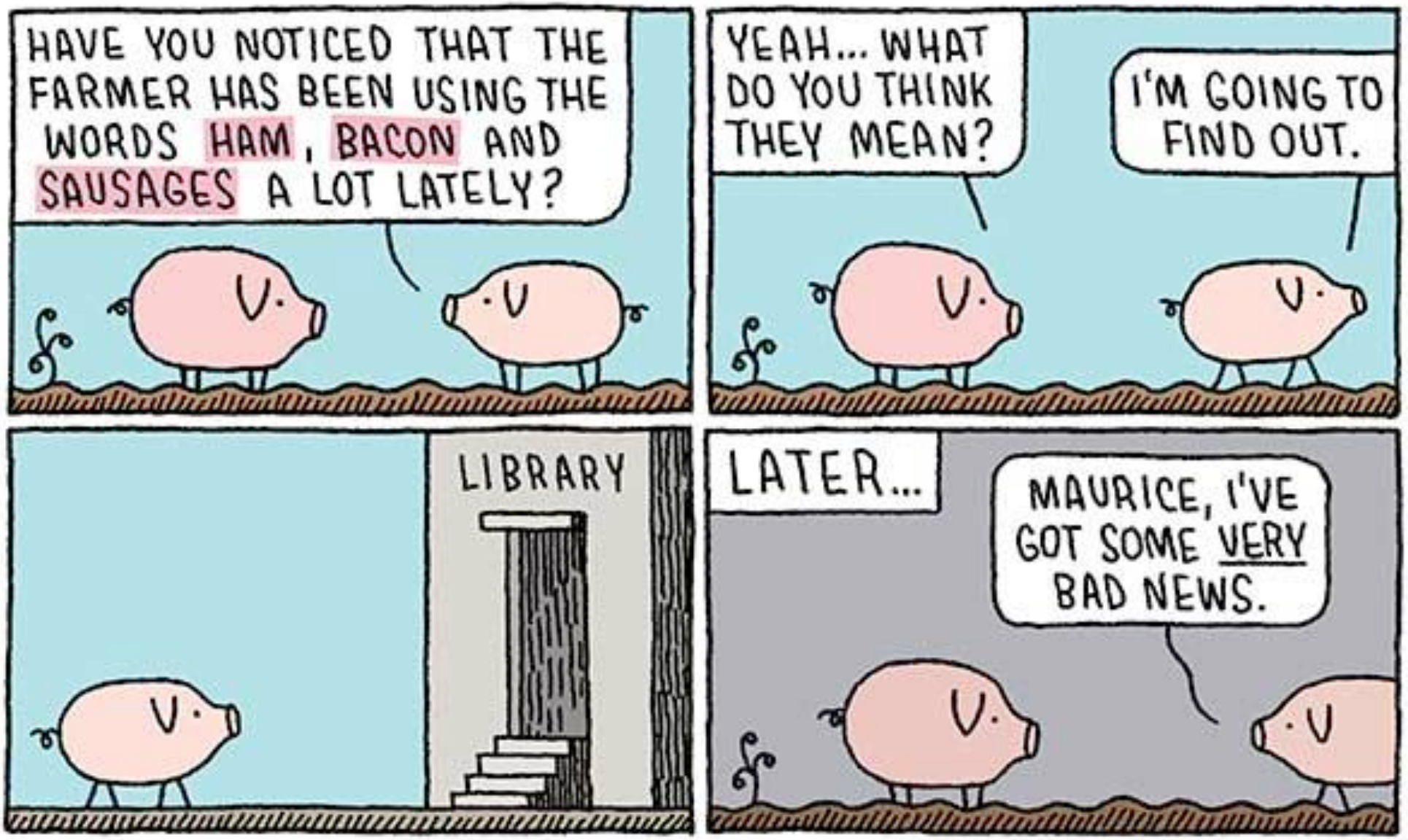
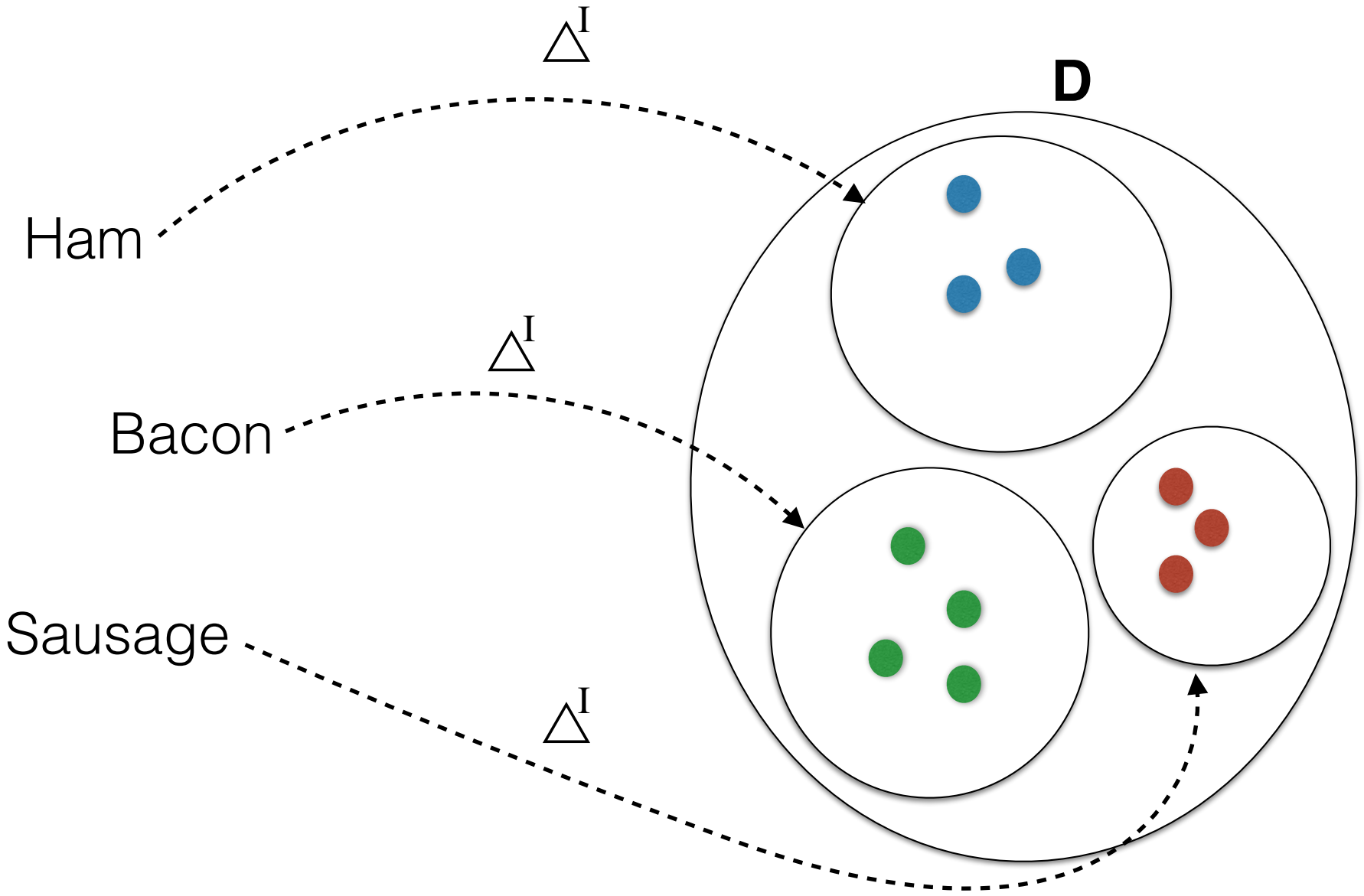
Conceptual Models as **Ontological Contracts**

Giancarlo Guizzardi
CORE/UNIBZ, Italy
(together with
Nicola Guarino and the
NEMO Group)


HAVE YOU NOTICED THAT THE FARMER HAS BEEN USING THE WORDS HAM, BACON AND SAUSAGES A LOT LATELY?
YEAH... WHAT DO YOU THINK THEY MEAN?
I'M GOING TO FIND OUT.
LIBRARY
LATER...
MAURICE, I'VE GOT SOME VERY BAD NEWS.

By Tom Gould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Bacon
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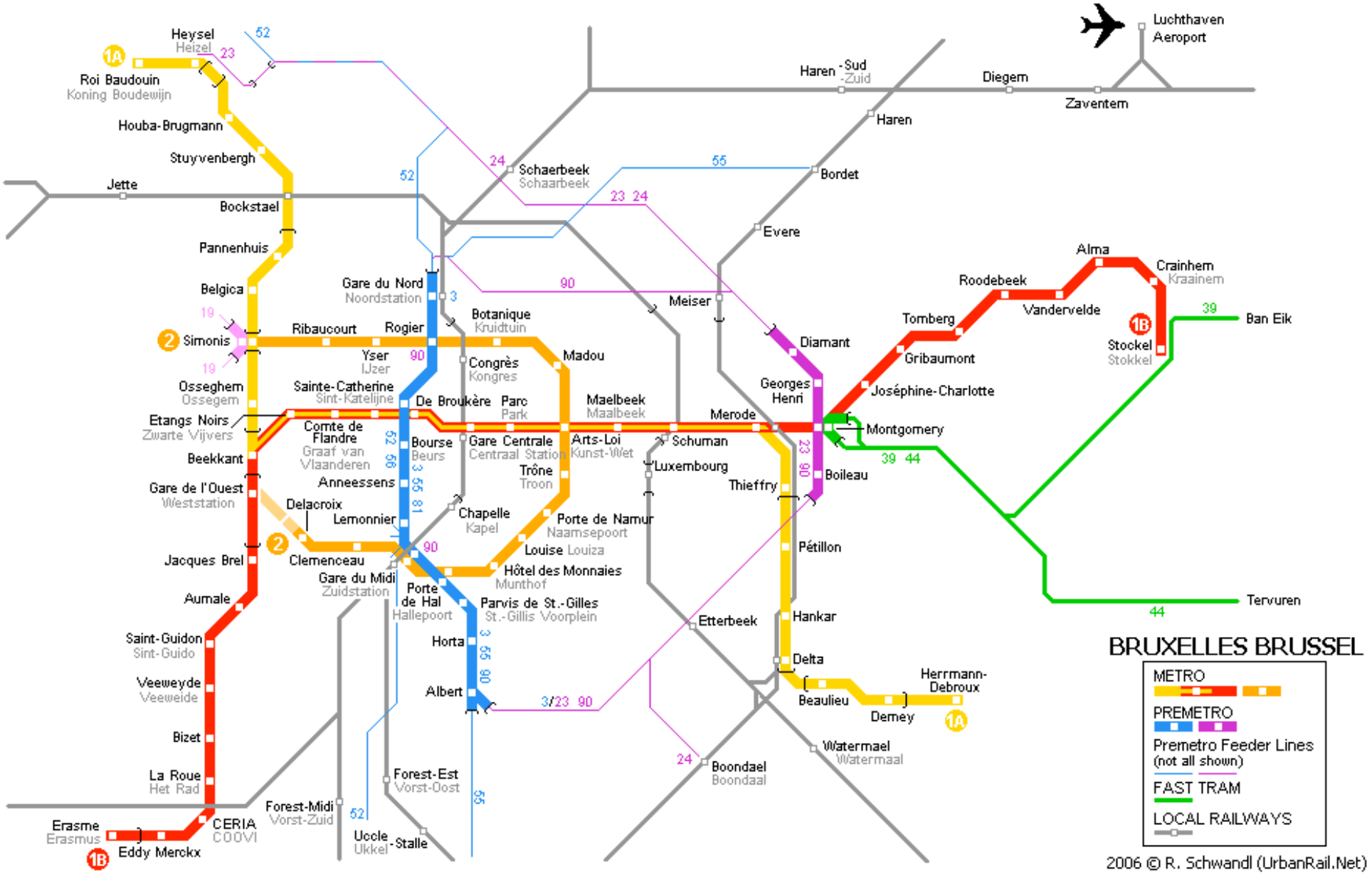
Real-World (**Ontological**)
Semantics

