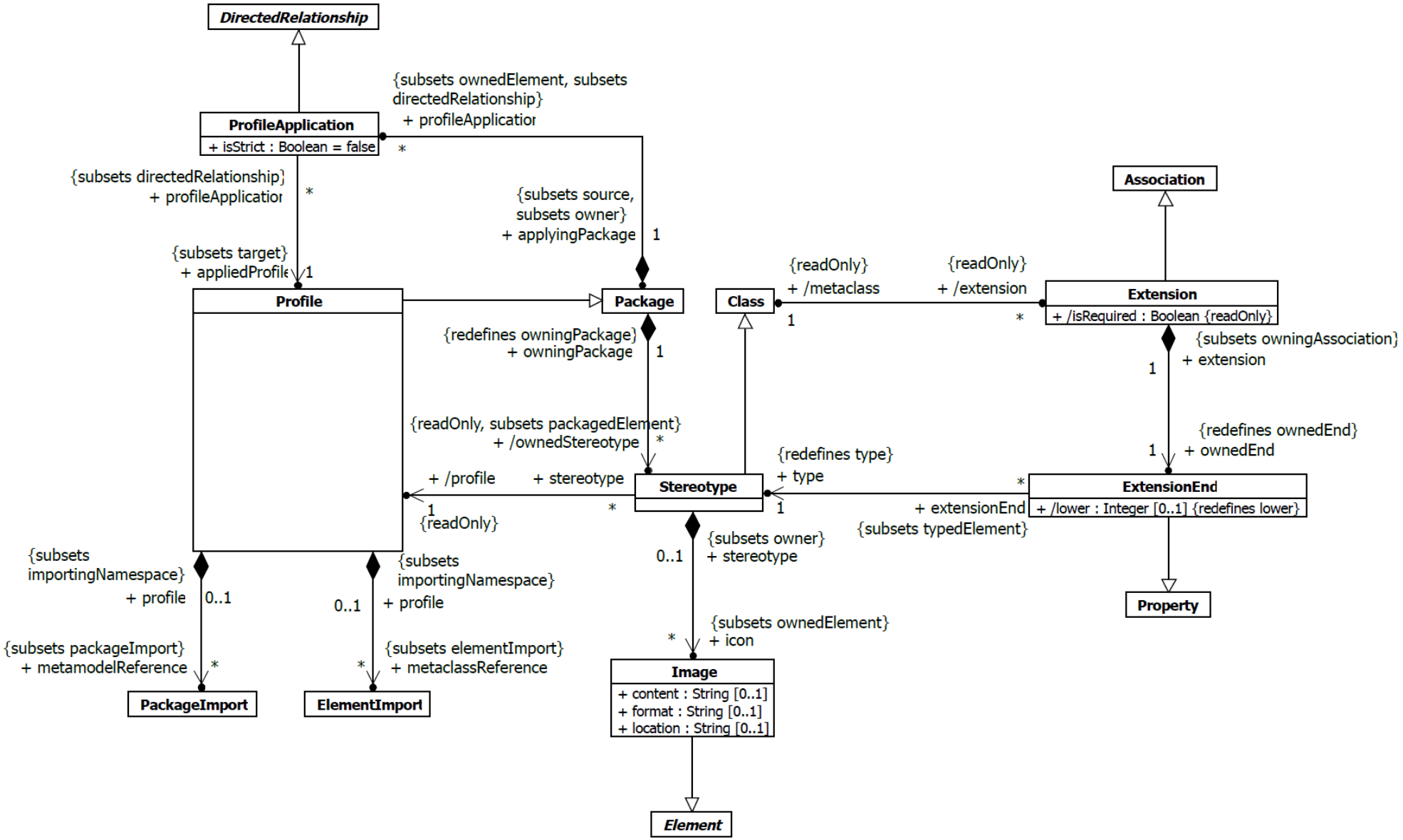
Profile

M2


DirectedRelationship
ProfileApplication
+ isStrict : Boolean = false
{subsets ownedElement, subsets directedRelationship}
+ profileApplicatior
{subsets directedRelationship}
+ profileApplicatior
{subsets target}
+ appliedProfile
{subsets source, subsets owner}
+ applyingPackage
Profile
Package
{redefines owningPackage}
+ owningPackage
{readOnly, subsets packagedElement}
+ /ownedStereotype
+ /profile
+ stereotype
{readOnly}
Stereotype
Class
{readOnly}
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Association
Extension
+ /isRequired : Boolean {readOnly}
{subsets owningAssociation}
+ extension
{redefines ownedEnd}
+ ownedEnd
{redefines type}
+ type
+ extensionEnd
{subsets typedElement}
ExtensionEnd
+ /lower : Integer [0..1] {redefines lower}
Property
{subsets importingNamespace}
+ profile
{subsets packageImport}
+ metamodelReference
PackageImport
{subsets importingNamespace}
+ profile
{subsets elementImport}
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ElementImport
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+ stereotype
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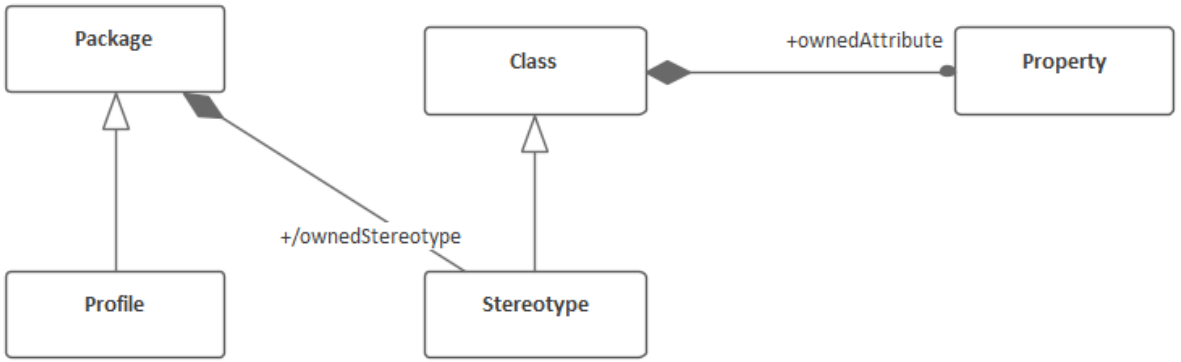
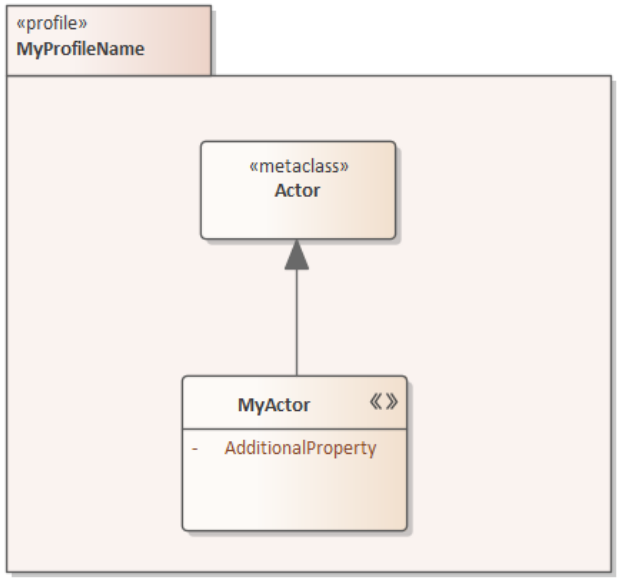
+ icon
Image
+ content : String [0..1]
+ format : String [0..1]
+ location : String [0..1]
Element

Profile – Simple Representation



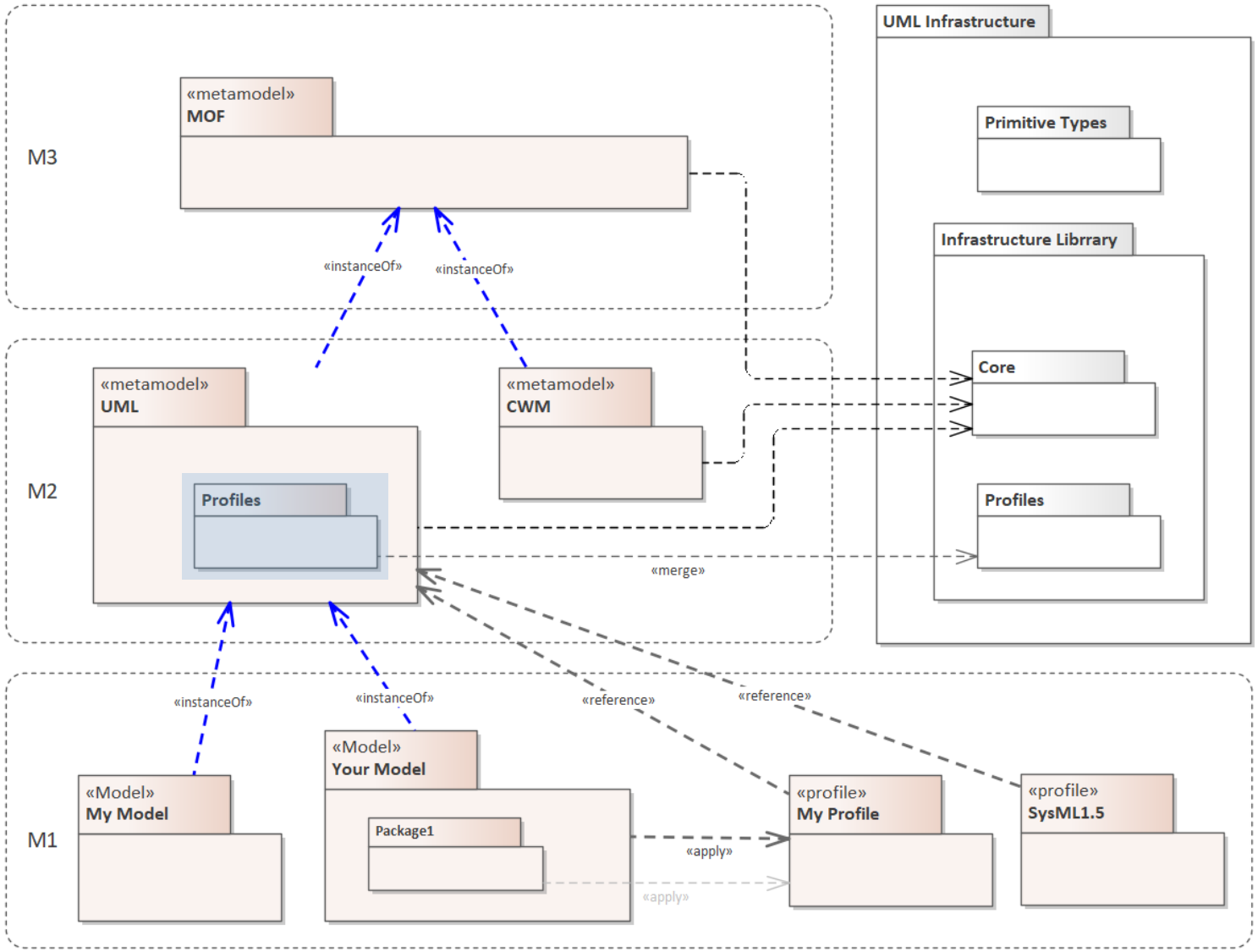
M2

M1

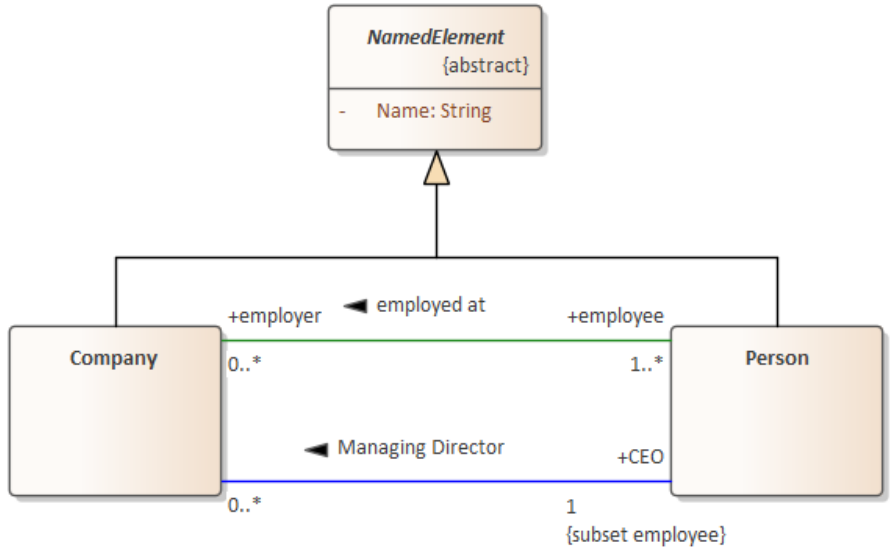


Meta Object Facility

The Language Stack

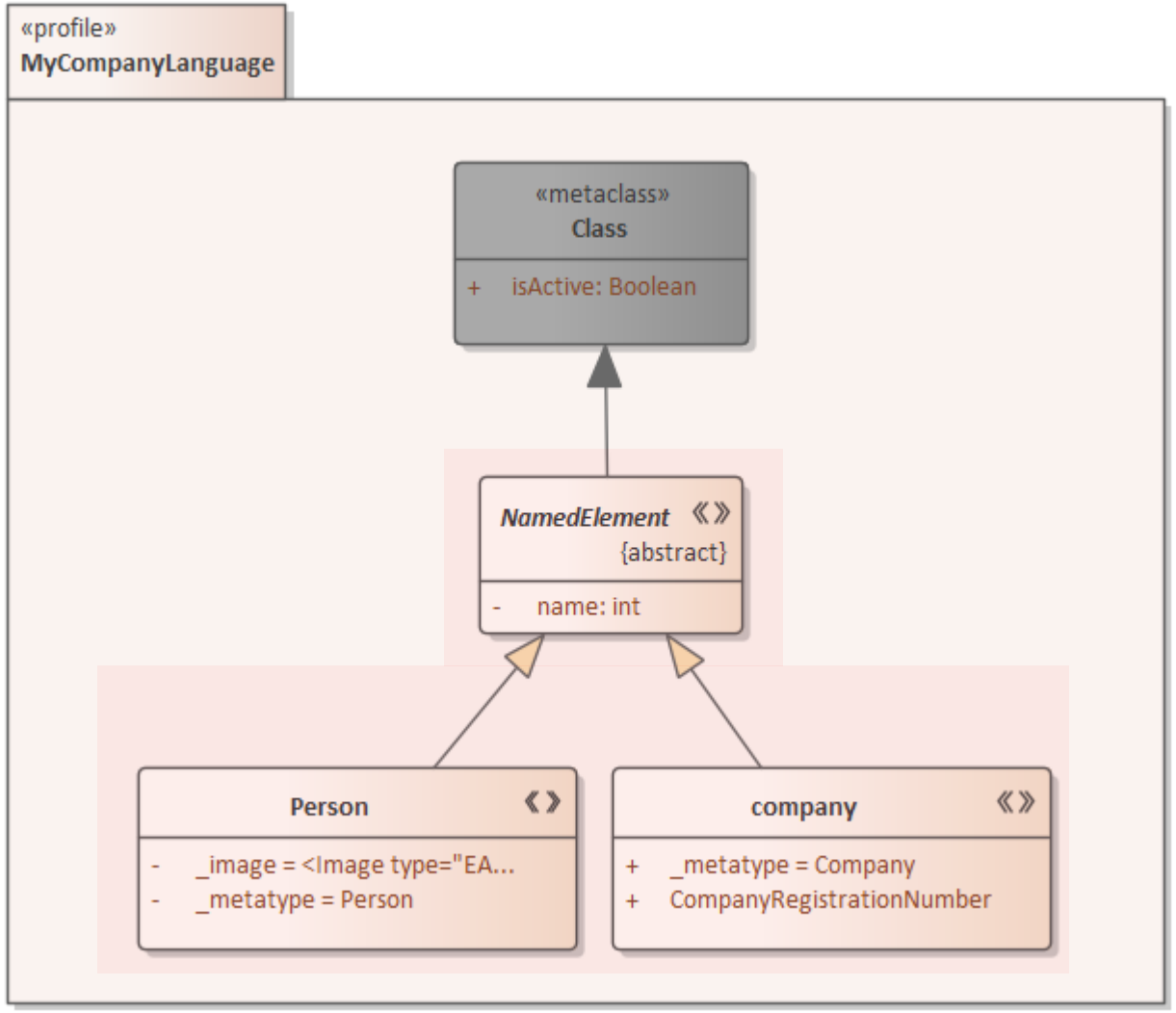


A Simple MetaModel



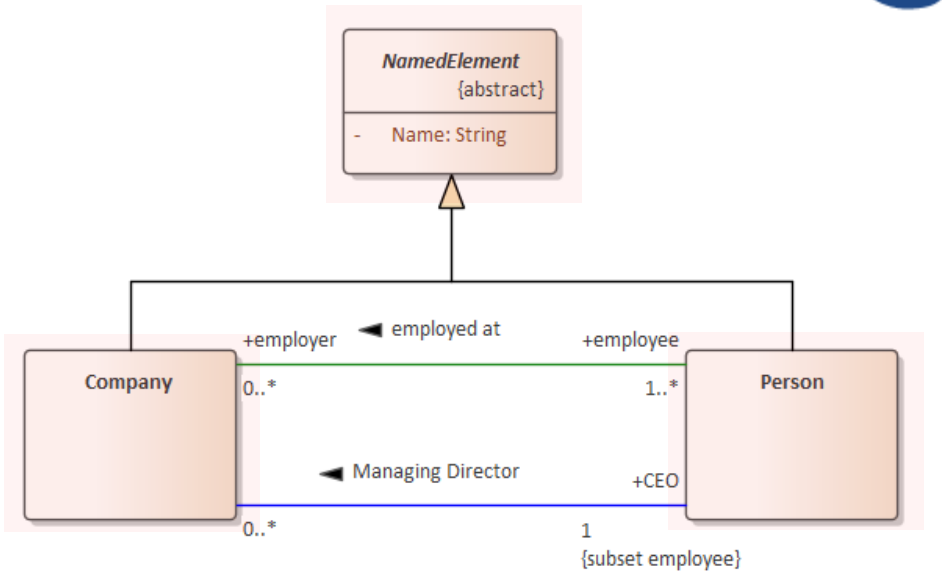
We translate the meta-model now into a UML Profile.

Translate a Meta-Model into a UML-Profile



Transform

A Simple MetaModel



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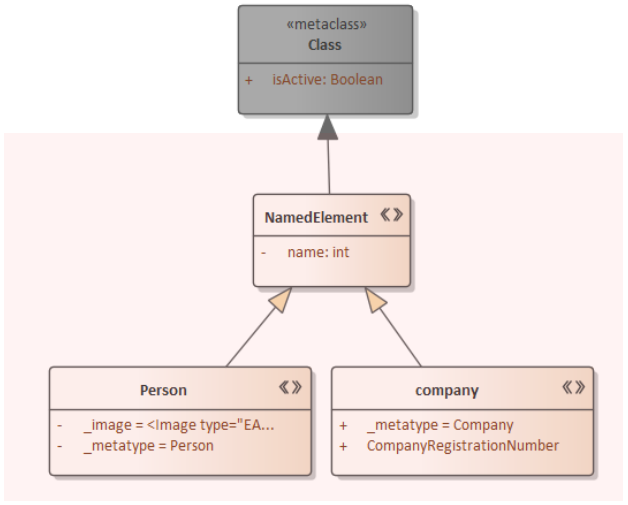

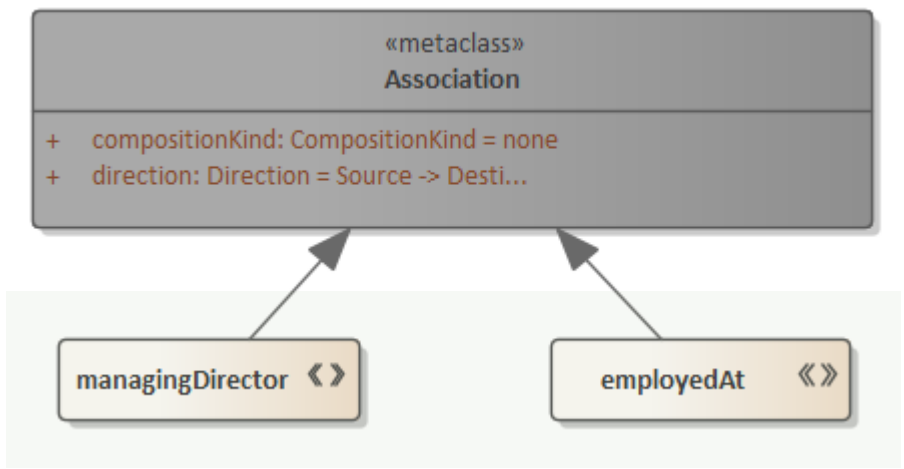

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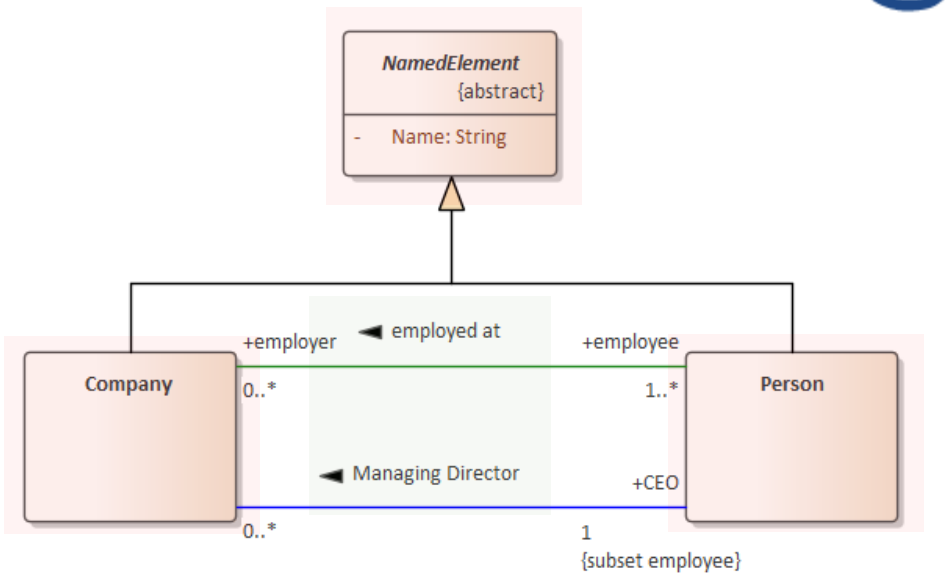

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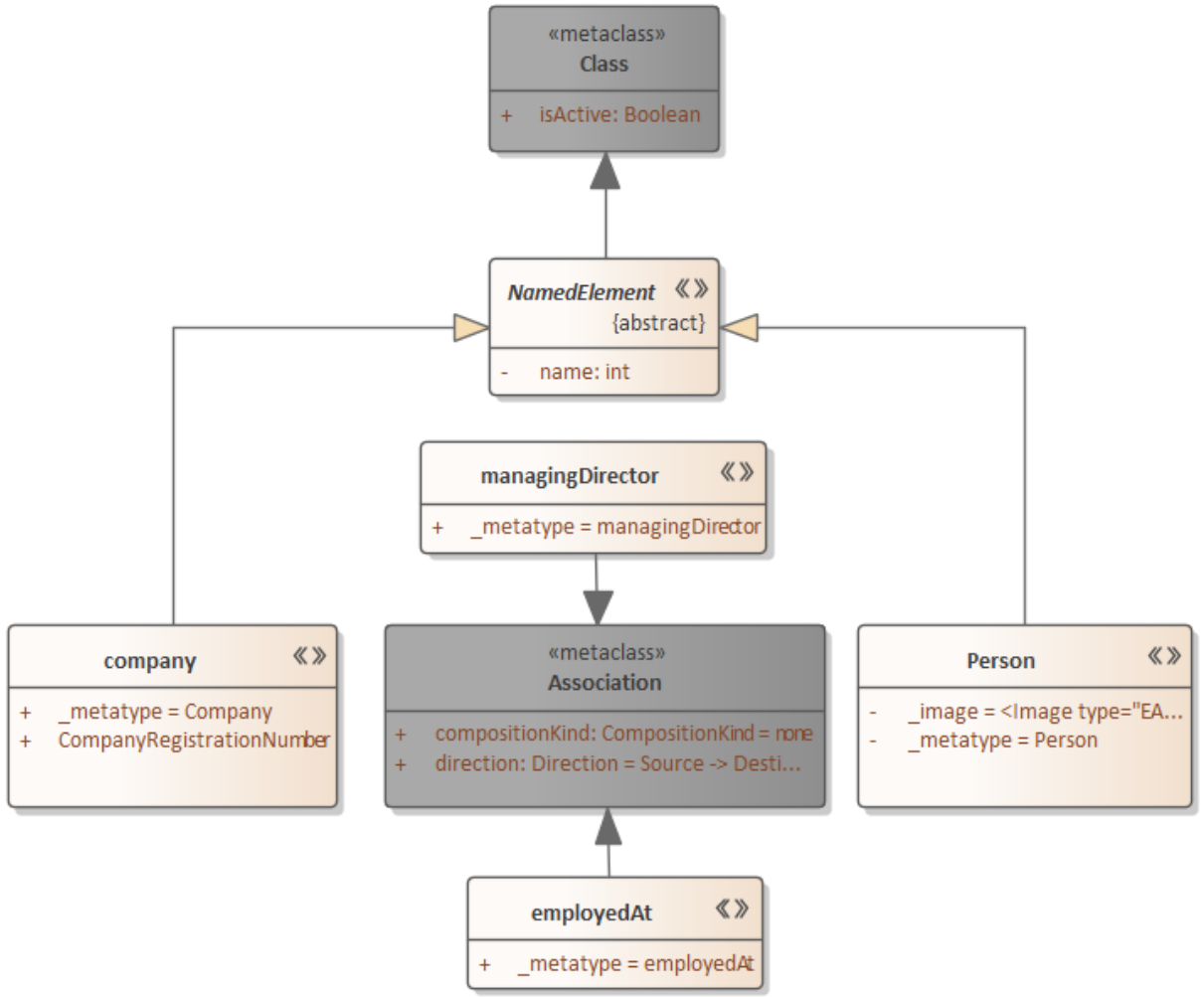
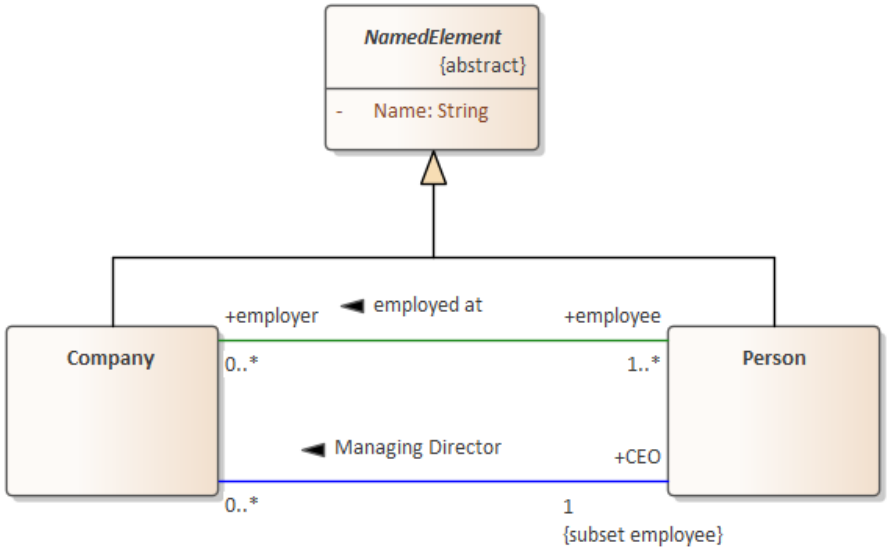
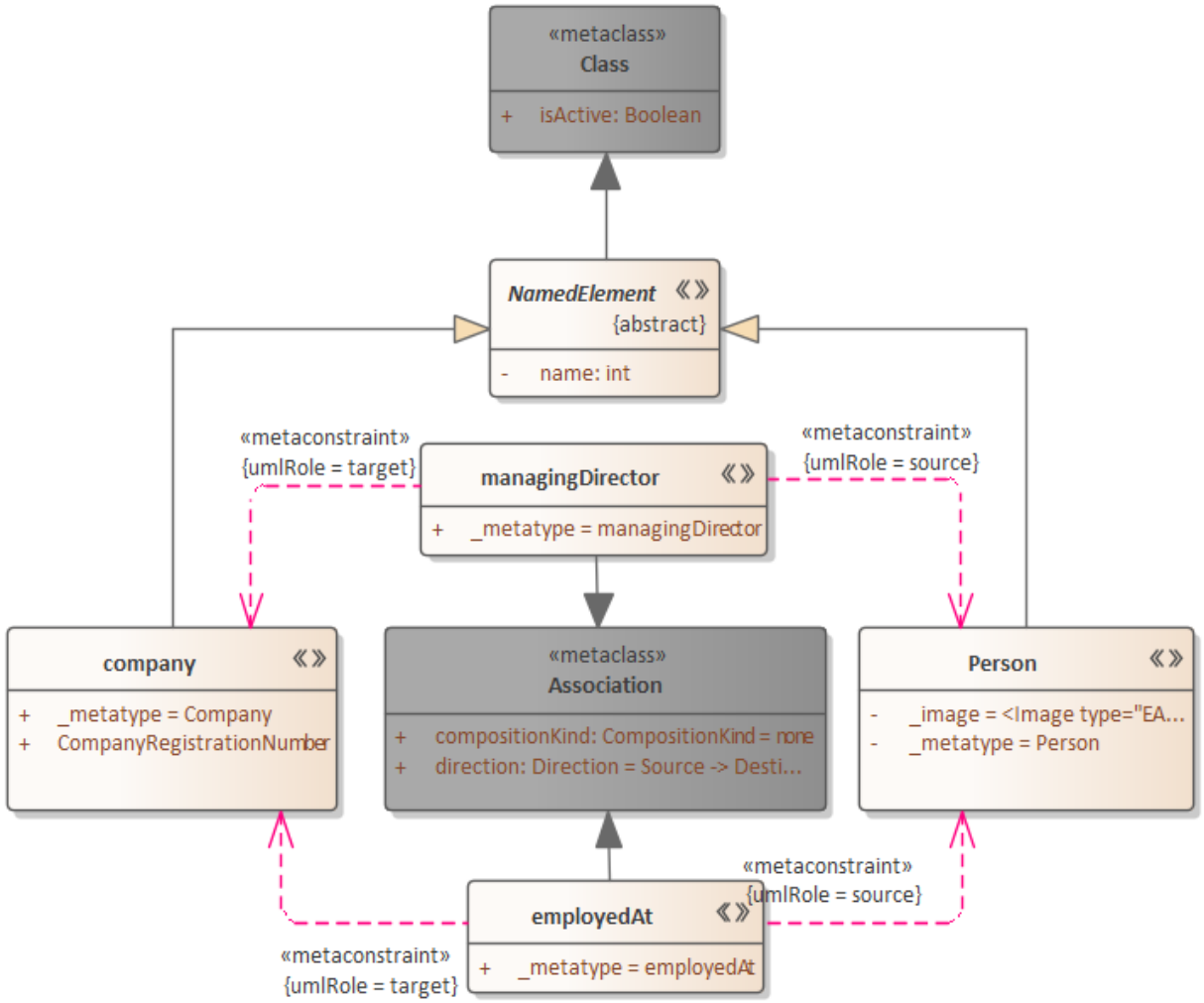
Translate a Meta-Model into a UML-Profile