X

Formal Semantics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Koning Boudewijn
Houba-Brugmann
Stuyvenbergh
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Belgica
Simonis
Osseghem
Ossegem
Etangs Noirs
Zwarte Vijvers
Beekkant
Gare de l'Ouest
Weststation
Jacques Brel
Aumale
Saint-Guidon
Sint-Guido
Veeweyde
Veeweide
Bizet
La Roue
Het Rad
Erasme
Erasmus
Eddy Merckx
CERIA
COOVI
Forest-Midi
Vorst-Zuid
Uccle
Ukkel
Stalle
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Vorst-Oost
Albert
Horta
Parvis de St.-Gilles
St.-Gillis Voorplein
Porte de Hal
Hallepoort
Gare du Midi
Zuidstation
Clemenceau
Lemonnier
Delacroix
Anneessens
Comte de Flandre
Graaf van Vlaanderen
Sainte-Catherine
Sint-Katelijne
Ribaucourt
Yser
IJzer
Rogier
Gare du Nord
Noordstation
Botanique
Kruidtuin
Congrès
Kongres
De Broukère
Bourse
Beurs
Parc
Park
Gare Centrale
Centraal Station
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Porte de Namur
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Madou
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Arts-Loi
Kunst-Wet
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Merode
Thieffry
Boileau
Pétillon
Hankar
Delta
Etterbeek
Boondael
Boondaal
Watermael
Watermaal
Beaulieu
Herrmann-Debroux
Demey
Georges Henri
Diamant
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Evere
Schaerbeek
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Diegem
Zaventem
Luchthaven
Aeroport
Joséphine-Charlotte
Gribaumont
Tomberg
Roodebeek
Vandervelde
Alma
Crainhem
Kraainem
Stockel
Stokkel
Ban Eik
Montgomery
Tervuren
BRUXELLES BRUSSEL
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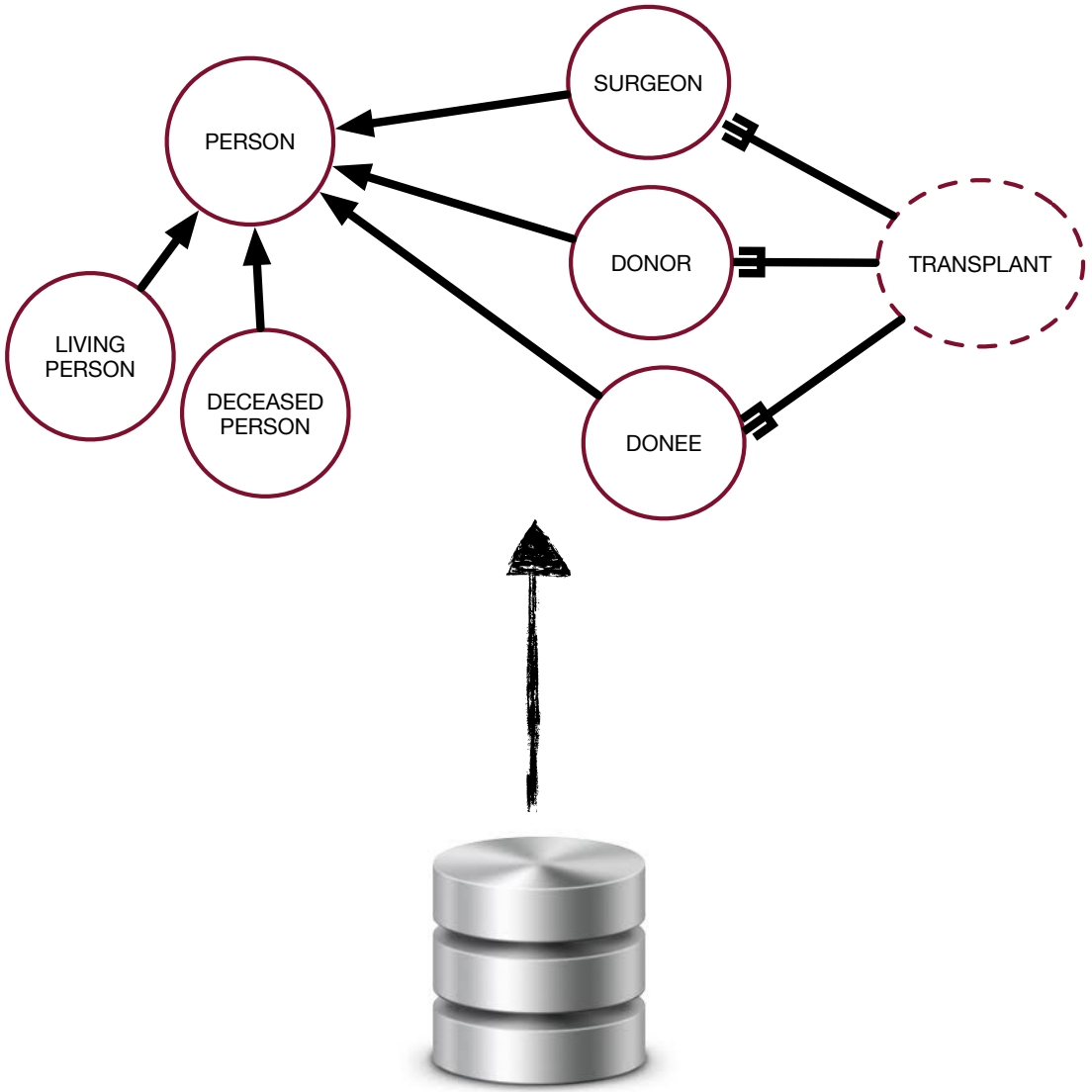
PREMETRO
Premetro Feeder Lines
(not all shown)
FAST TRAM
LOCAL RAILWAYS
2006 © R. Schwandl (UrbanRail.Net)


SURGEON
PERSON
DONOR
TRANSPLANT
LIVING PERSON
DECEASED PERSON
DONEE

Another look at data

by GEORGE H. MEALY
Computer Consultant
Scituate, Massachusetts

INTRODUCTION

We do not, it seems, have a very clear and commonly agreed upon set of notions about data—either what they are, how they should be fed and cared for, or their relation to the design of programming languages and operating systems. This paper sketches a theory of data which may serve to clarify these questions. It is based on a number of old ideas and may, as a result, seem obvious. Be that as it may, some of these old ideas are not common currency in our field, either separately or in combination; it is hoped that rehashing them in a somewhat new form may prove to be at least suggestive.

To begin on a philosophical plane, let us note that we usually behave as if there were three realms of interest in data processing: the real world itself, ideas about it existing in the minds of men, and symbols on paper or some other storage medium. The latparticular ontology, we can avoid a quarrel by adopting the nominalist's position.

Our plan of attack is to indicate the nature of the theory of relations, based on the example of genealogical data. This will lead immediately to formulation of our notions about data in general, including rather precise definitions of concepts such as data structure, list processing, and representation. These notions are used in the second part of the paper as the basis for some remarks and suggestions concerning language and system design.

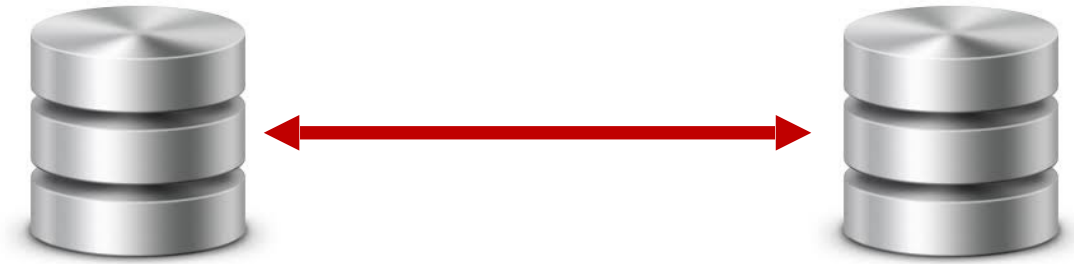
Toward a theory of data

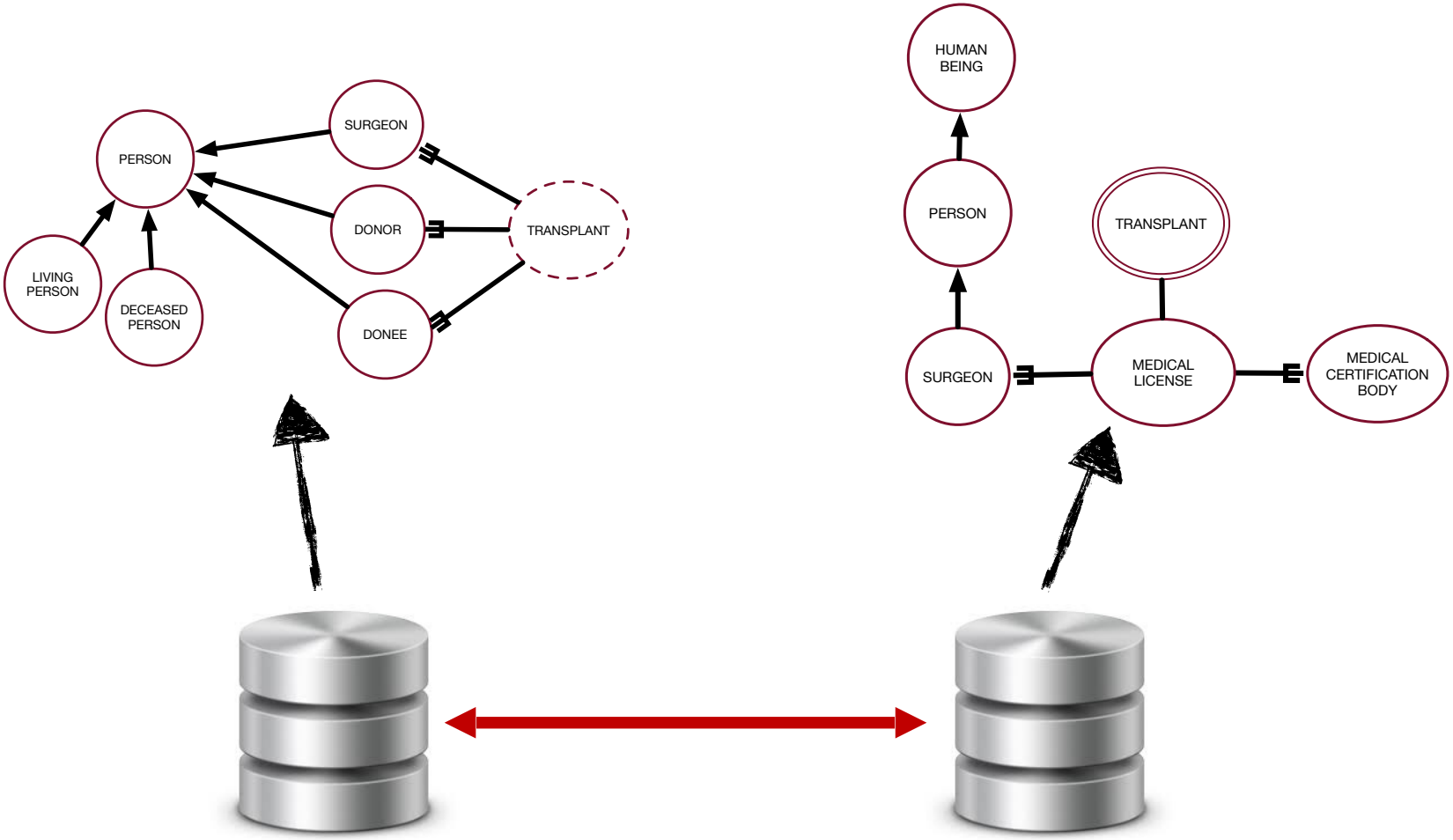
Relations

To fix our ideas, consider the following example of genealogical data, taken from Reference 2:

*"data are fragments of **a theory of the real world**, and data processing juggles representations of these fragments of theory...The issue is **ontology**, or the question of what exists."*

(G.H. Mealy,
Another Look at Data, 1967)

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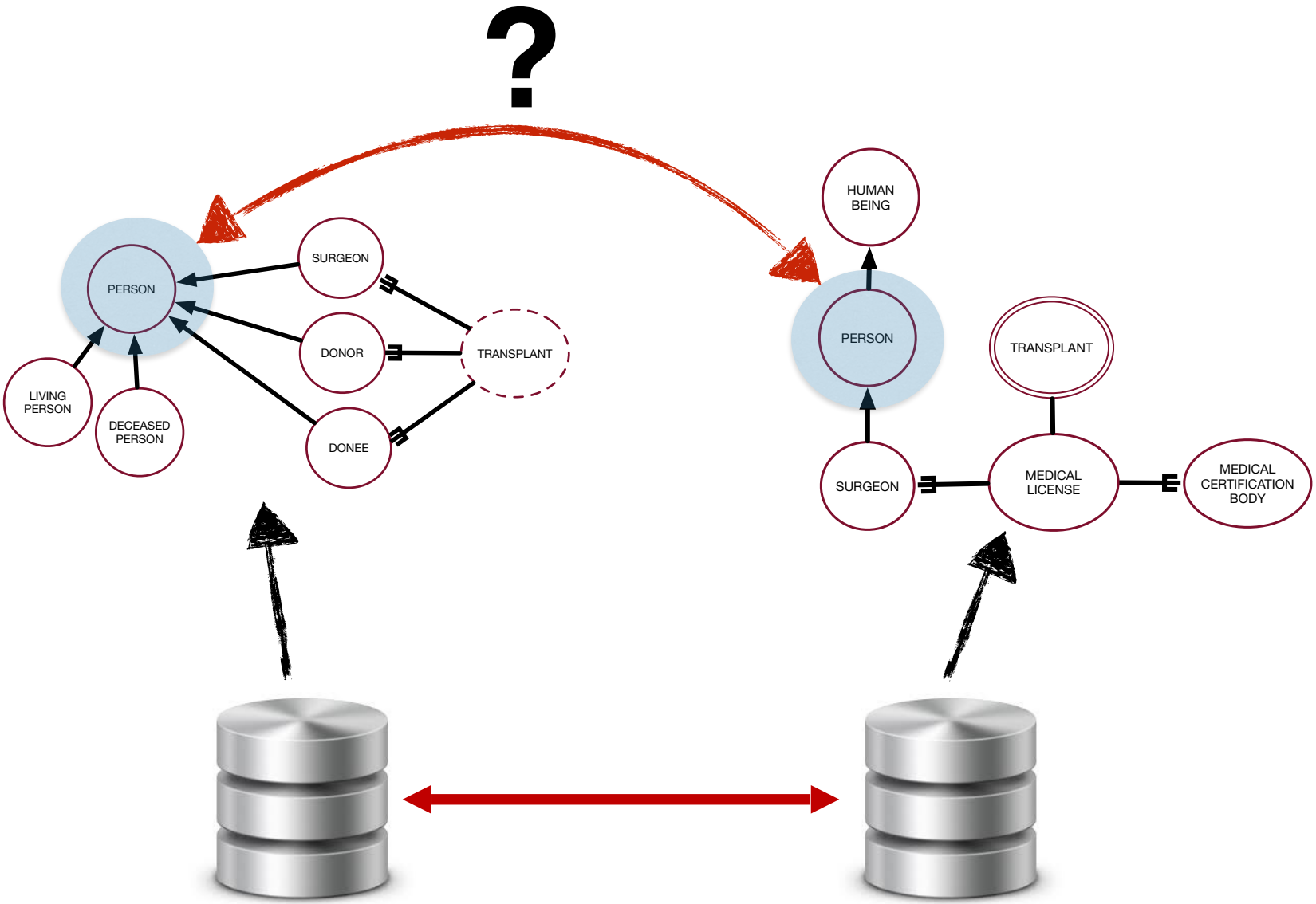
DONEE
LIVING PERSON
DECEASED PERSON
HUMAN BEING
PERSON
TRANSPLANT
SURGEON
MEDICAL LICENSE
MEDICAL CERTIFICATION BODY