Transform



Add MetaModel Constraints



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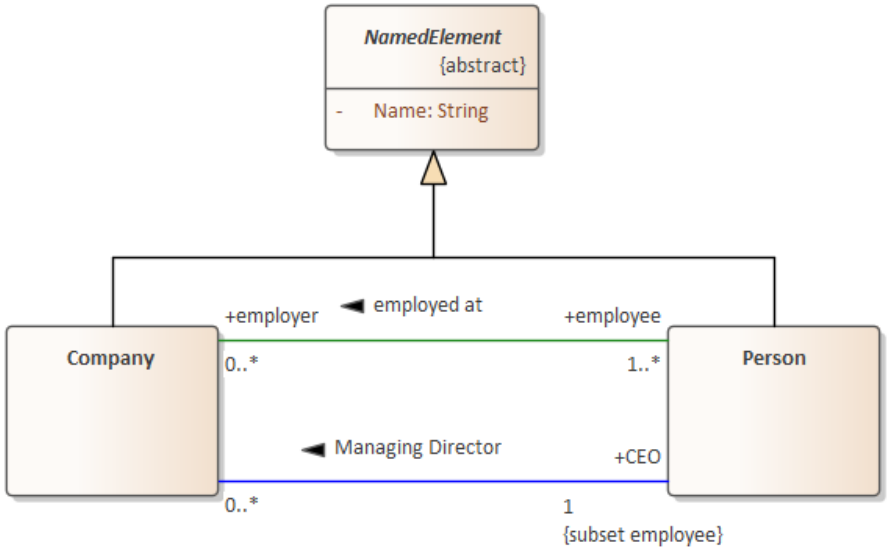
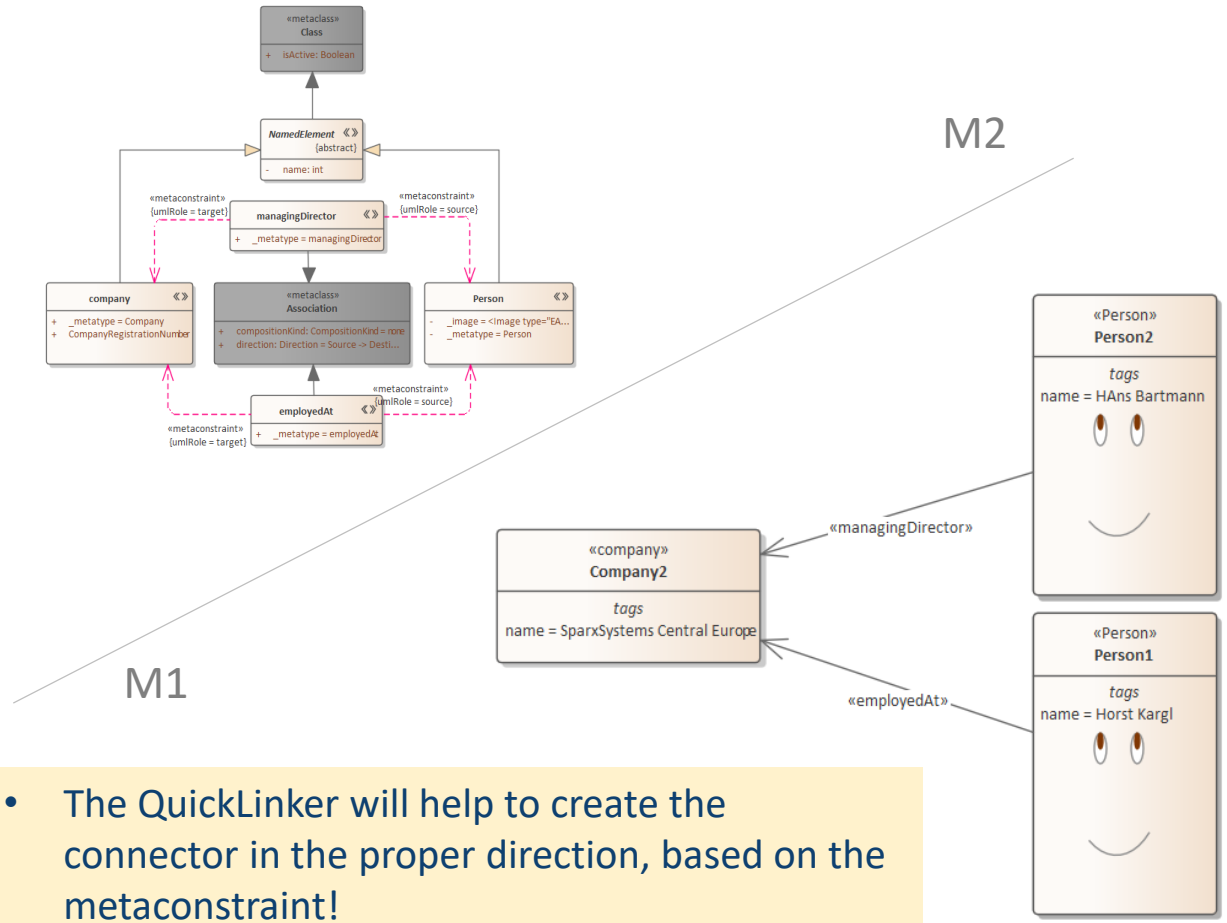
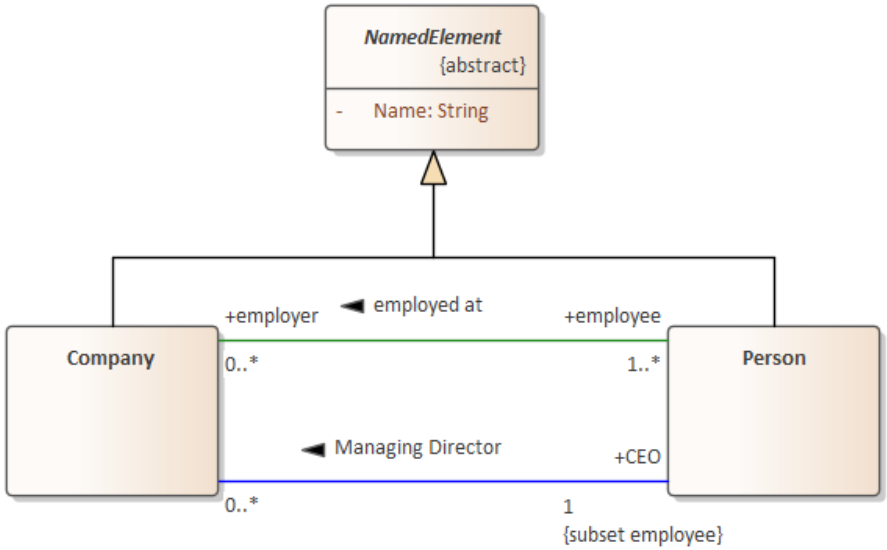