Semantic Interoperability

relating different **worldviews**, i.e., different **conceptualizations** of reality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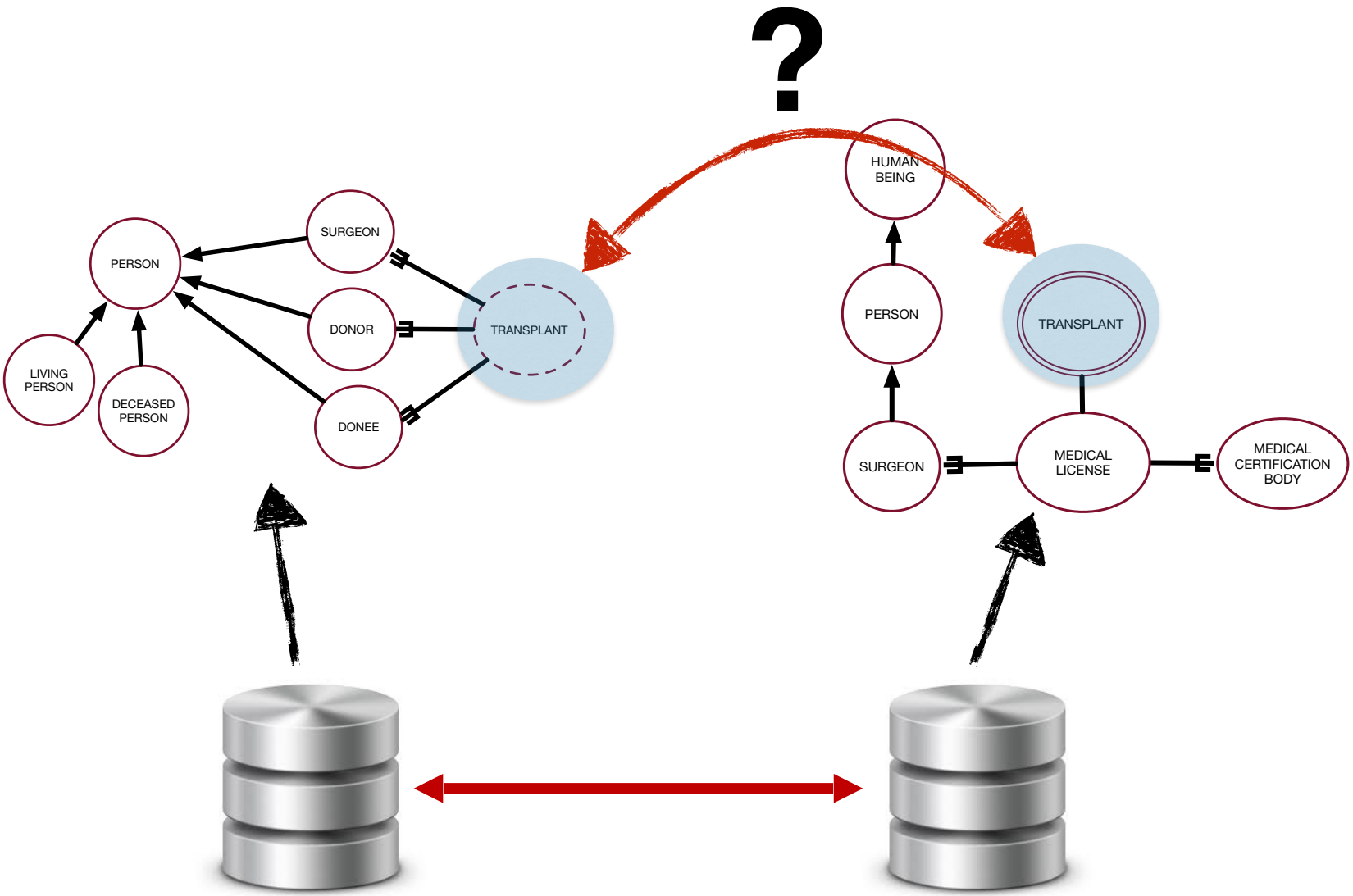
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World Trade Centre insurance

Bad forms

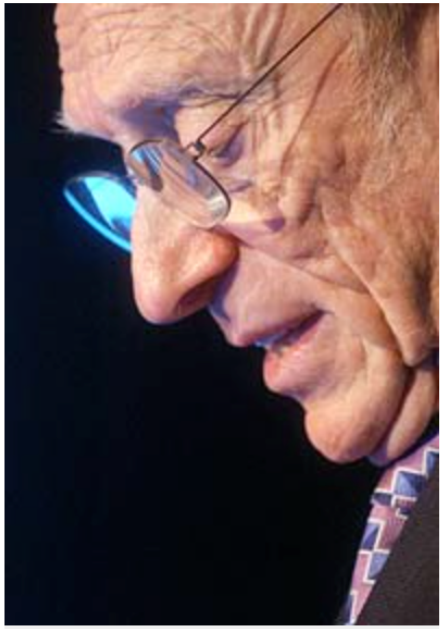
After a rancorous trial, relief for many insurers of the twin towers

May 6th 2004 | From the print edition

IT WAS a $3.5 billion question: was the crashing of two aeroplanes into New York's twin towers in September 2001 one event or two? One, many insurers are relieved to know. On May 3rd a jury ruled that Swiss Re, the world's second-largest reinsurer, which wrote about a quarter of the coverage for the World Trade Centre, was bound by a form that classed such attacks as a single occurrence. Last week the same jury had reached a similar verdict for several Lloyd's of London syndicates and seven other insurers. The loser was Larry Silverstein, the centre's leaseholder. He had argued that another form was valid, in the hope of claiming around $7 billion for two events. Now he may get only half that.

In most disaster insurance, “occurrence” is carefully defined. Earthquake coverage typically treats all shaking

AP



Silverstein's the loser

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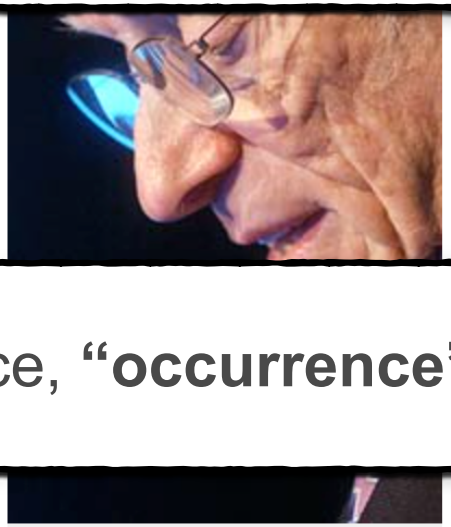

"In most disaster insurance, "**occurrence**" is carefully defined…"

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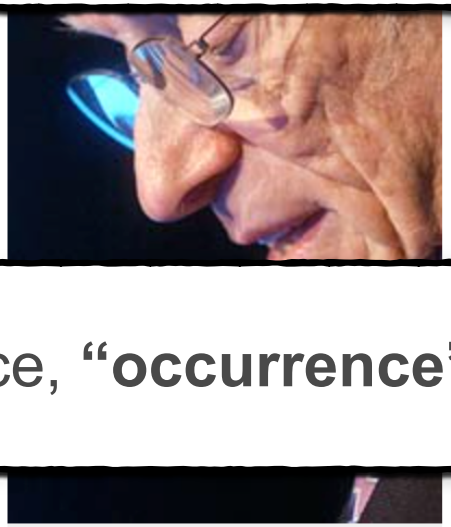

Silverstein's the loser

"In most disaster insurance, "**occurrence**" is carefully defined…"

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World Trade Centre insurance

One into two

Having lost one legal case to insurers, the towers' leaseholder wins a second

Dec 9th 2004 | NEW YORK | From the print edition

SEVEN months ago, a jury in lower Manhattan ruled that under the forms covering insurance of the World Trade Centre, the striking of the twin towers by two aeroplanes constituted only one "occurrence". Consequently, Larry Silverstein, who had recently leased the Trade Centre complex, was entitled to one payment, not two—a difference of $3.5 billion. On December 6th, in the same courtroom with the same judge presiding, another jury decided that under the documents used by nine other insurers the attacks were two events, thus qualifying for two payments. The verdict will provide Mr Silverstein with as much as $1.1 billion extra for rebuilding the Trade Centre. It will also ensure that he remains in control of the project.

Why, after two weeks of deliberation, did the second jury come to a different conclusion from the first? The main reason lay in the preliminary paperwork signed by the underwriters. Because the Trade Centre had been leased to Mr Silverstein only weeks before the attack, the final insurance contracts had yet to be signed. The insurers in the first trial had signed a form with a much tighter definition of an "occurrence" than in the form signed by the nine insurers in the second trial. In addition, the insurance companies' claim that they always defin[FaceTime]e" precisely may have been undermined by testimony that they had been flexible in other cases—for example, involving sequences of

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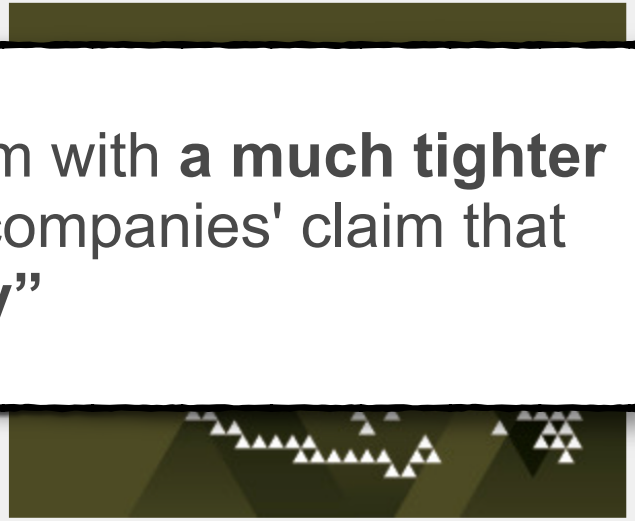


1

There is no doubt about the brute reality. The issue is **interpreting** that part of **reality according to a** certain **system of categories**

2

There are **multiple views on reality** that can conflict and unless we are fully aware of their distinctions, we cannot safely harmonize those views

3

The is no experiment that can be done to settle these conflicts. It can only be resolve by **conceptual clarification** and **meaning negotiation** relying on **a prioristic** system of categories

Ontology as a **Calculus** of Content

- For that we need a *a prioristic* system of categories and their ties addressing issues of Identity, Unity (Parts and Wholes), Individuation, Change, Classification and Taxonomic Structures, Dependence (Existential, Historical, Relational, Notional), Causality, Essential and Accidental Characterization