How the Model could Look Like



Transform

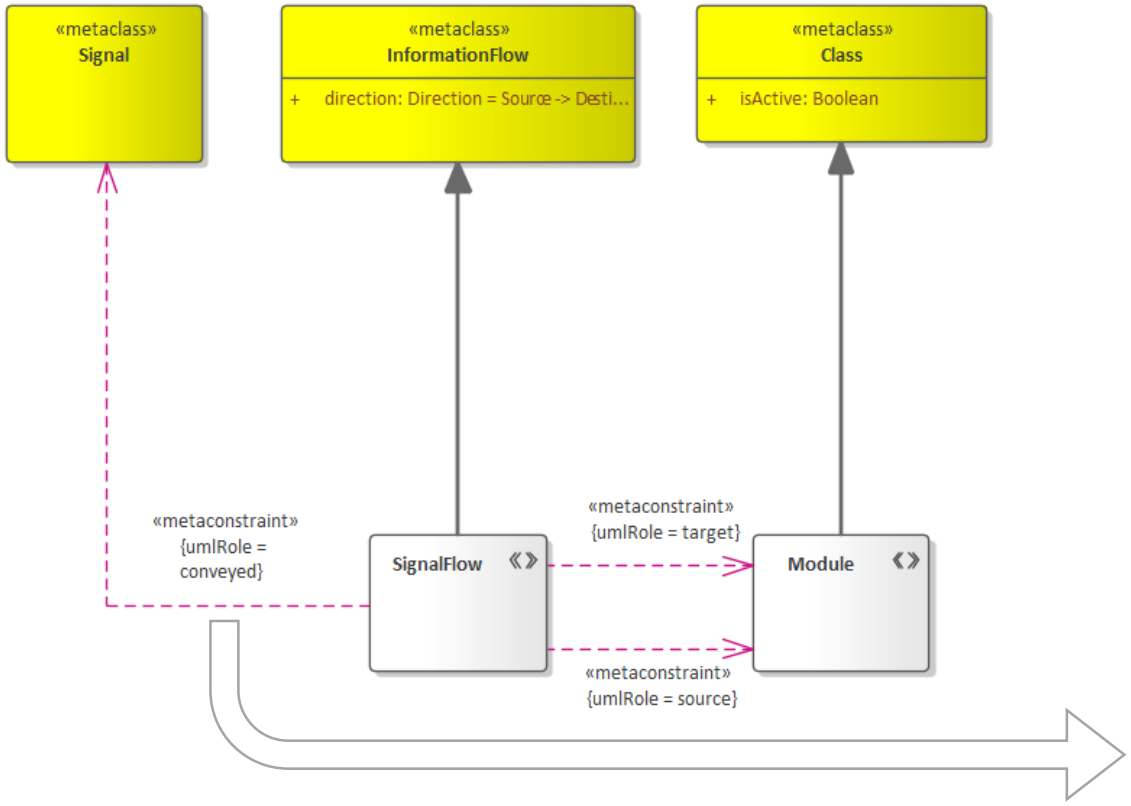


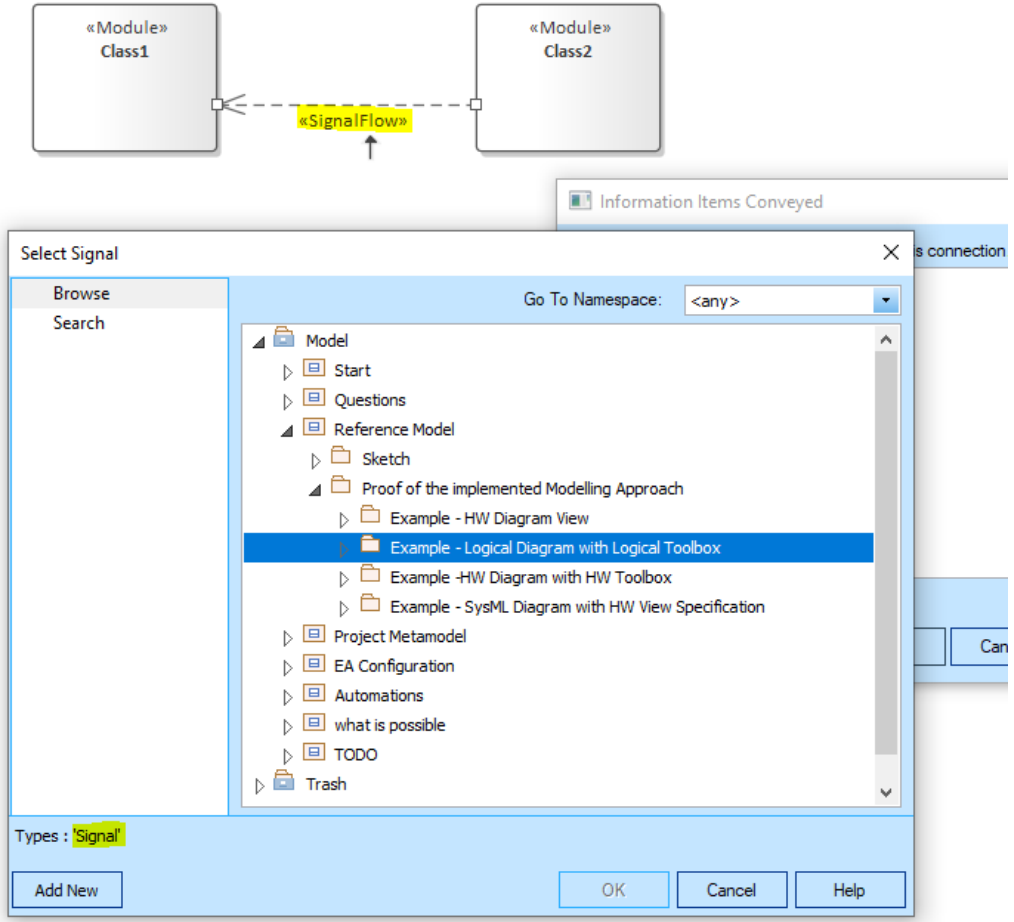
- The QuickLinker will help to create the connector in the proper direction, based on the metaconstraint!
- Model Validation will also find connectors with wrong direction based on the metaconstraint!

Other MetaModel Constraints

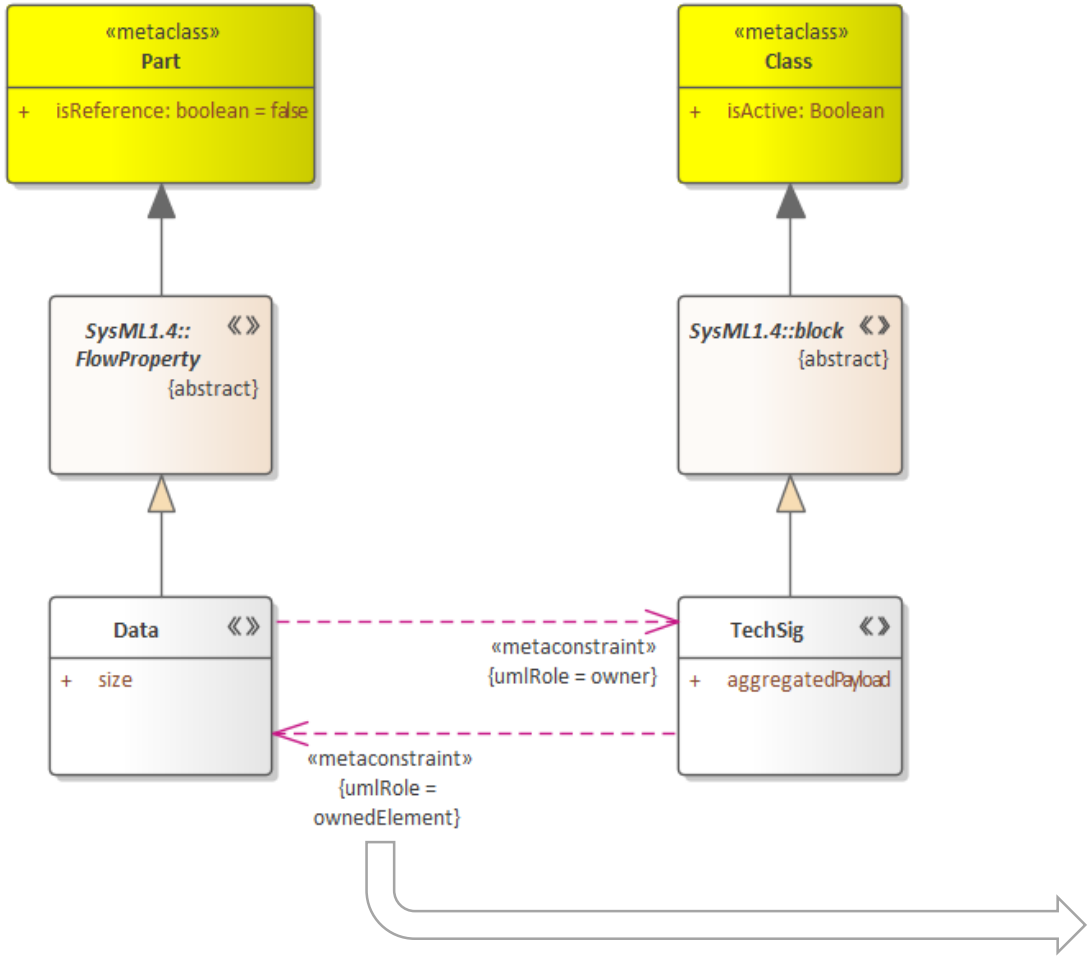
- …
- **Classifier/Type** – restricts the classifier/Type for the source Stereotype element to the target Stereotype element
- **behavior** - restricts the behavior for the source Stereotype () element to the target Stereotype element
- **conveyed** - restricts the conveyed element for the source Stereotype element to the target Stereotype element
- **slot** - restricts the slot for the source Stereotype element to the target Stereotype element
- **client/source/end[0].role/informationSource** – restricts the source of a connector to the target Stereotype element
- **supplier/target/end[1].role/informationTarget** - restricts the target of a connector to the target Stereotype element
- **realizingConnector/realizingActivityEdge/realizingMessage** - restricts the relationship that can realize an information flow
- **typedElement/instanceSpecification** – when dropping as classifier from the **Browser window**, this constraint restricts the type to the target Stereotype element
- **owner/class/activity/owningInstance** – restricts the container of this element to the target Stereotype element; this constraint is used to create embedded element rules for the Quick Linker and validate nesting during Model Validation
- **ownedElement/ownedAttribute/ownedOperation/ownedParameter/ownedPort** – restricts the element/attribute/operation/parameter/port that can be owned by the source Stereotype element; this constraint is typically used to validate nesting during Model Validation
- **annotatedElement/constrainedElement** – restricts the target of a Note Link connector to the target Stereotype element
- …