- We need **Formal Ontology** and **Ontological Analysis**

Ontology-Driven Conceptual **Modeling**

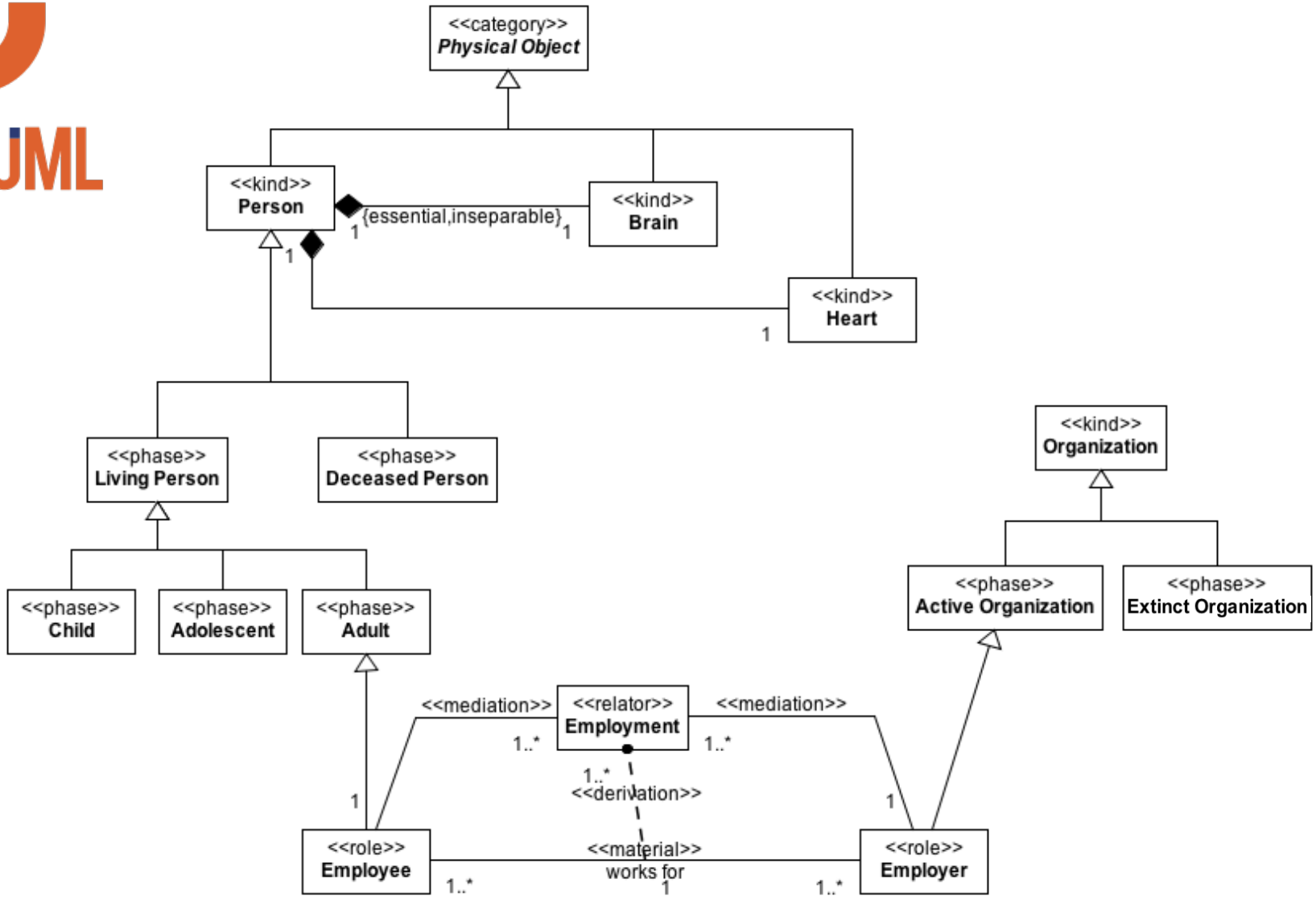
A discipline aiming at developing ontology-based methodologies, computational tools and **modeling languages** for the area of Conceptual Modeling

UFO
(Unified Foundational Ontology)

- Over the years, we have built a Philosophically and Cognitively well-founded Ontology to contribute to the general goal of serving as a Foundation for Conceptual Modeling

- This Ontology has been used to as a theory for addressing may classical conceptual modeling constructs such as **Object Types, Identity and Taxonomic Structures** (CAISE 2004, CAISE 2007, CAISE 2012, Synthese 2015, ER 2018), **Part-Whole Relations** (CAISE 2007, CAISE 2009, FOIS2010, CAISE 2011), **Intrinsic and Relational Properties** (ER 2006, ER 2008, ER 2011, CAISE 2015, DKE 2015, ER 2018), **Weak Entities, Attributes and Datatypes** (ER 2006), **Events** (ER 2013, BPM 2016), **Multi-Level Modeling and Powertypes** (JOWO 2015, ER 2015, DKE 2017, ER 2018), etc…