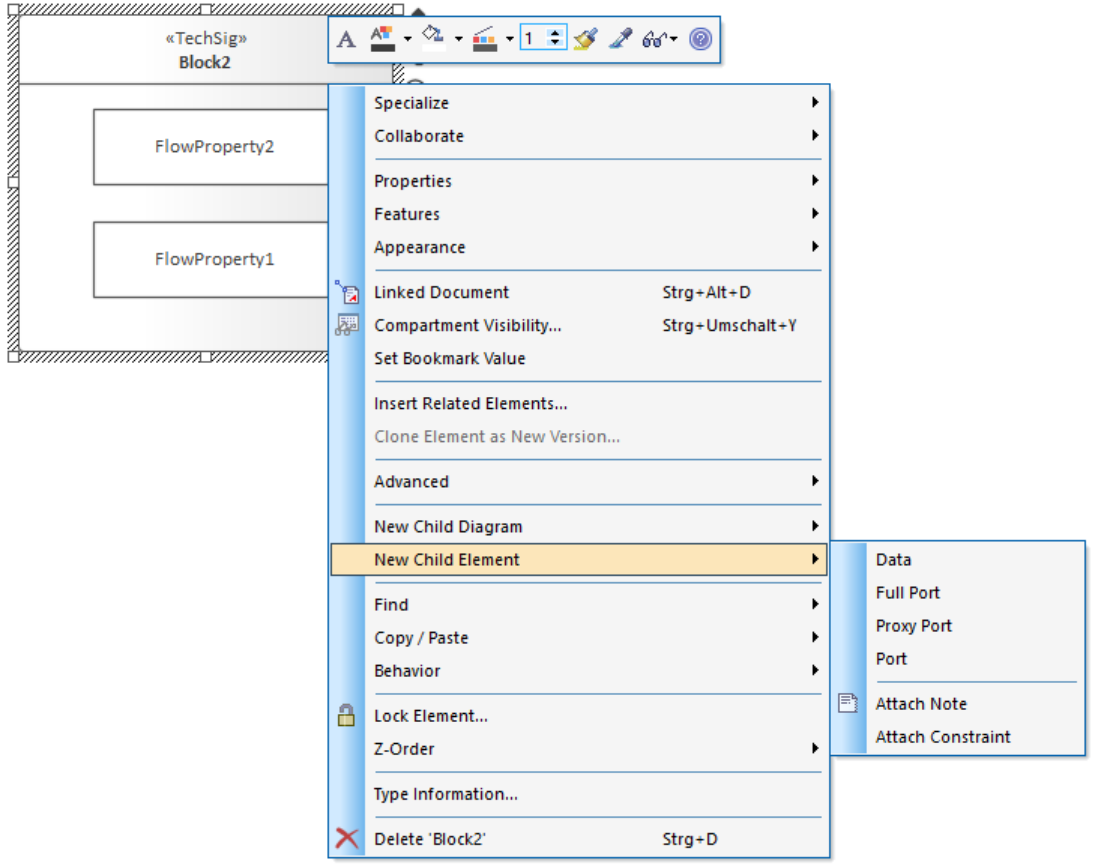
Other MetaModel Constraints



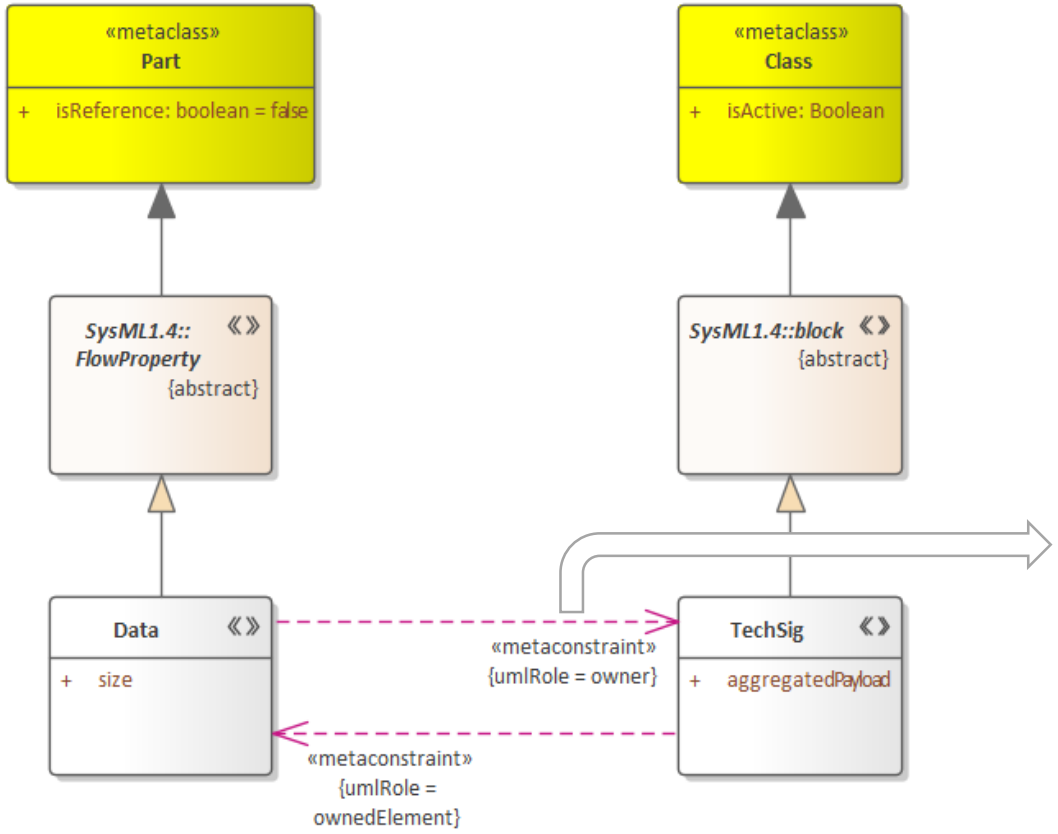


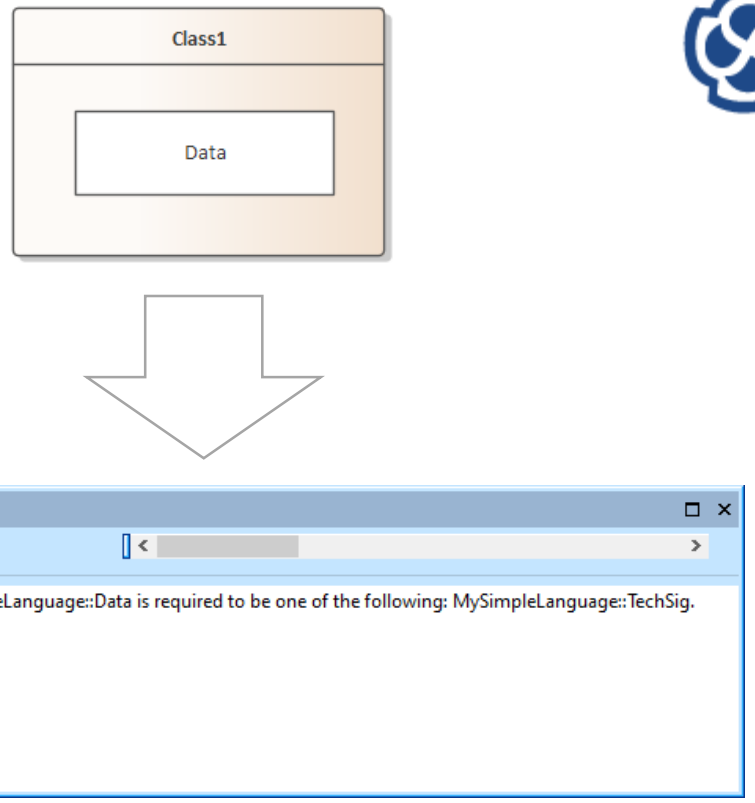
Other MetaModel Constraints



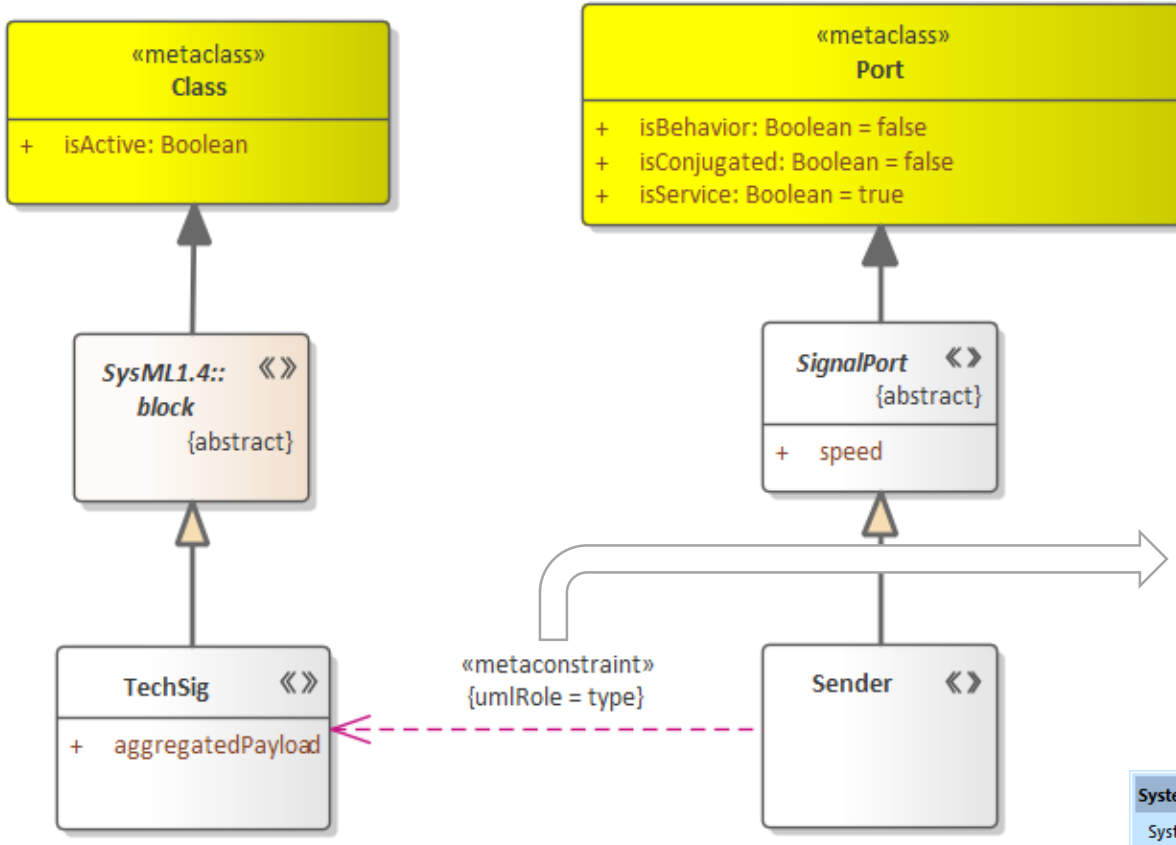


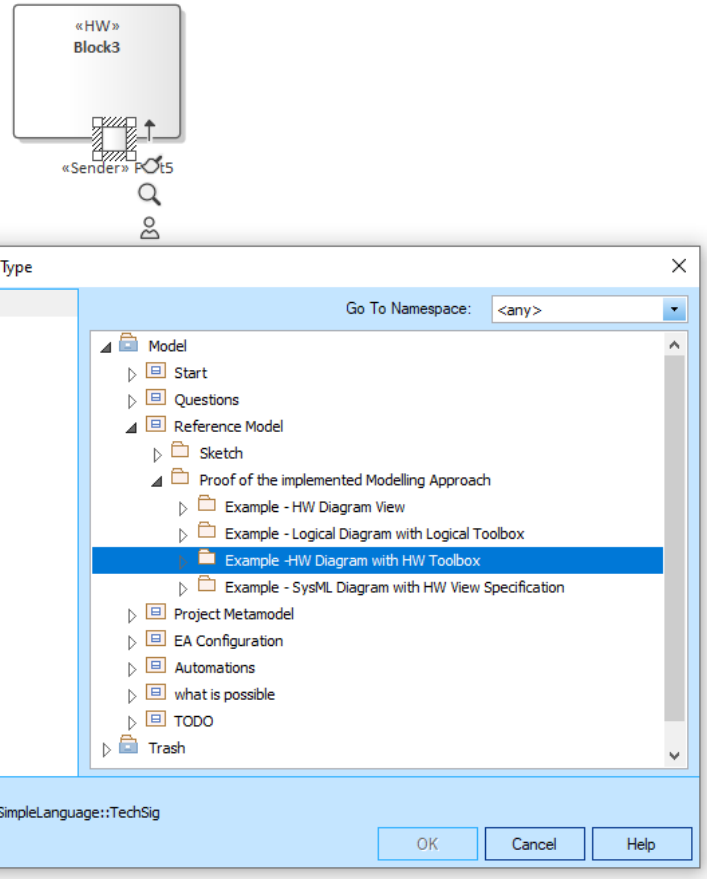
Other MetaModel Constraints

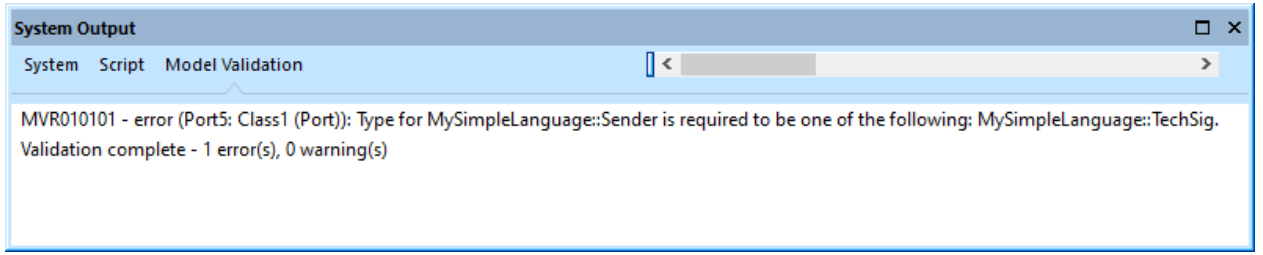




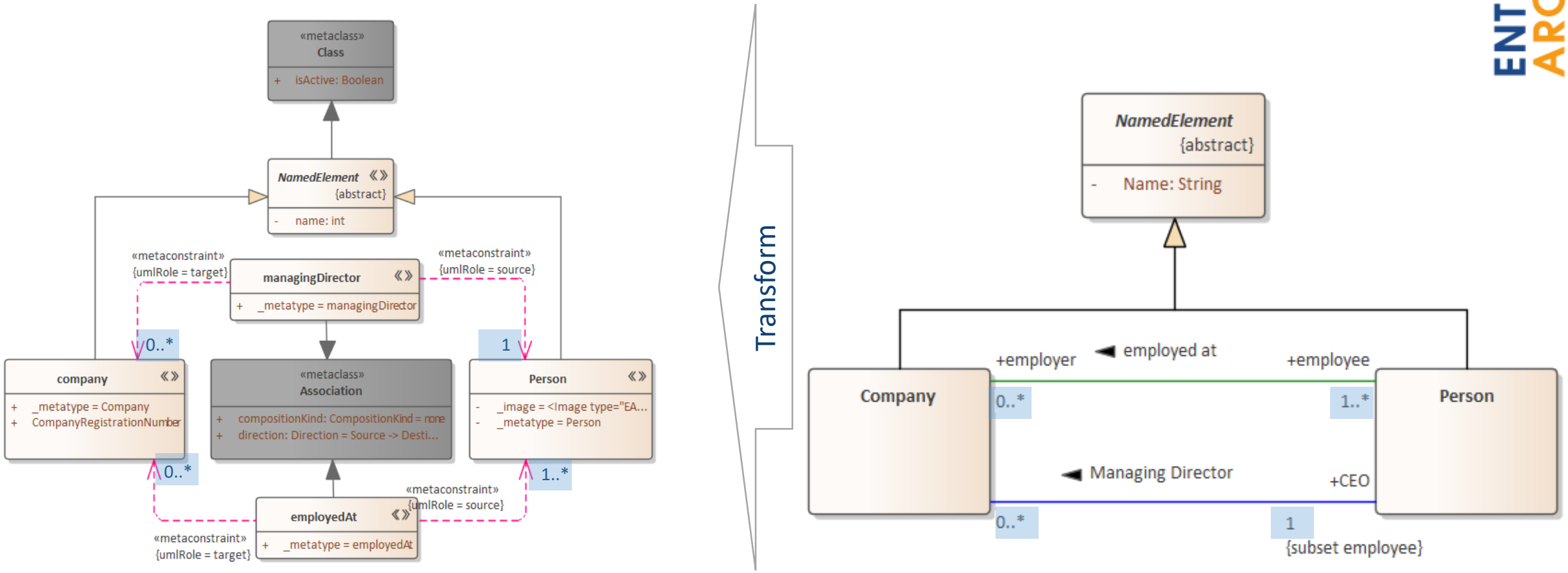
Other MetaModel Constraints





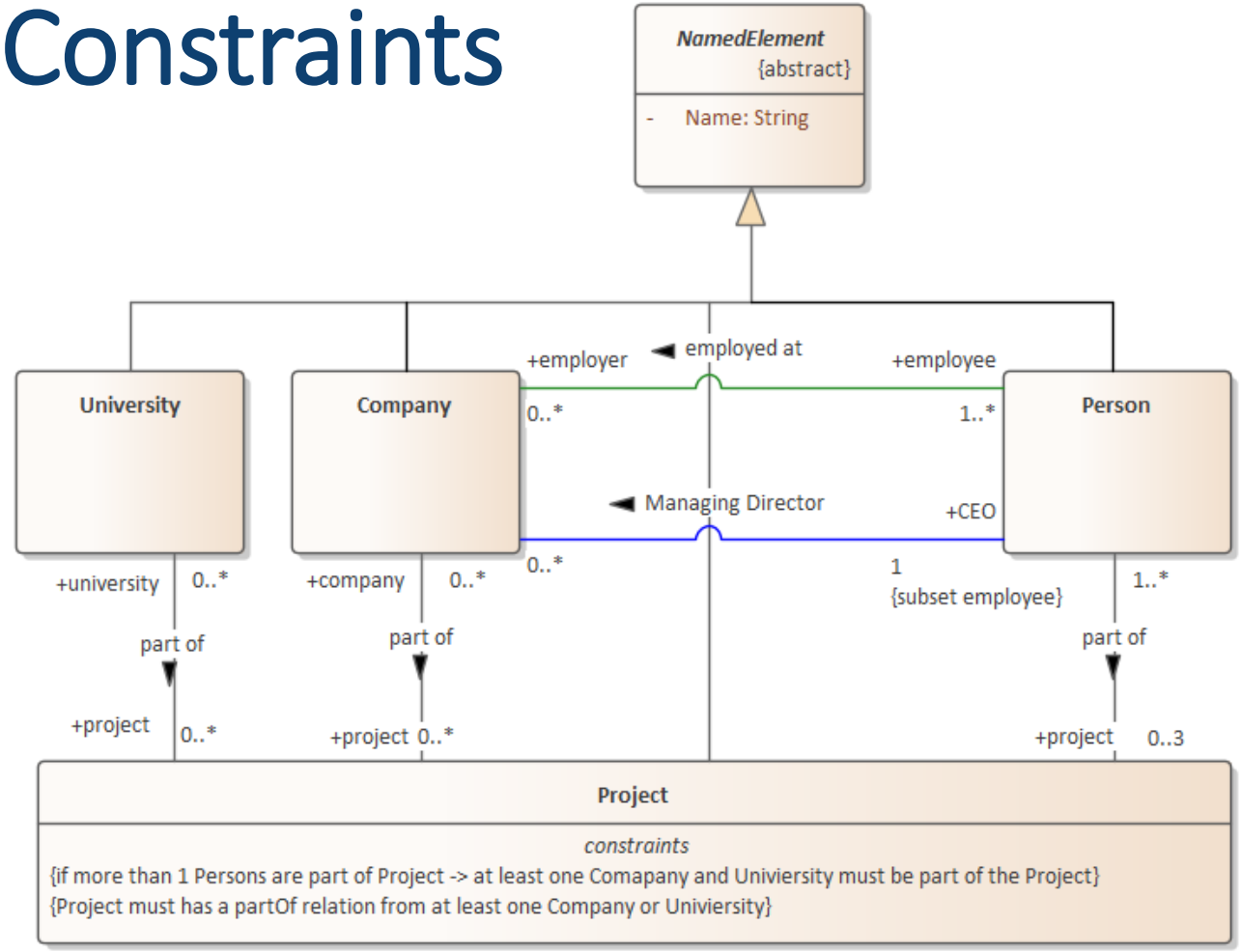


Additional Constraints



But what about constraints which cannot be expressed in a MetaModel?