ONTOUML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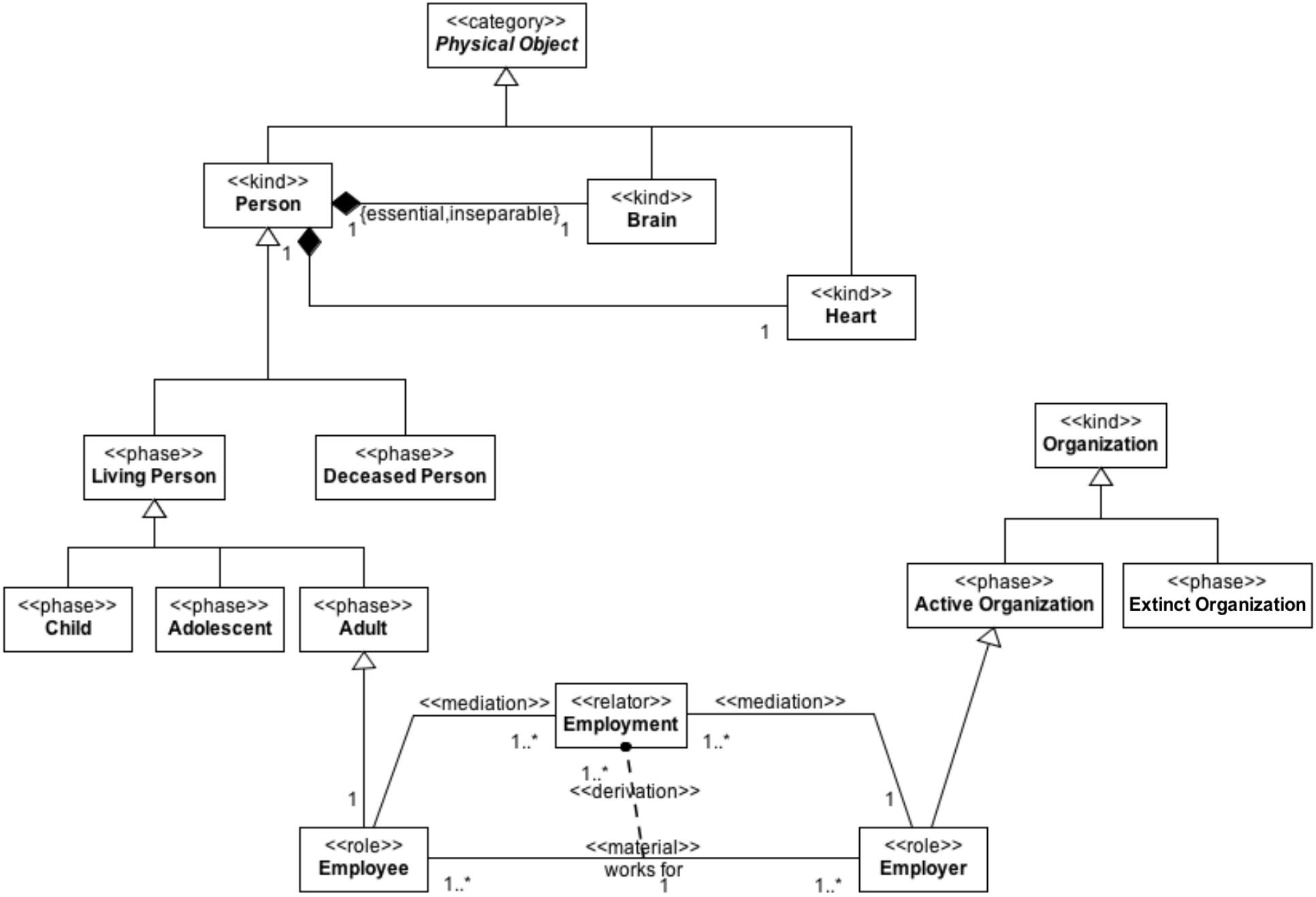
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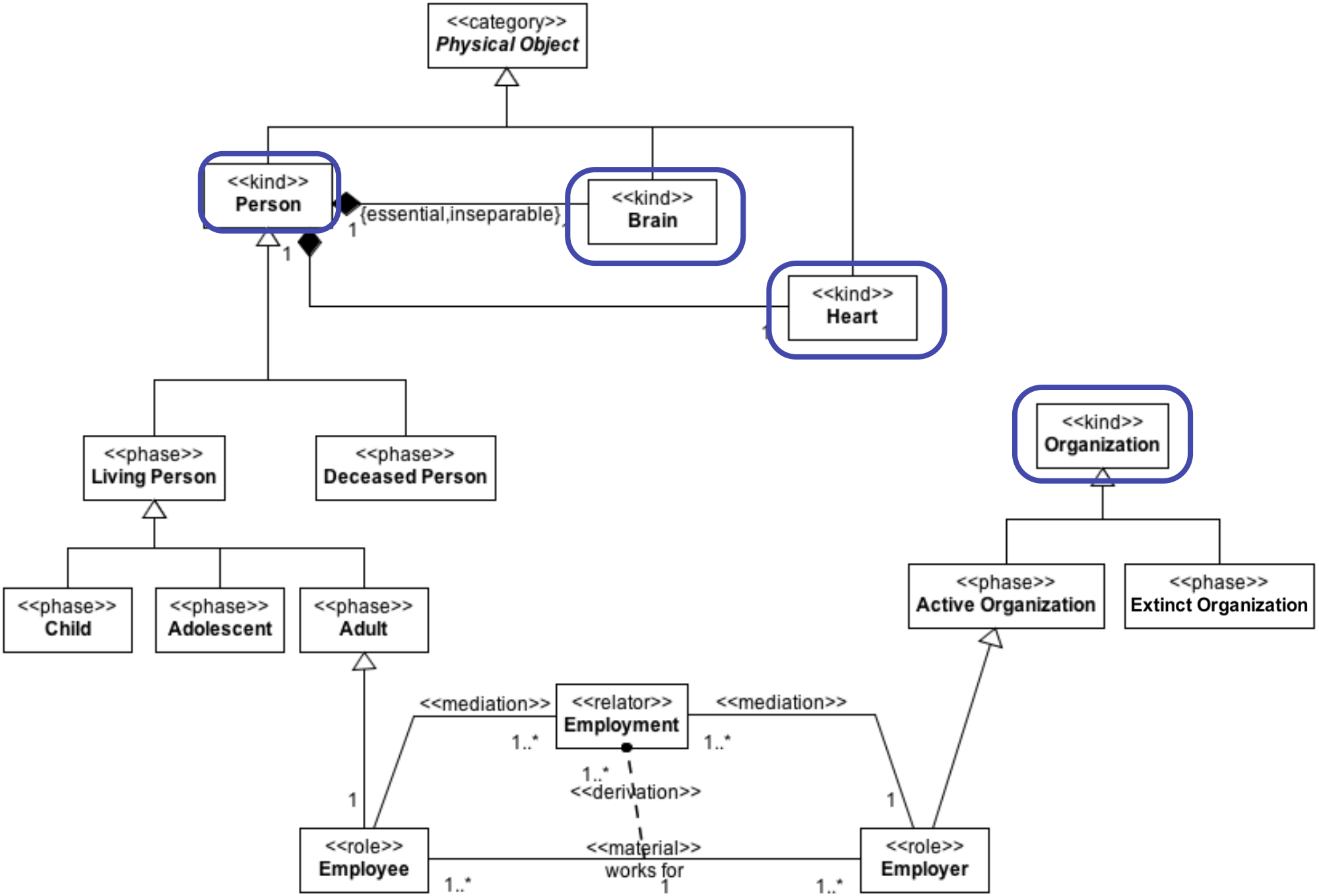
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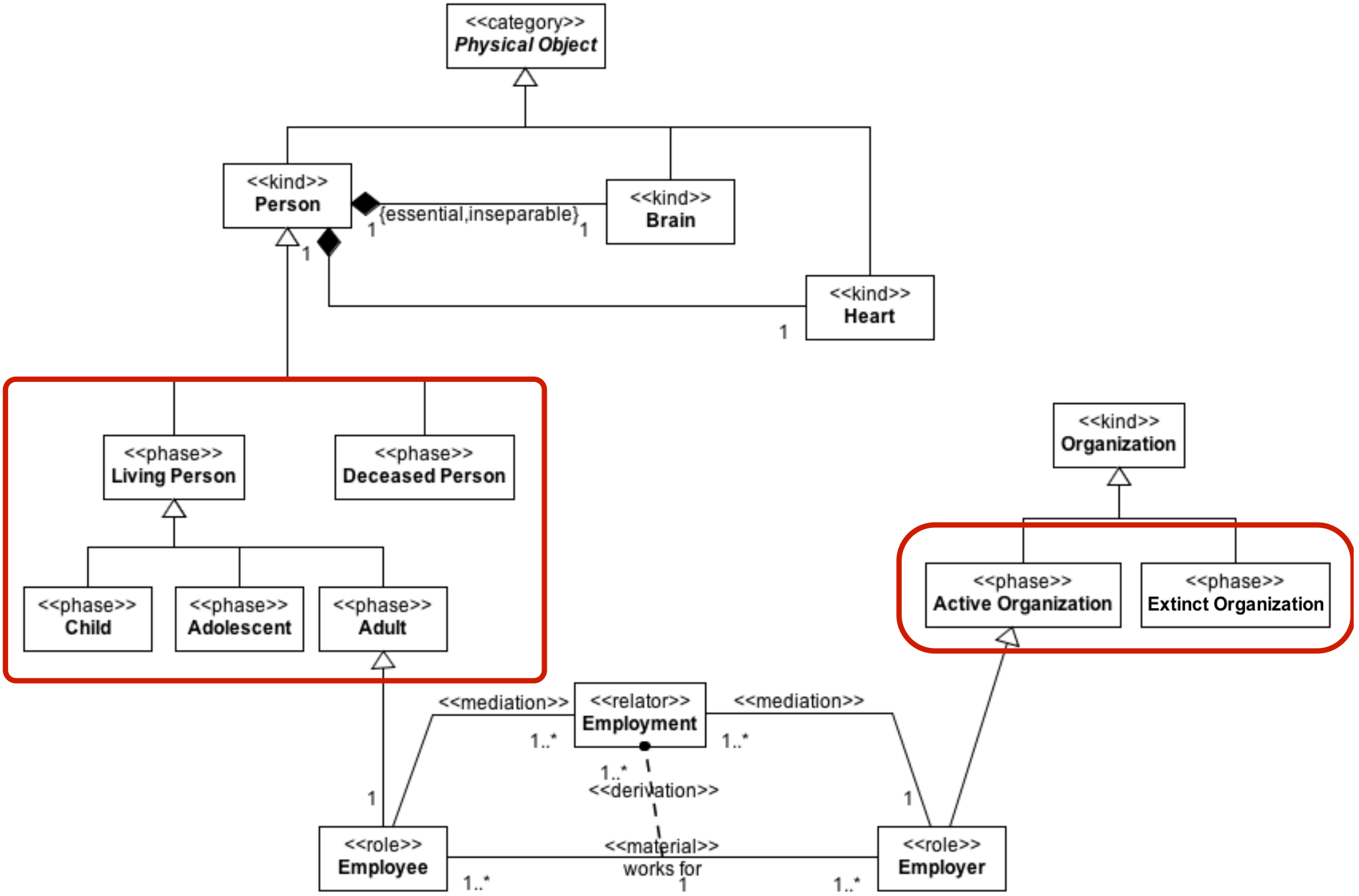
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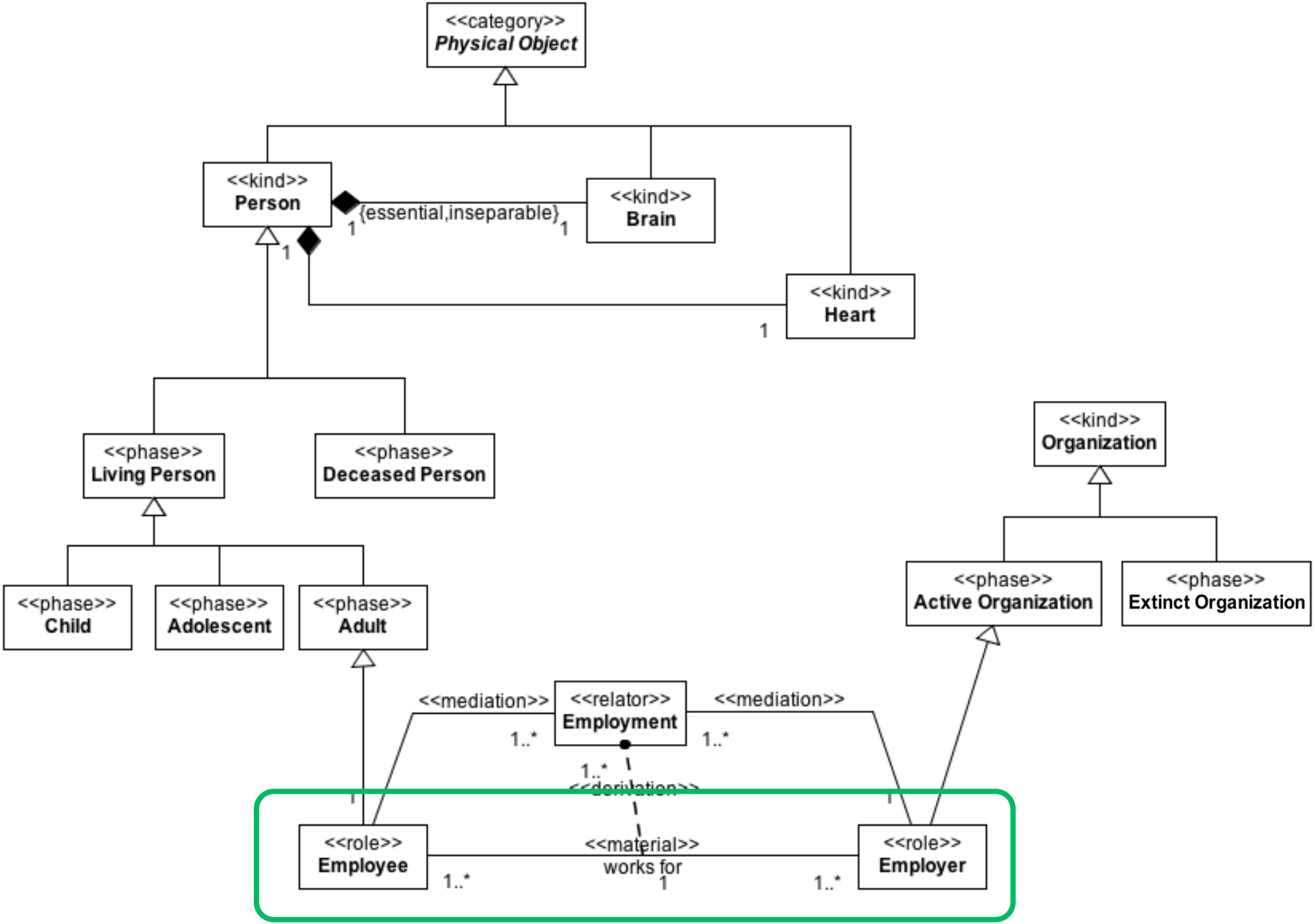
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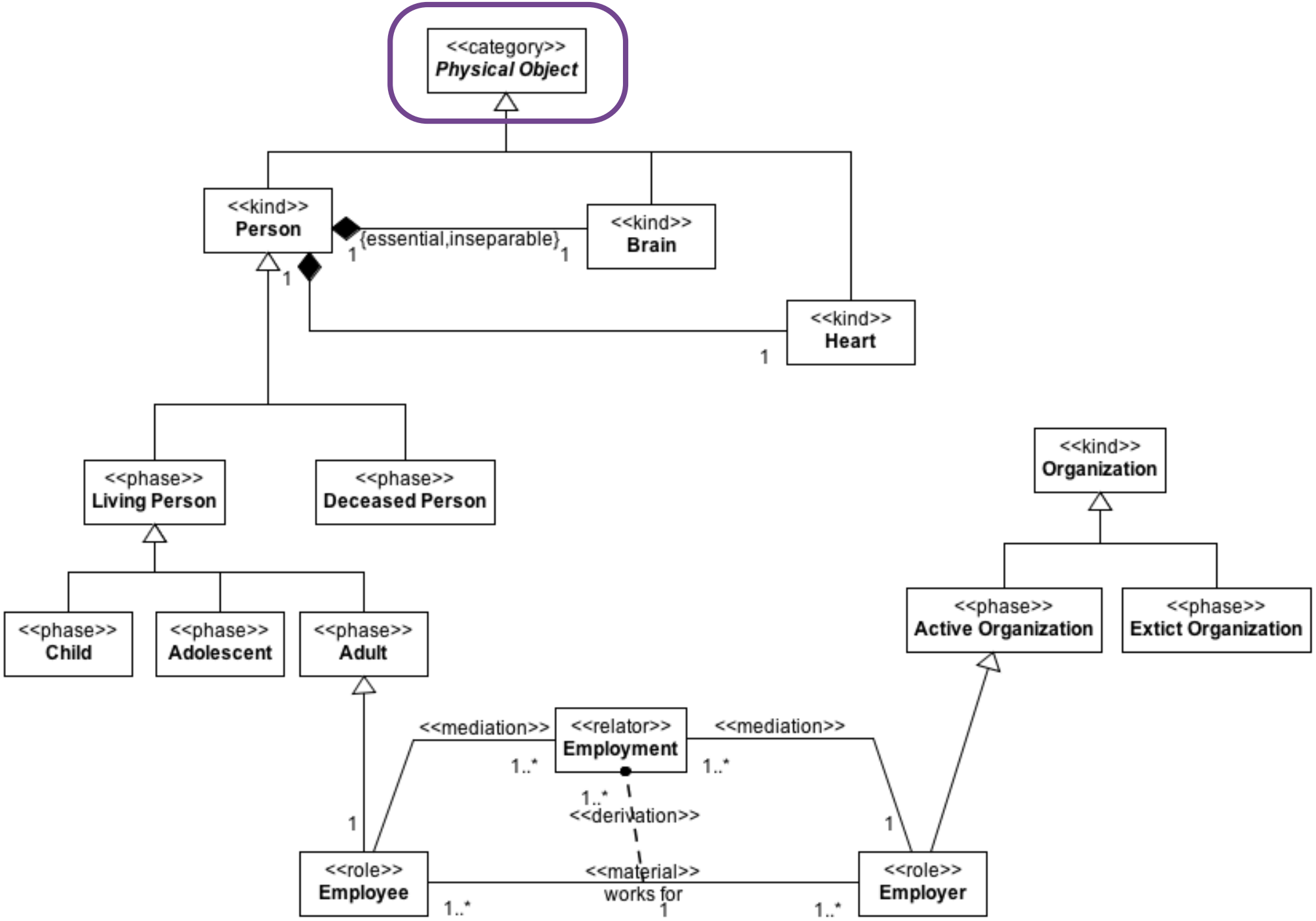
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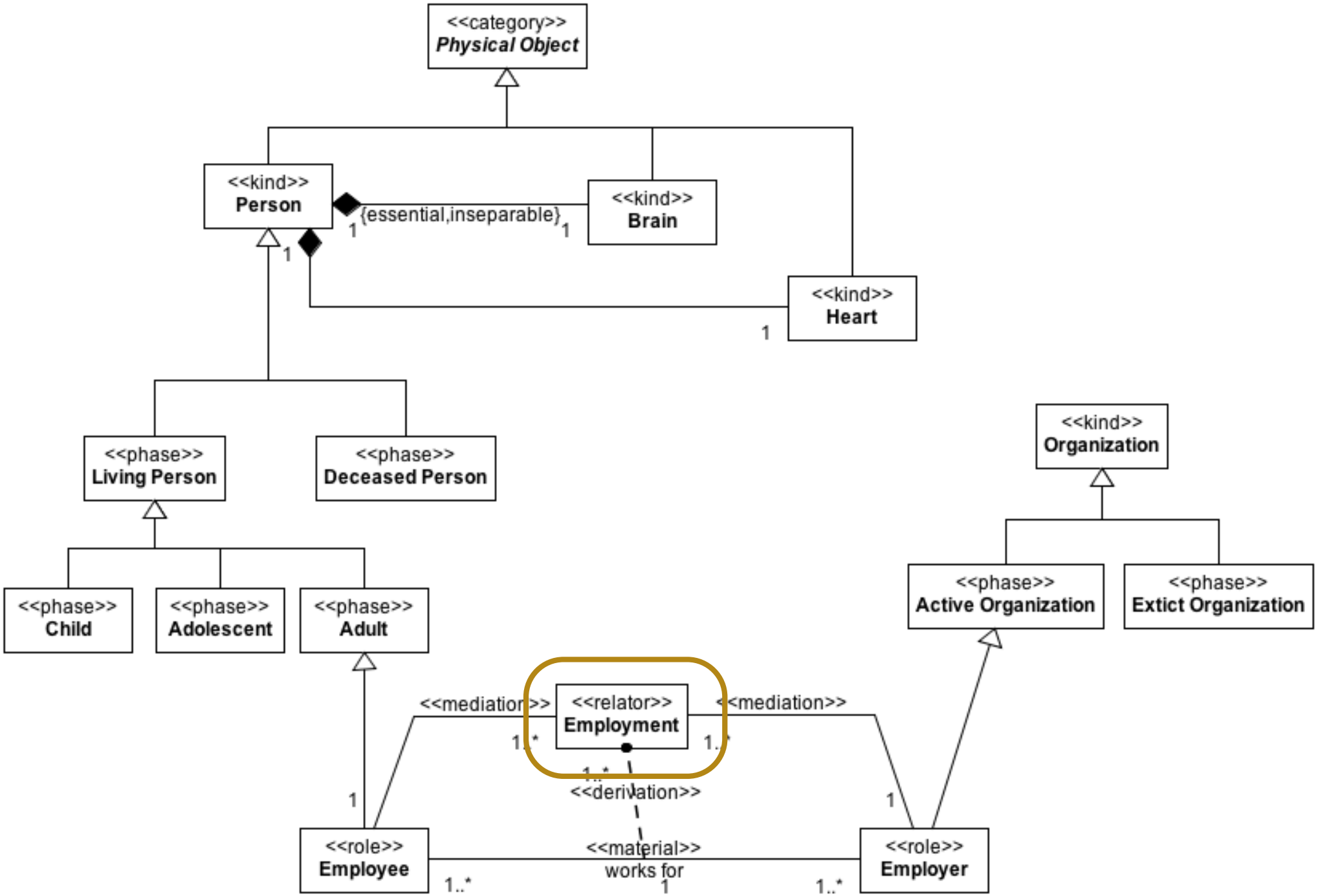
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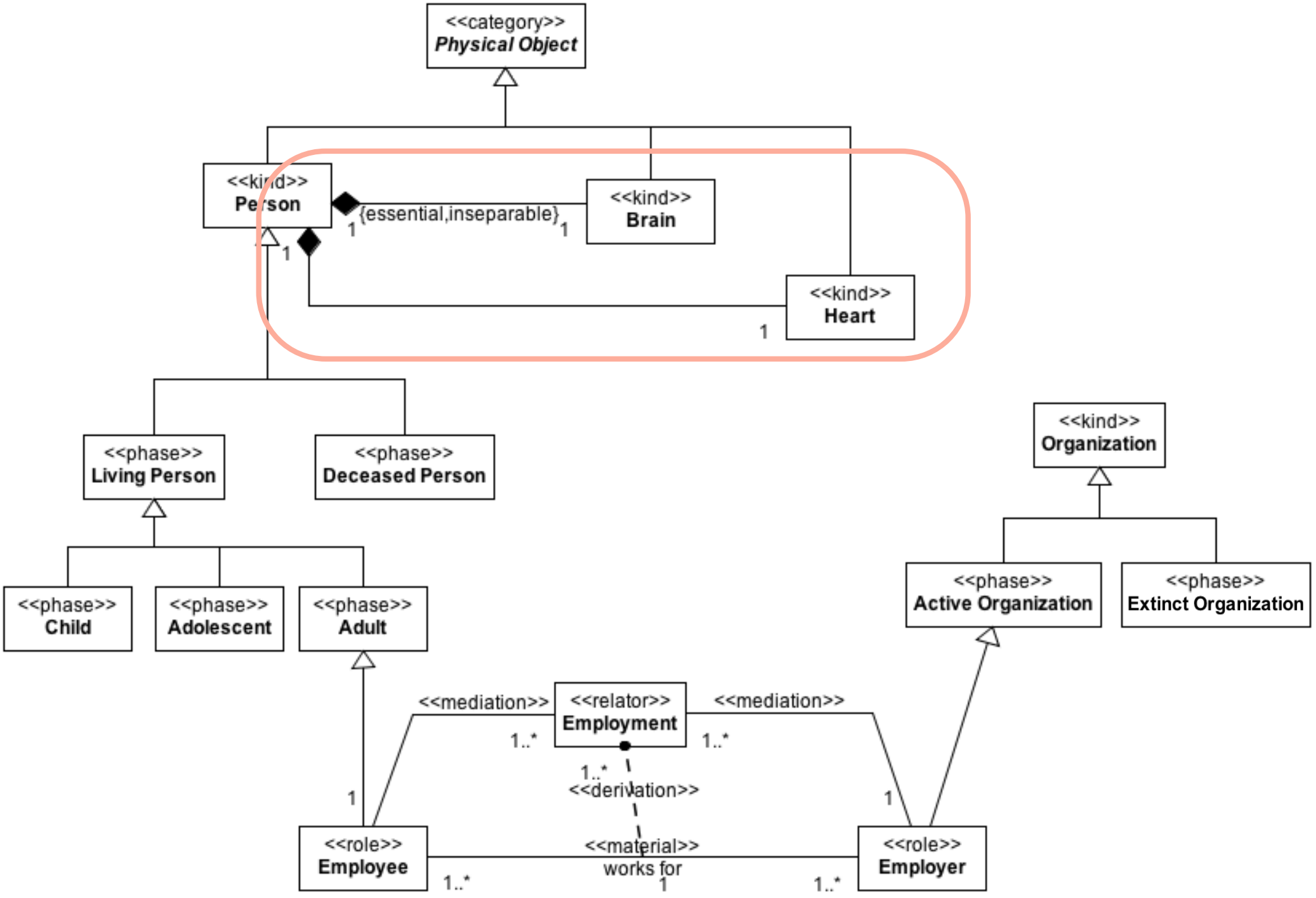
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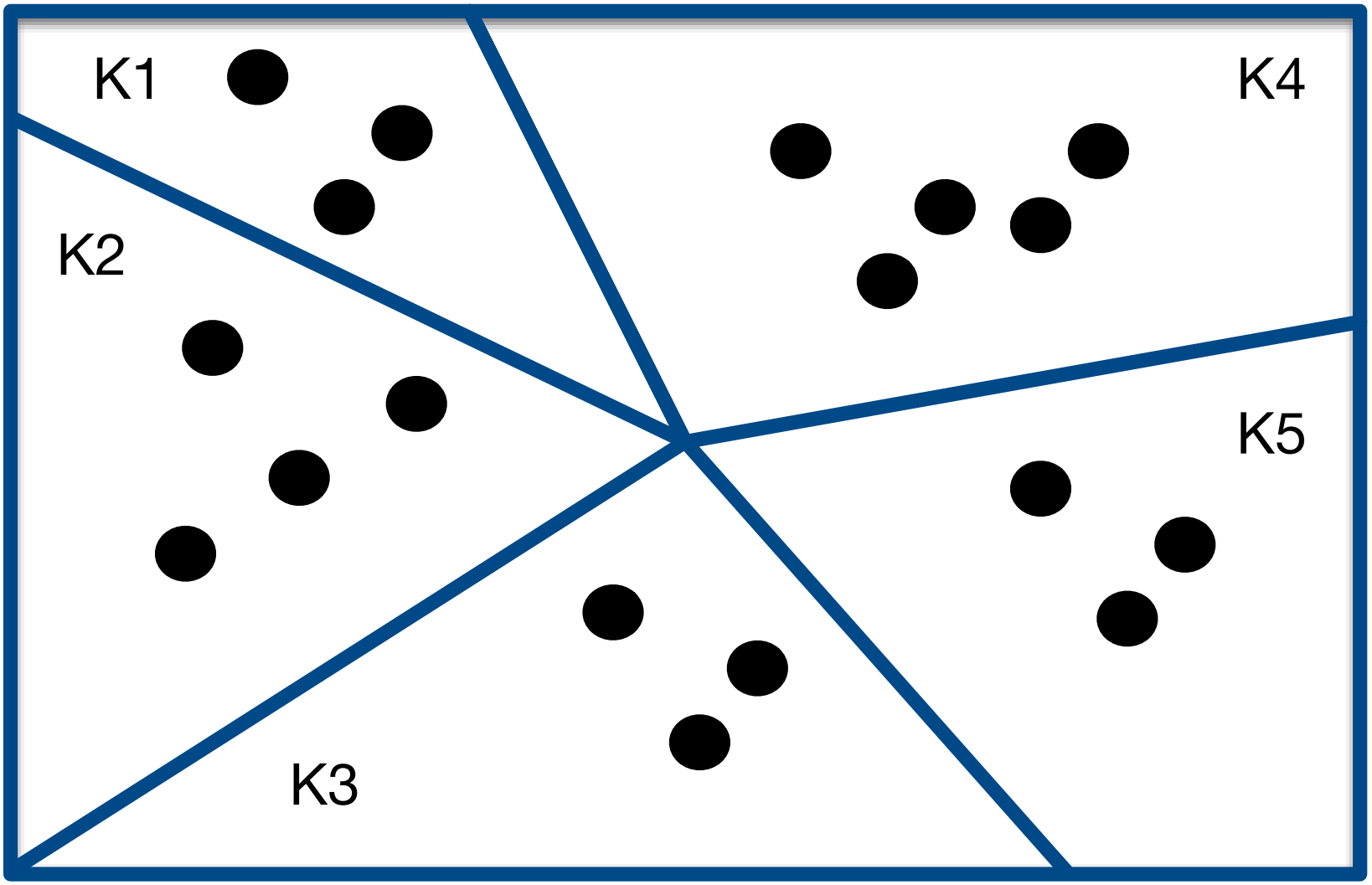
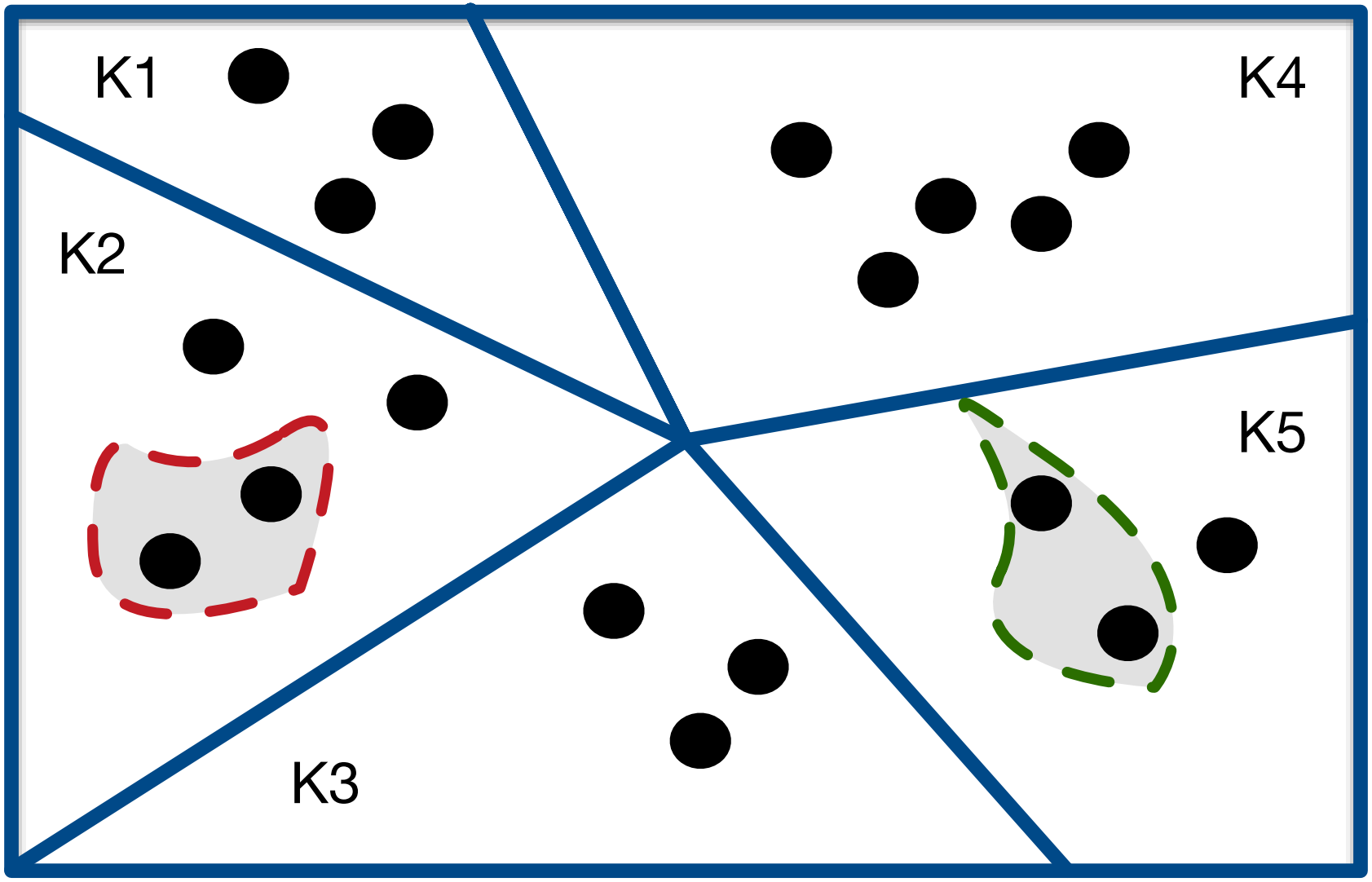