Additional Constraints



But what about constraints which cannot be expressed in a MetaModel?

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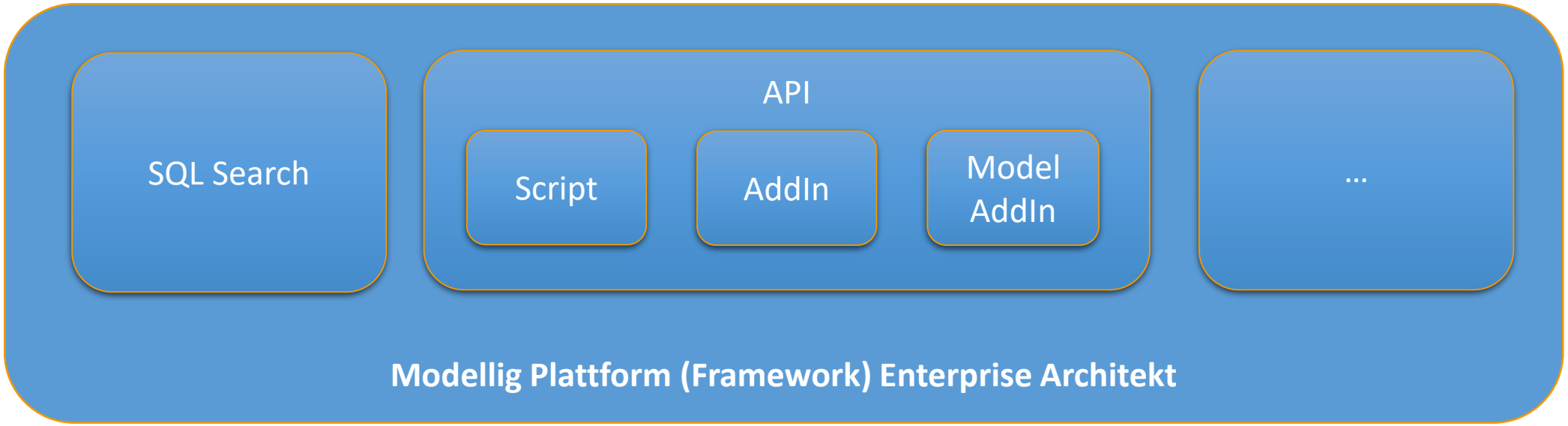
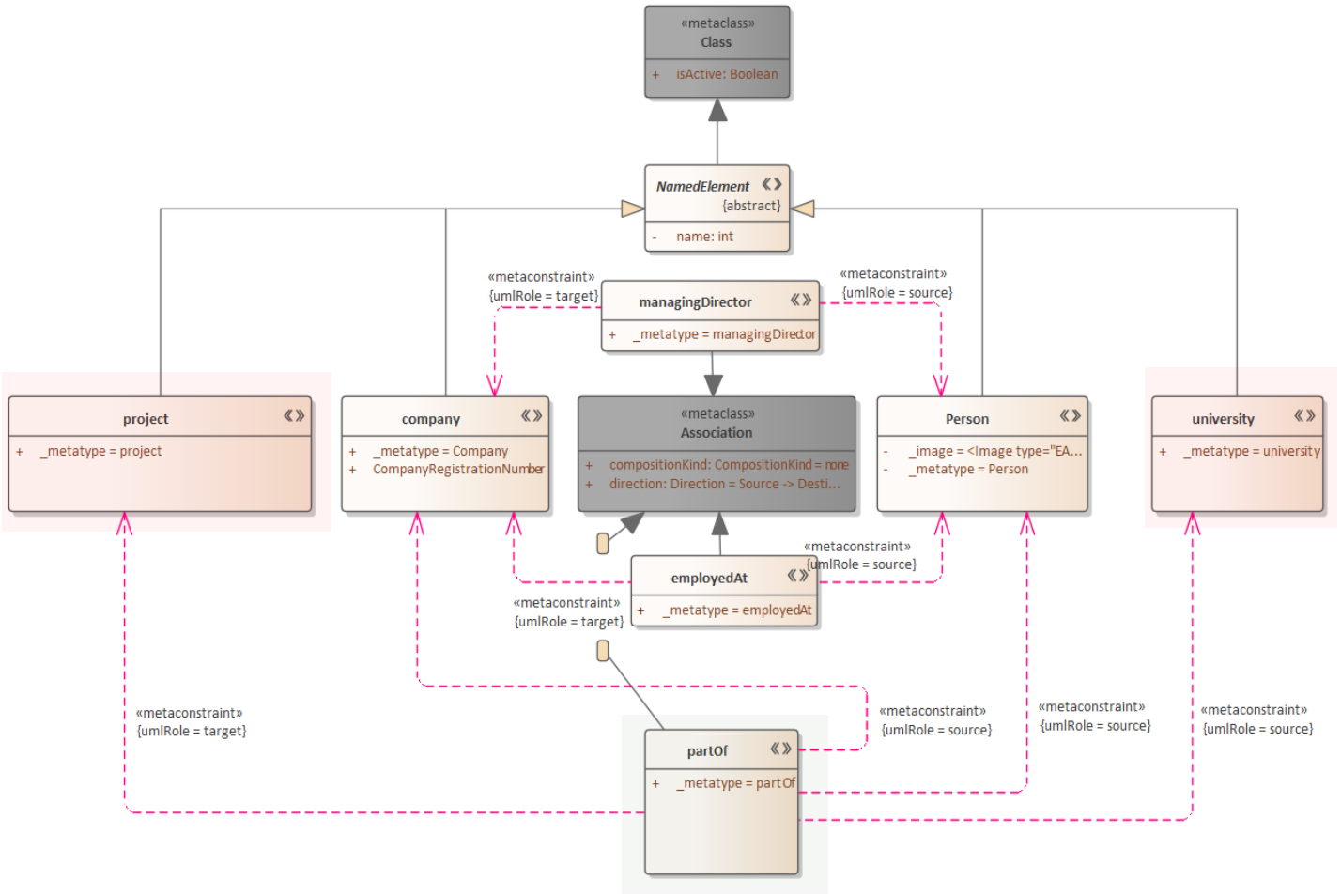
Additional Constraints

But what about constraints which cannot be expressed in a MetaModel?

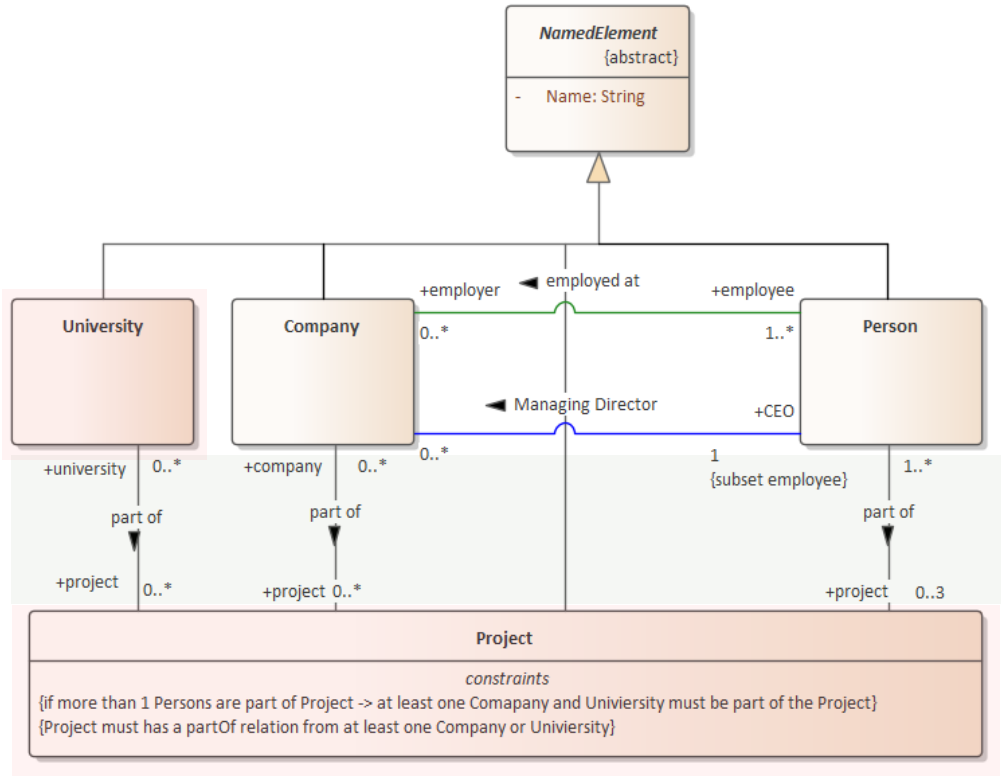
We can use the Platform (Framework) Features of EA in order to customize EA to our needs.



Translate the Extended Metamodel into a Profile



Transform

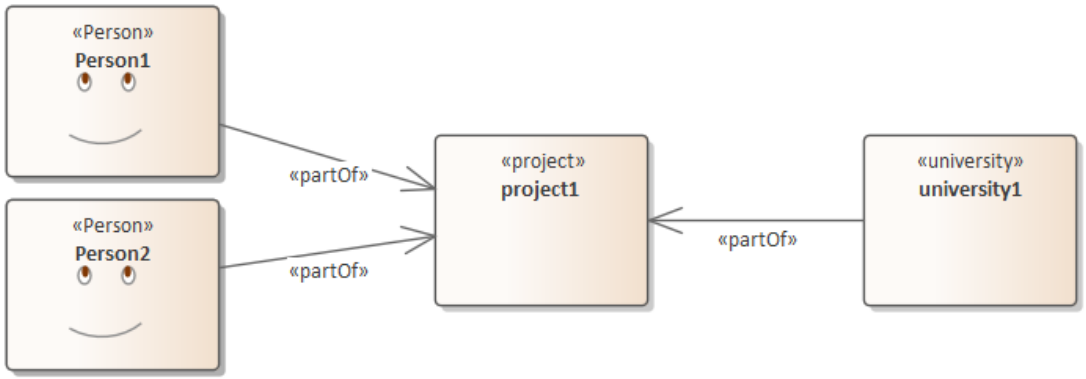


Additional Constraints in the MetaModel

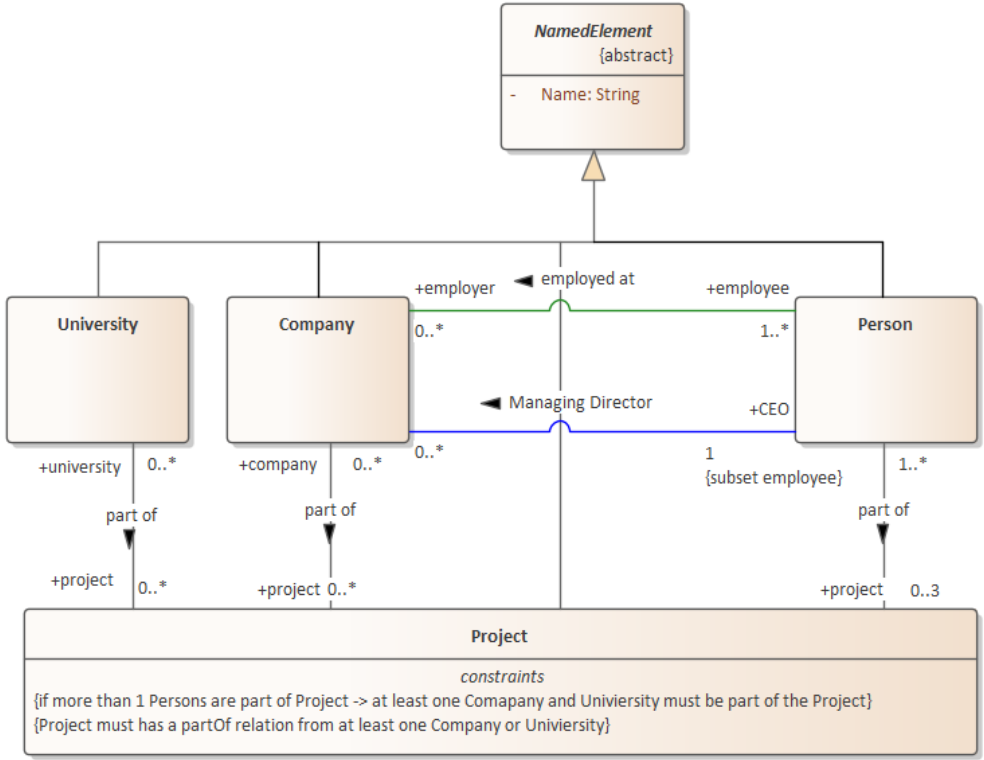
But what about constraints which cannot be expressed in a MetaModel?

Additional Constraint:

If more than one ***Person*** is ***part of*** a ***Project***, at least one ***University*** and one ***Company*** must be also ***part of*** the ***Project***.