Anti-Rigid Sortals (**Roles** and **Phases**)



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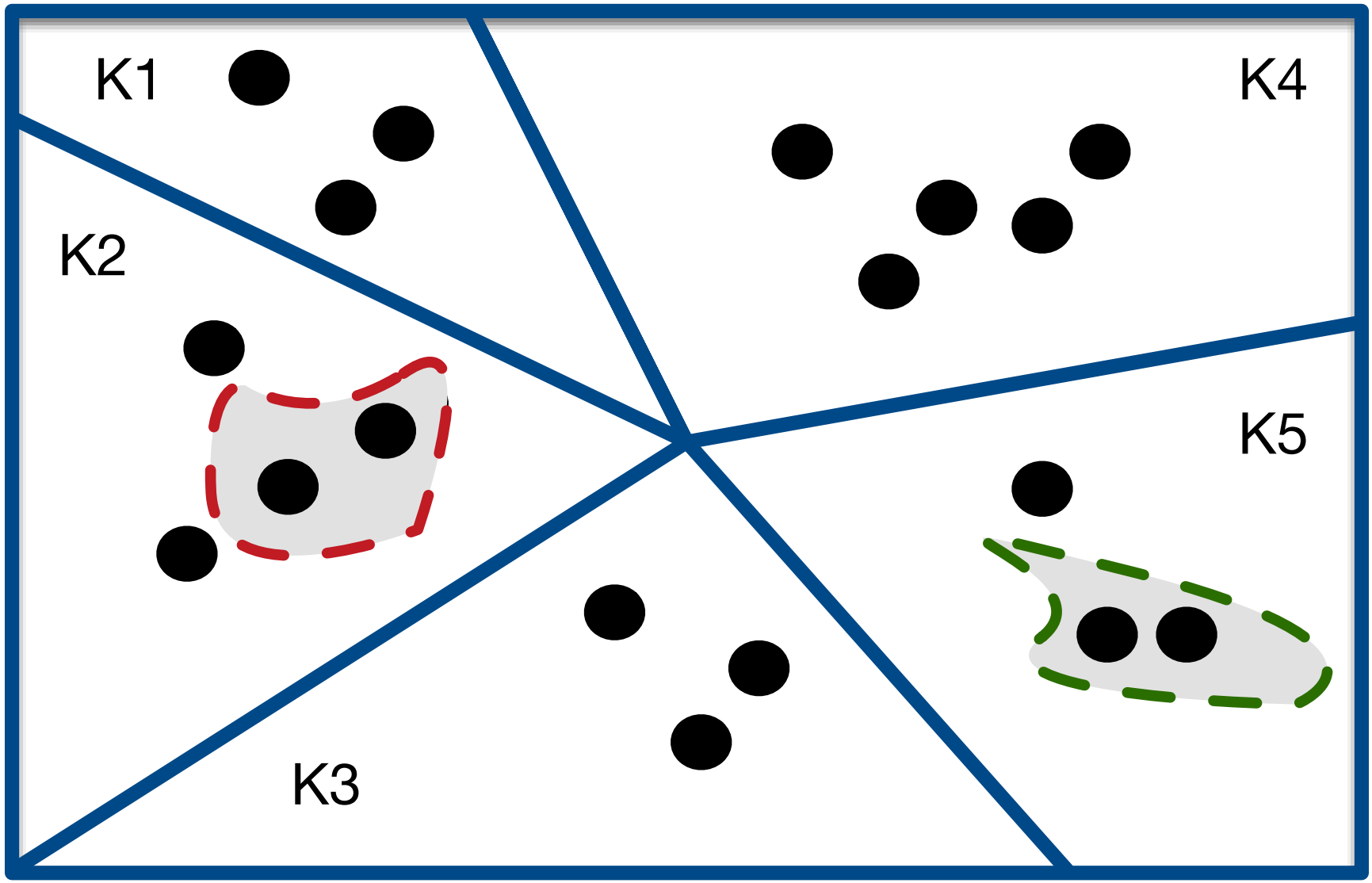
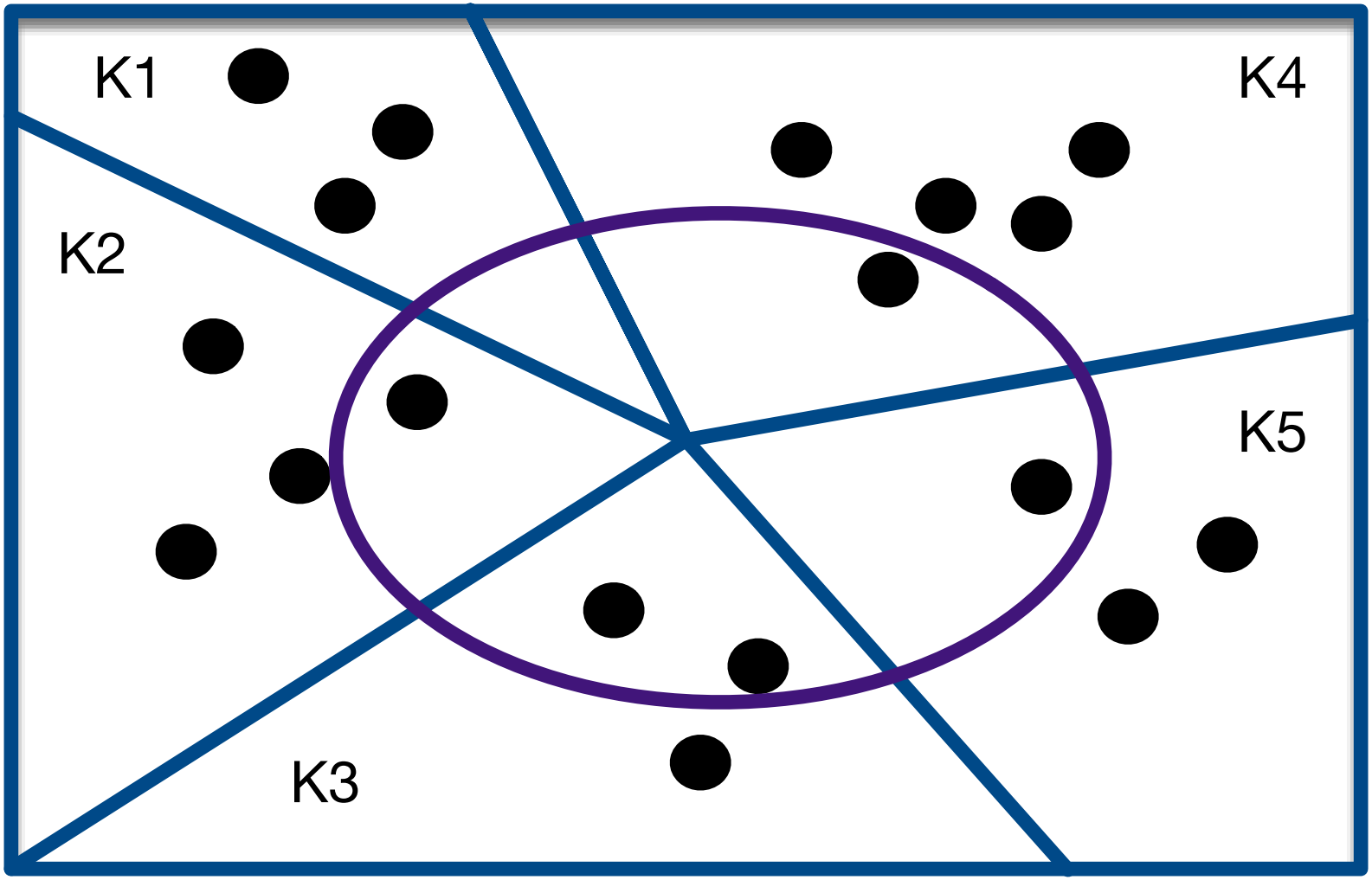
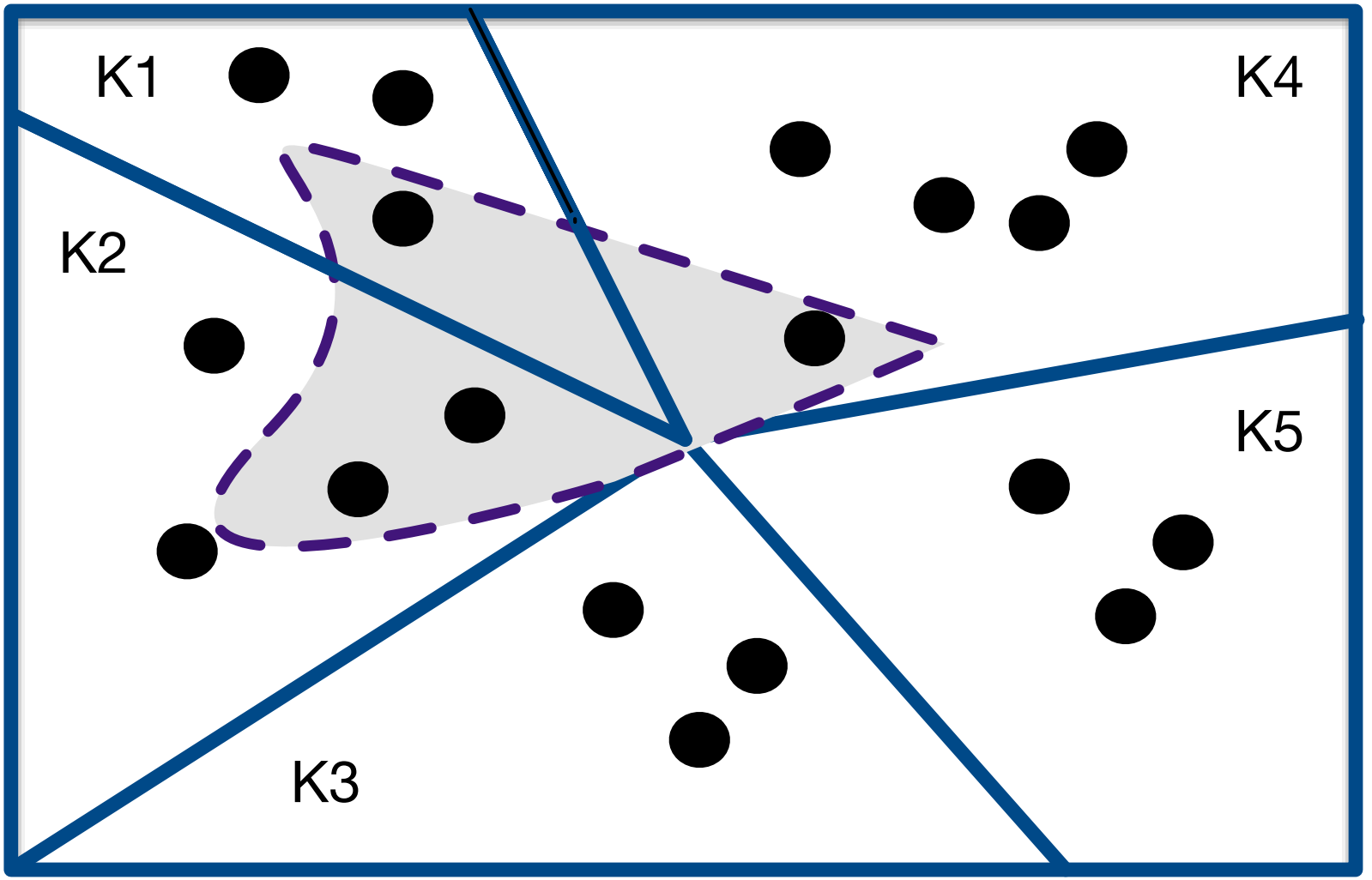