… at lease one ***Company*** must be also ***part of*** the ***Project***



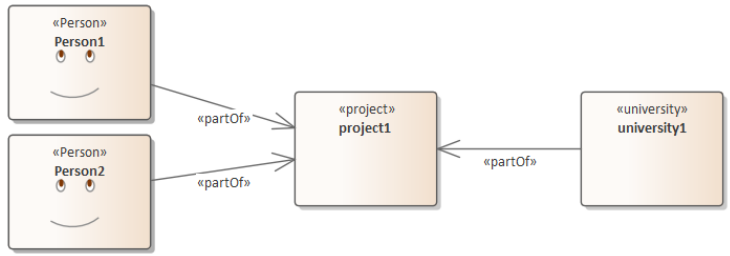
Using the EA API to define Validation Rules

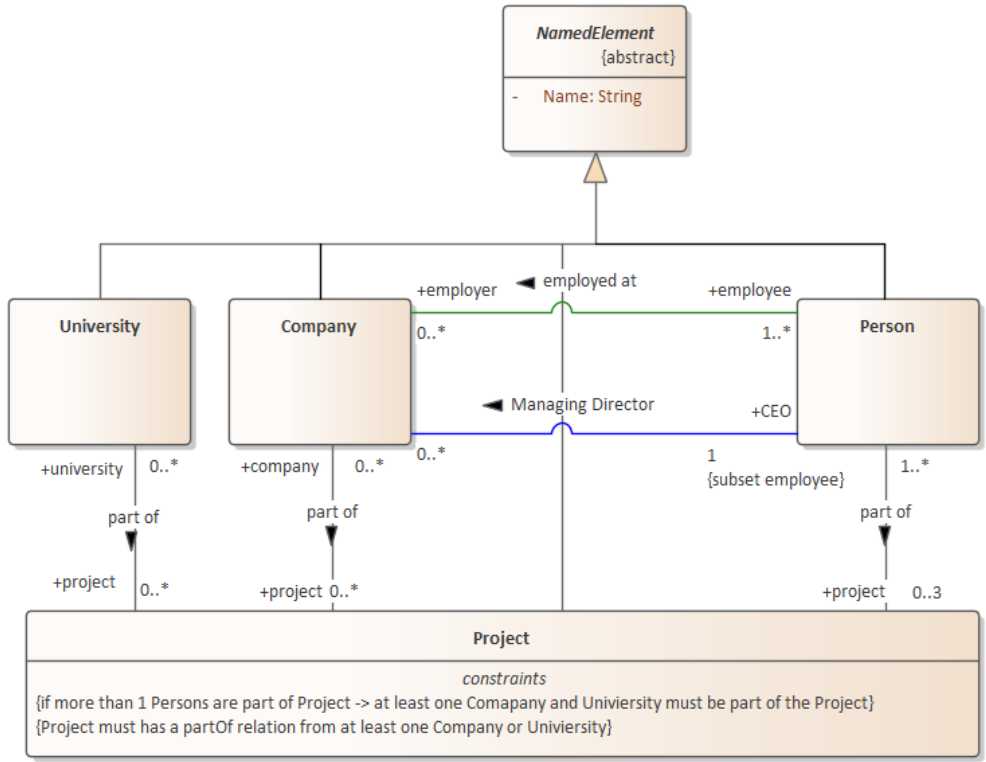
But what about constraints which cannot be expressed in a MetaModel?

```
public bool ProjectConstraintEaApi(Element self)
{
    if (self.MetaType != "project")
        return true;

    int personCount = 0;
    int universityCount = 0;
    int companyCount = 0;

    foreach(Connector connector in self.Connectors)
    {
        if (connector.MetaType != "partOf")
            continue;

        int oppositeEnd = self.ElementID == connector.ClientID ? connector.SupplierID : connector.ClientID;
        Element oppositeElement = _repo.GetElementByID(oppositeEnd); //may rais an exception -> should be in try Catch

        if(oppositeElement.MetaType == "university")
        {
            universityCount++;
        }
        else if (oppositeElement.MetaType == "company")
        {
            companyCount++;
        }
        else if (oppositeElement.MetaType == "Person")
        {
            personCount++;
        }
    }

    return personCount > 1 ? universityCount >= 1 && companyCount >= 1 : true;
}
```

Additional Constraint:

If more than one ***Person*** is ***part of*** a ***Project***, at least one ***University*** and one ***Company*** must be also ***part of*** the ***Project***.





Search for ***EA API*** at: https://blog.sparxsystems.de/

Search for ***Model Validation Example*** at: https://www.sparxsystems.com

Using Extensions to the EA API

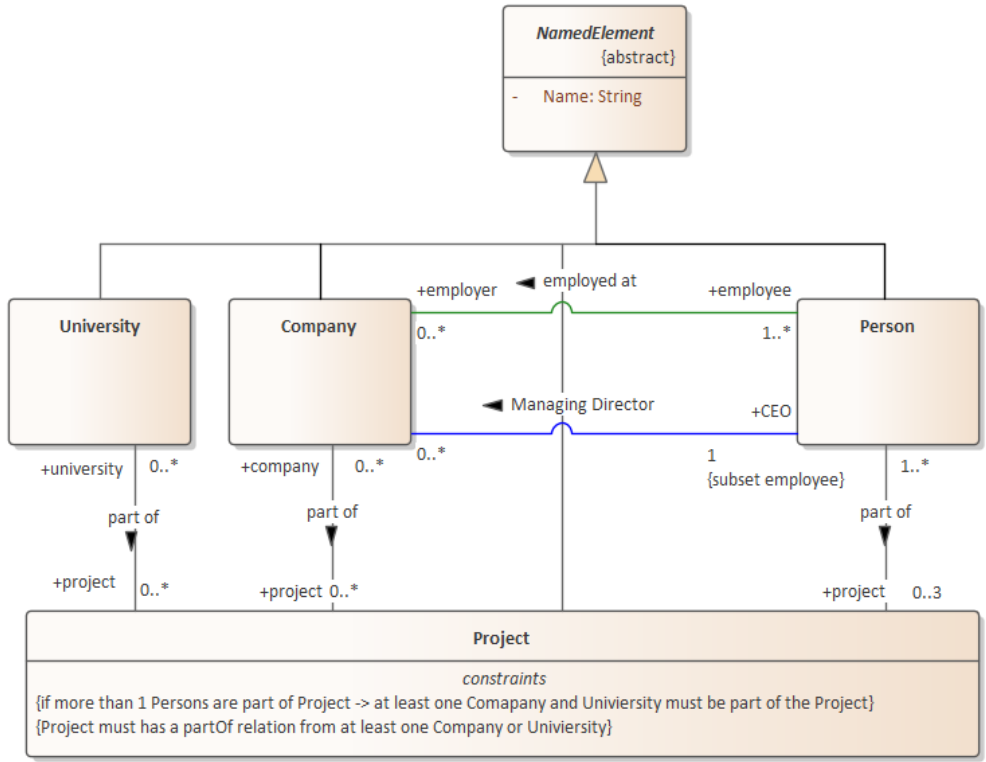
But what about constraints which cannot be expressed in a MetaModel?

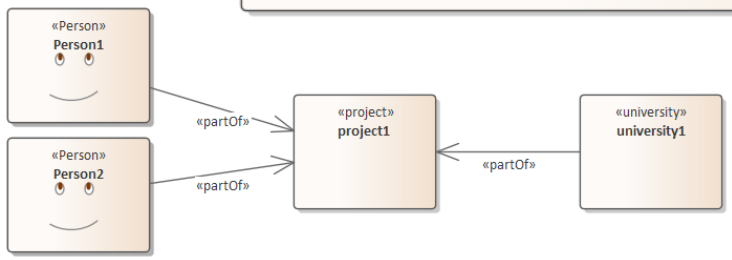
Additional Constraint:

If more than one ***Person*** is ***part of*** a ***Project***, at least one ***University*** and one ***Company*** must be also ***part of*** the ***Project***.

```
public bool ProjectConstraintExtendedApi(Element self)
{
    if (self.MetaType != "project")
        return true;

    return (self.ConnectorWithType("partOf").ToType("Person").Count() >= 1).Implies(
        (self.ConnectorWithType("partOf").ToType("university").Count() >= 1)
        && (self.ConnectorWithType("partOf").ToType("company").Count() >= 1));
}
```

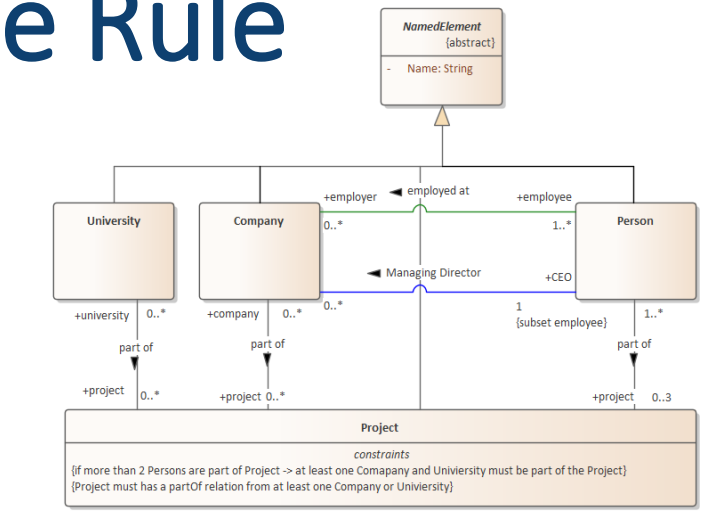
Fluent API with additional OCL like operations





A more Integrated way to Define the Rule

But what about constraints which cannot be expressed in a MetaModel?



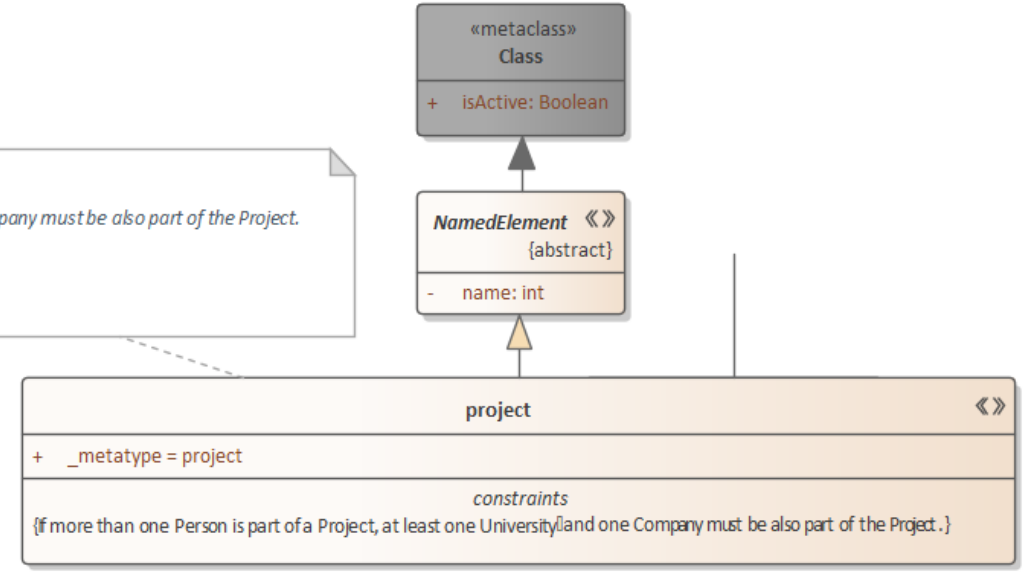
Additional Constraint:

If more than one ***Person*** is ***part of*** a ***Project***, at least one ***University*** and one ***Company*** must be also ***part of*** the ***Project***.

Part of derived UML Profile

```
public bool ProjectConstraintExtendedApi(Element self)
{
    if (self.MetaType != "project")
        return true;

    return (self.ConnectorWithType("partOf").ToType("Person").Count() >= 1).Implies(
        (self.ConnectorWithType("partOf").ToType("university").Count() >= 1)
        && (self.ConnectorWithType("partOf").ToType("company").Count() >= 1));
}
```

«Invariant»
{If more than one Person is part of a Project, at least one Universityand one Company must be also part of the Project.
: (self.ConnectorWithType("partOf").ToType("Person").Count() >= 1).Implies(
(self.ConnectorWithType("partOf").ToType("university").Count() >= 1)
&& (self.ConnectorWithType("partOf").ToType("company").Count() >= 1))}



Generated, compiled and executed during EA's Model Validation

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Other Examples of Fluent Rules

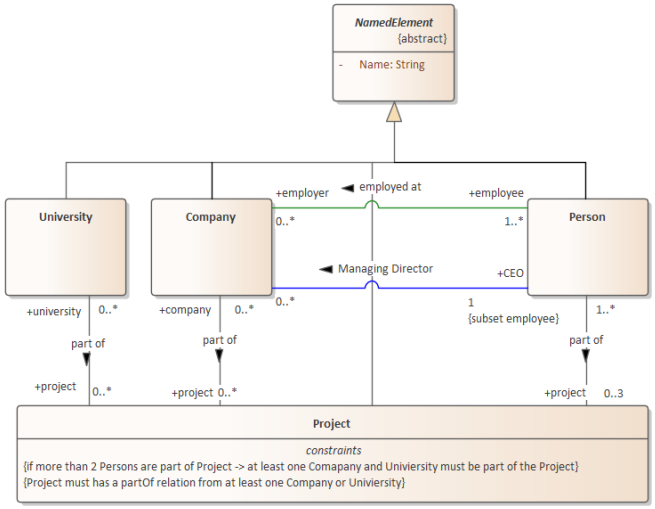
Plain EA API

```
public bool DuplicatedPartOfTest(Element self)
{
    bool result = false;
    var connectorList = new Dictionary<string, int>();

    foreach (Connector connector in self.Connectors)
    {
        if (connector.MetaType != "partOf")
            continue;

        string key = connector.ClientID + connector.MetaType + connector.SupplierID;
        if (connectorList.ContainsKey(key))
        {
            connectorList[key]++;
            result = true;
        }
        else
        {
            connectorList.Add(key, 1);
        }
    }

    return result;
}
```



Plain EA API + C# LINQ + Custom Extensions

```
public bool DuplicatedPartOfTest2(Element self)
{
    //group by ElementId //wehre group contains more than one, skip the group with 1
    //re-expand the group and return the duplicate
    return ! self.ConnectorWithType("partOf").ToType("project").GroupBy(project => project.ElementID).
        Where(group => group.Skip(1).Any()).SelectMany(entry => entry).Any();
}
```

Only one ***partOf*** relation between ***Person*** and ***Project*** is allowed.



Plain EA API + C# LINQ + Custom Extensions for Duplicated

```
public bool DuplicatedPartOfTest3(Element self)
{
    //more easy solution with a custom Duplicated operation
    return ! self.ConnectorWithType("partOf").Duplicated().ToType("project").Any();
}
```

Possibilities of the EA API

		Performance	UI	Deployment	Event
COM, C#, Delphi, VB	Add In	++	+++	Installer	+++
JavaScript	Script	- -	-	MDG (-)	-
	Model Add In	- -	0	Modell/Template	+++
	Scriptlet	- -	0	Model/Template	+

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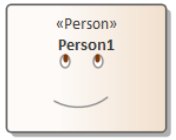
What we can do with UML Profiles in EA

- Extend the Language UML with additional Type
  - Elements and Connectors
  - Additional Properties as Tagged Values



- Define alternate graphical representations.



- Validate the model based on constraint Metamodel Rules.

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MDG Technologies in EA



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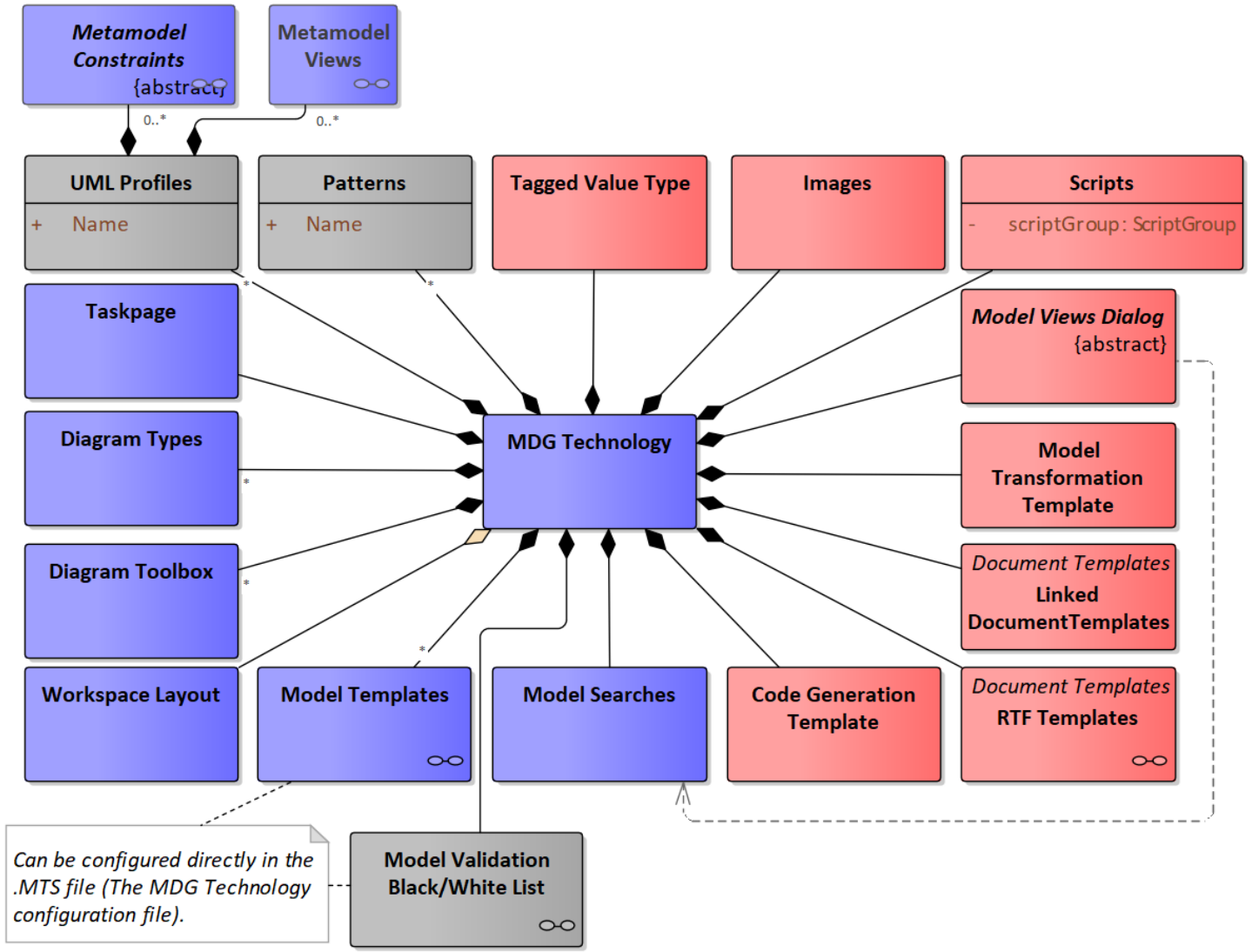
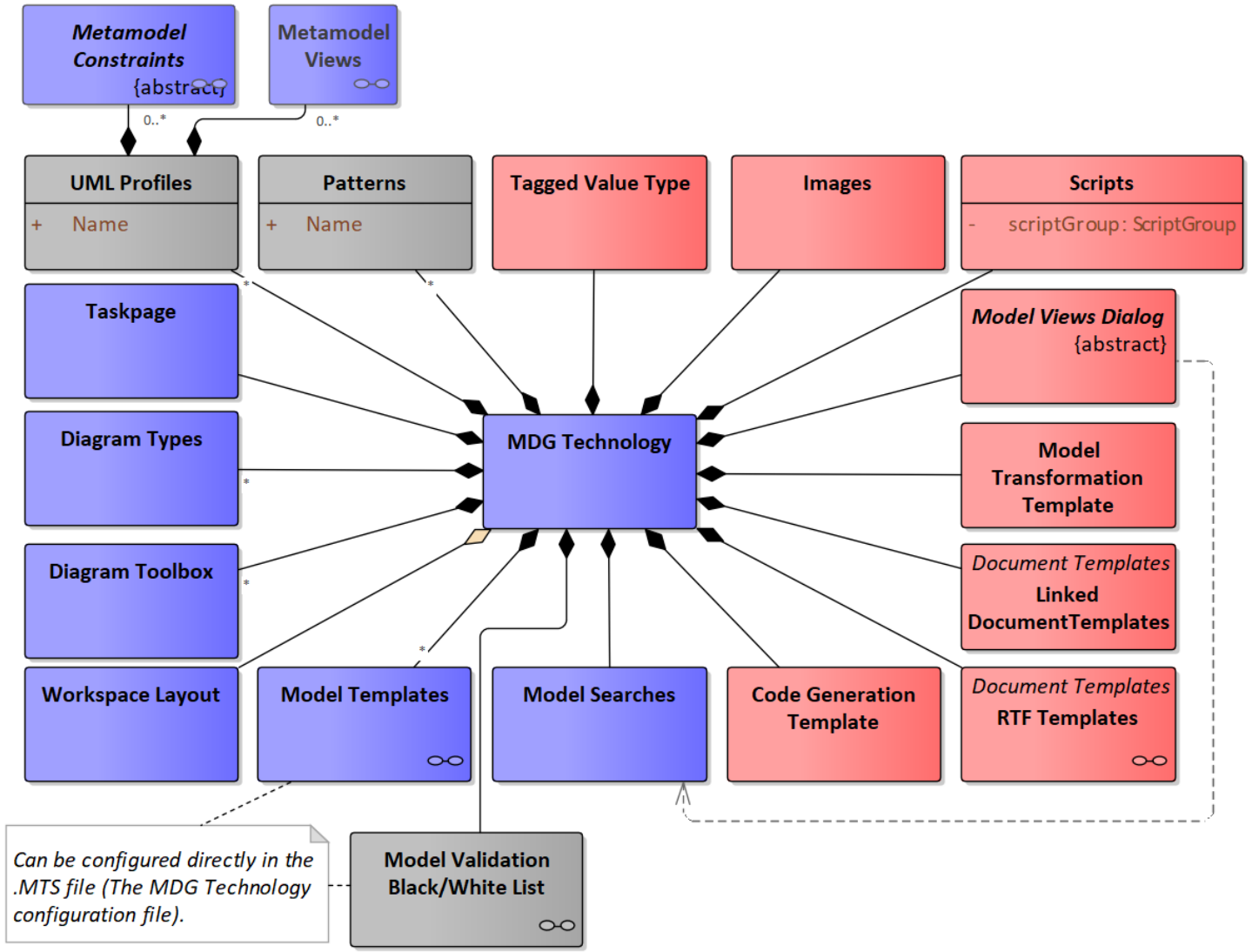
MDG Technologies in EA



MDG Technologies in EA



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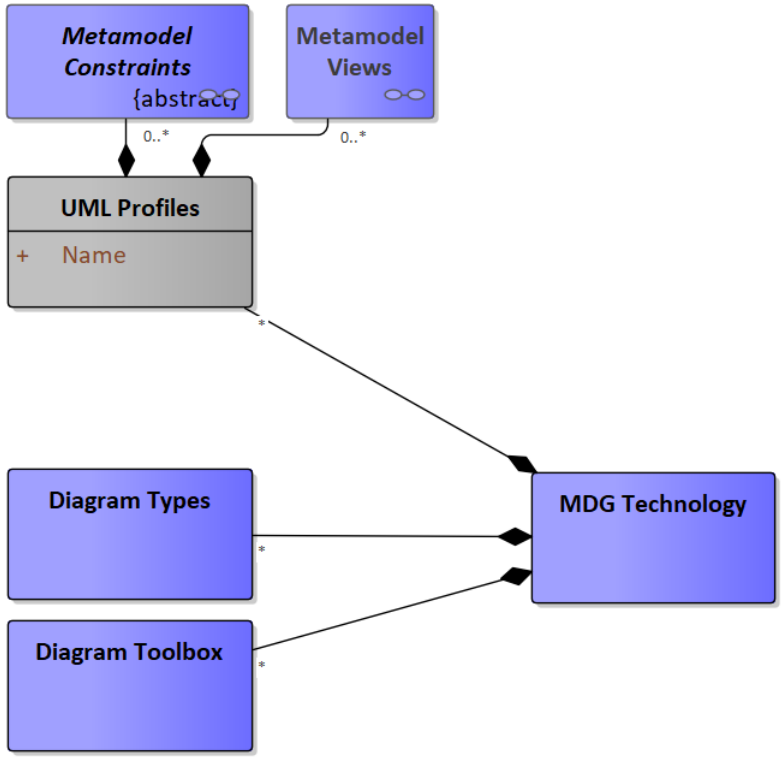

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What we have learned

- ✓MetaModels are defined using UML Profiles in Enterprise Architect.
- ✓Constraint Metamodel provide the possibility to:
  - ✓Automatically get adopted UI support based on the constraints.
  - ✓Automatic model validation based on constraints in the UML Profile.
- ✓Possibility to add custom validation rules with the help of the Framework API.
  - ✓Additional extensions of the API will make it easier for you.

Look for the next Edition of the



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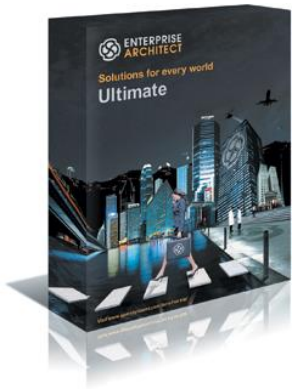
We are happy to support you to bring
your modelling approach alive in EA.

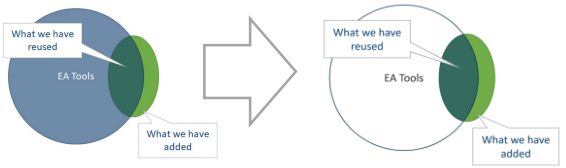
Recommendation: ***How to Succeed with your Modelling Approach in EA***



Part 1: *About the benefit of a model based specification and how you find a suitable Modelling Approach.*

Part 2: Support the Modelling Approach with MetaModels, Constraints and Configurations.

Part 3: Support the Modelling Approach with Wizards and Automation.



Dr. Horst Kargl
Horst.Kargl@sparxsystems.eu
vendor@sparxsystems.eu



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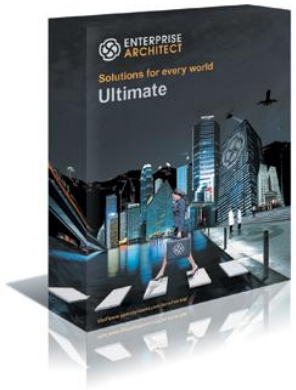

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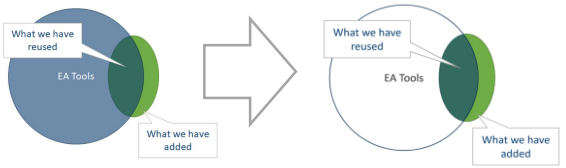

Dr. Horst Kargl
Horst.Kargl@sparxsystems.eu
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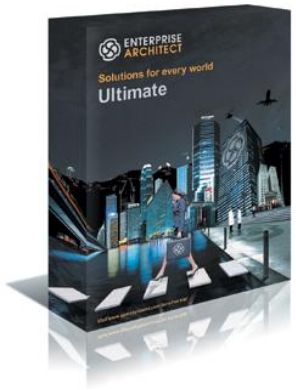

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vendor@sparxsystems.eu