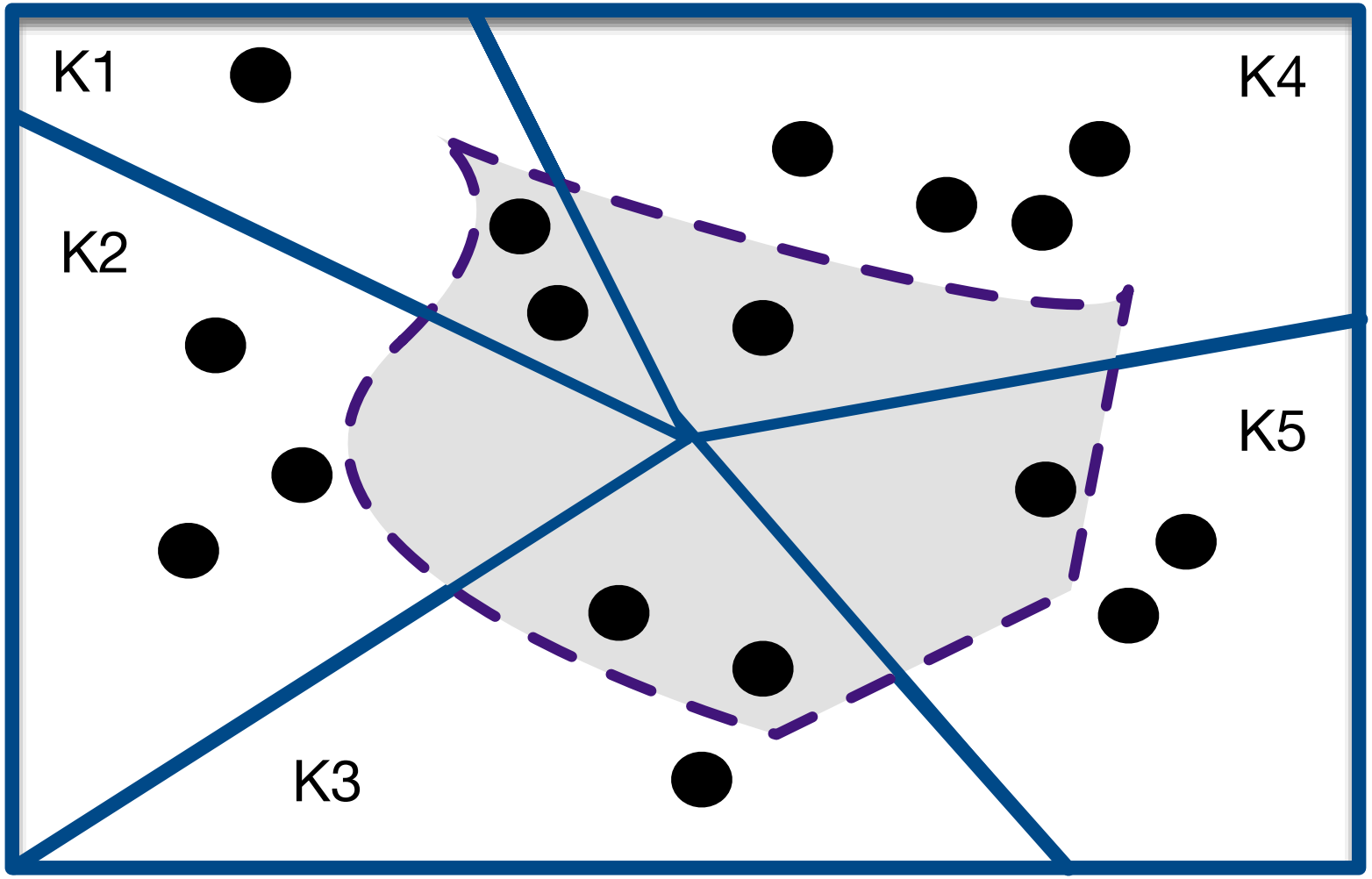
Rigid Mixins

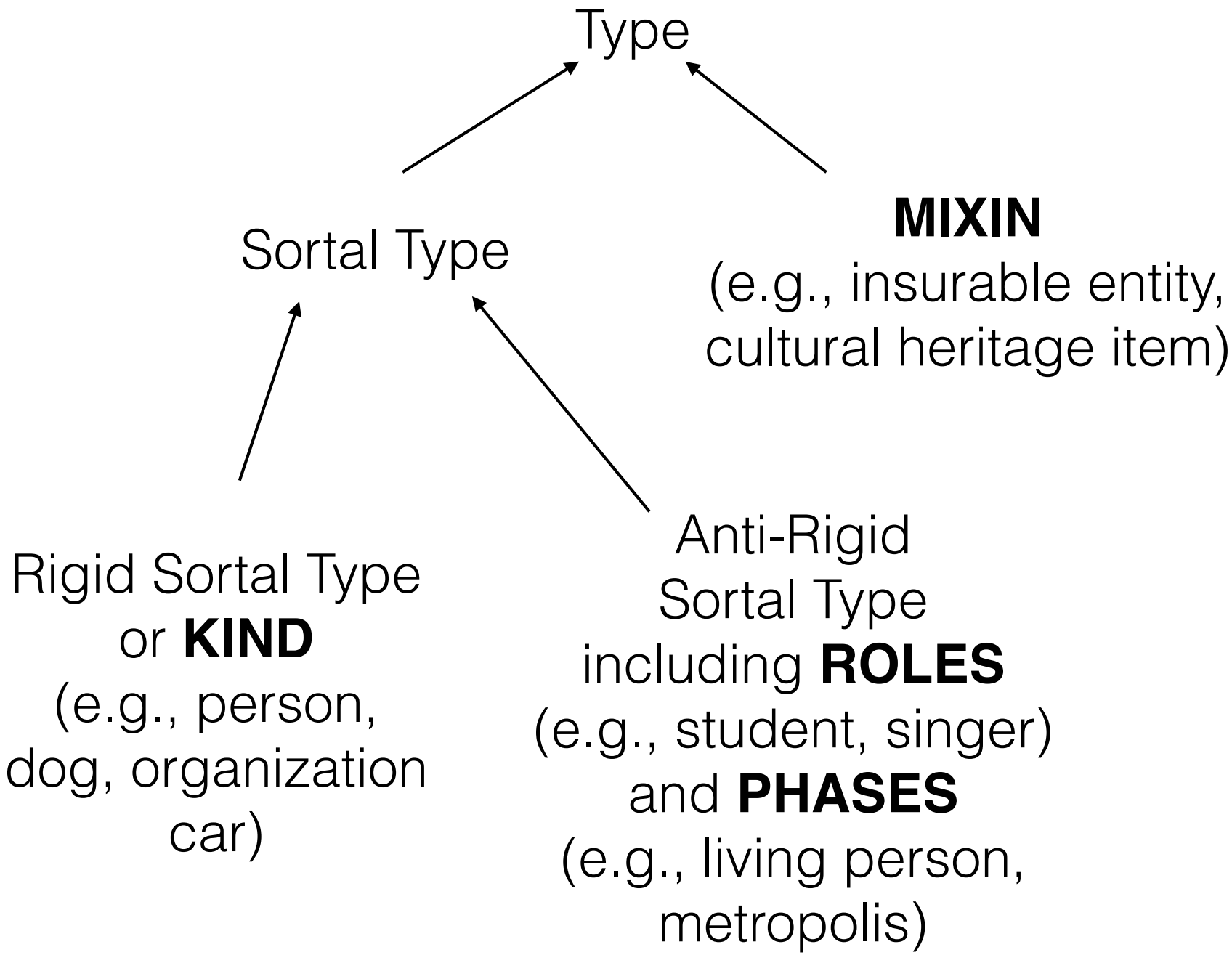


Anti-Rigid Mixins

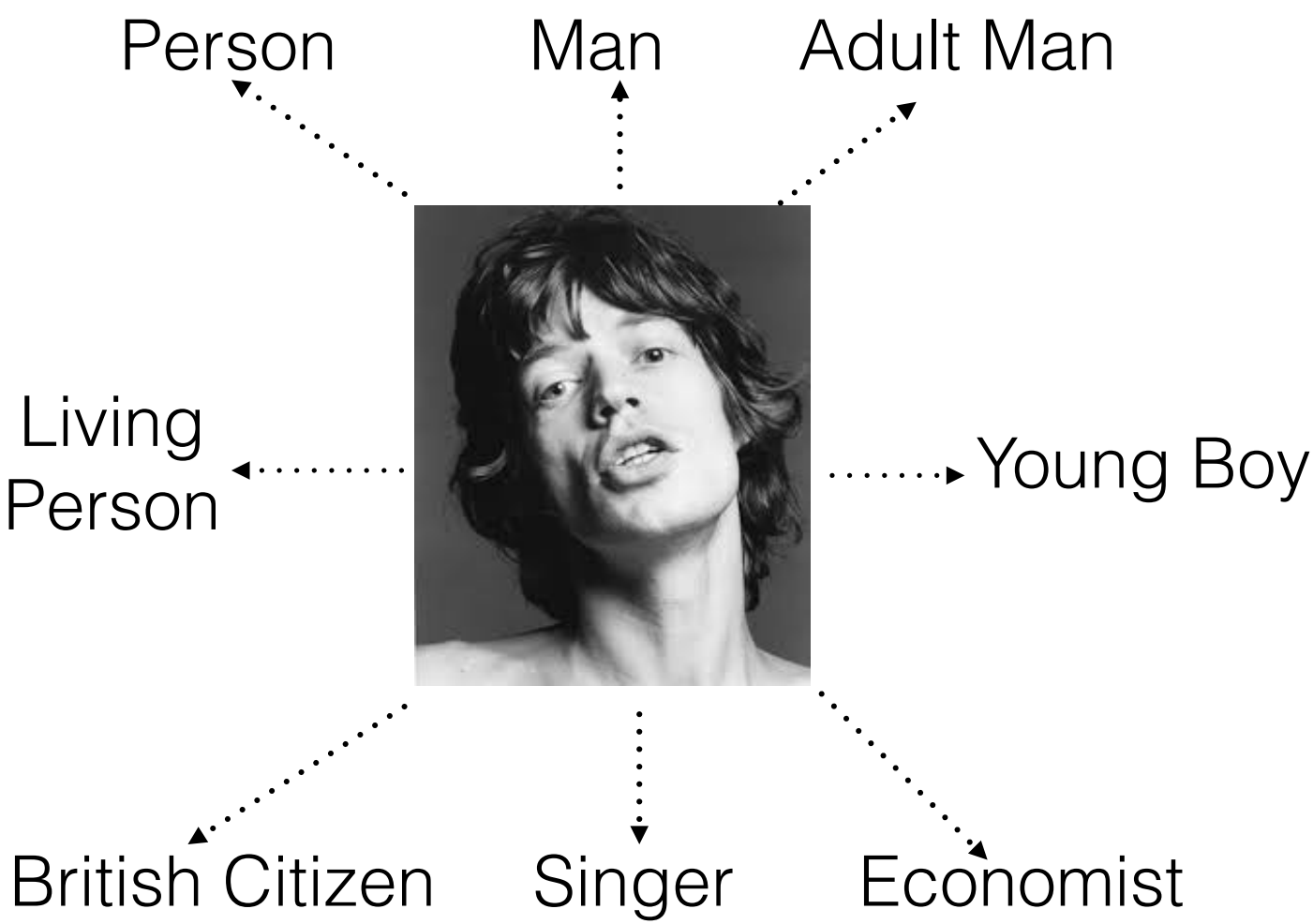


Anti-Rigid Mixins




Type
Sortal Type
MIXIN
(e.g., insurable entity,
cultural heritage item)
Rigid Sortal Type
or **KIND**
(e.g., person,
dog, organization
car)
Anti-Rigid
Sortal Type
including **ROLES**
(e.g., student, singer)
and **PHASES**
(e.g., living person,
metropolis)


© NBC


Person
Man
Adult Man
Living Person
Young Boy
British Citizen
Singer
Economist

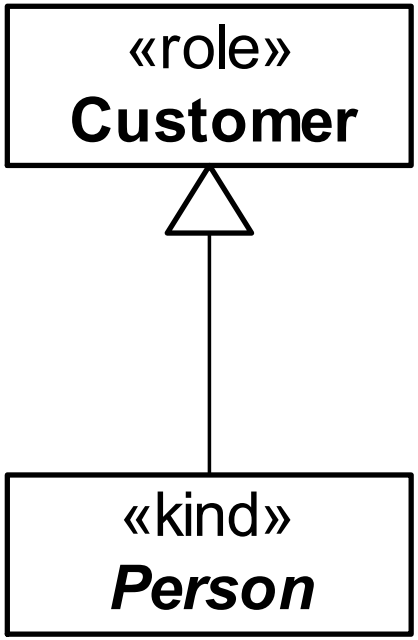
Solution

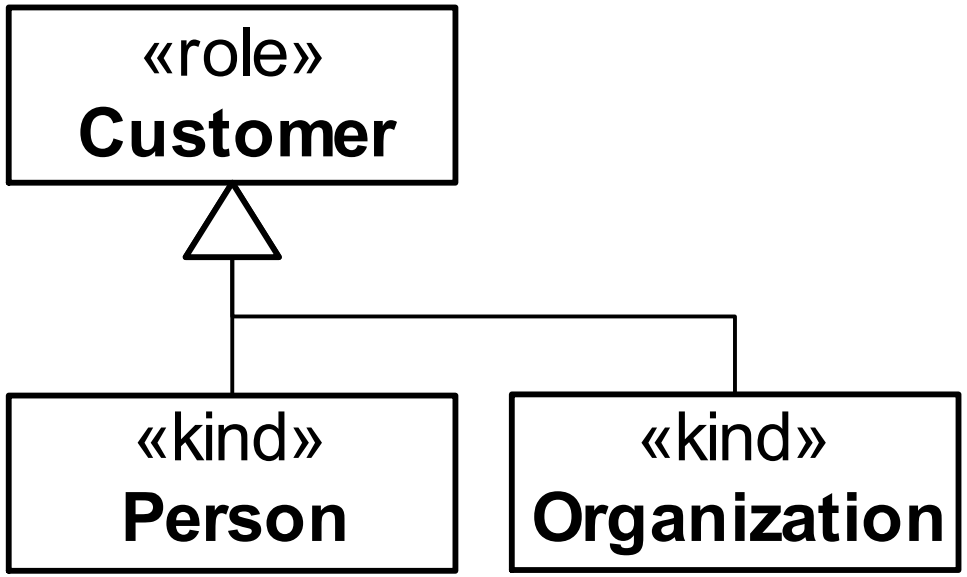
1. Characterizing the difference between:

   - NATURAL TYPE/KIND (e.g., **PERSON**) = **RIGID SORTAL**
   - ROLE (e.g., **SINGER, ECONOMIST, BRITISH CITIZEN, KNIGHT OF THE BRITISH EMPIRE**) = **ANTI-RIGID + RELATIONALLY DEPENDENT SORTAL**
   - PHASE (e.g., **LIVING PERSON, ADULT MAN**) = **ANTI-RIGID + RELATIONALLY INDEPENDENT SORTAL**
   - MIXIN (e.g., **CULTURAL HERITAGE ENTITY, PHYSICAL ENTITY, INSURABLE ITEM**)? = **MIXIN**

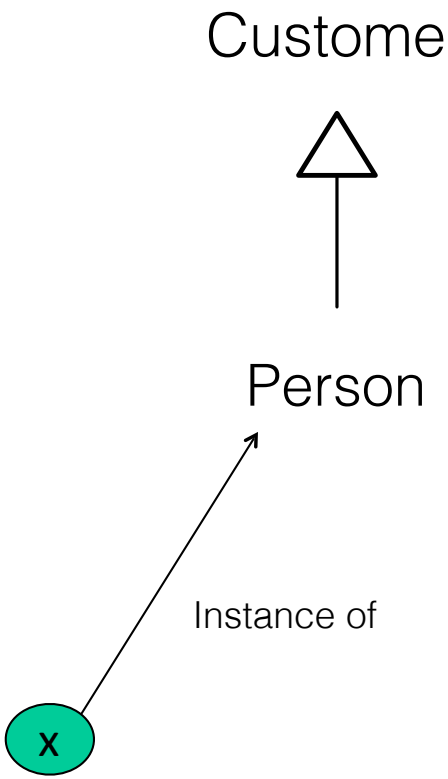
Role

- All instances of a given ROLE are of the same KIND (e.g., all Students are Person)
- All instances of a ROLE instantiate that type only contingently (e.g., no Student is necessarily a Student)
- Instances of a KIND instantiate that ROLE when participating in a certain RELATIONAL CONTEXT (e.g., instances of Person instantiate the Role Student when enrolled in na Educational Institution)
- **A ROLE cannot be a supertype of a Rigid Type**

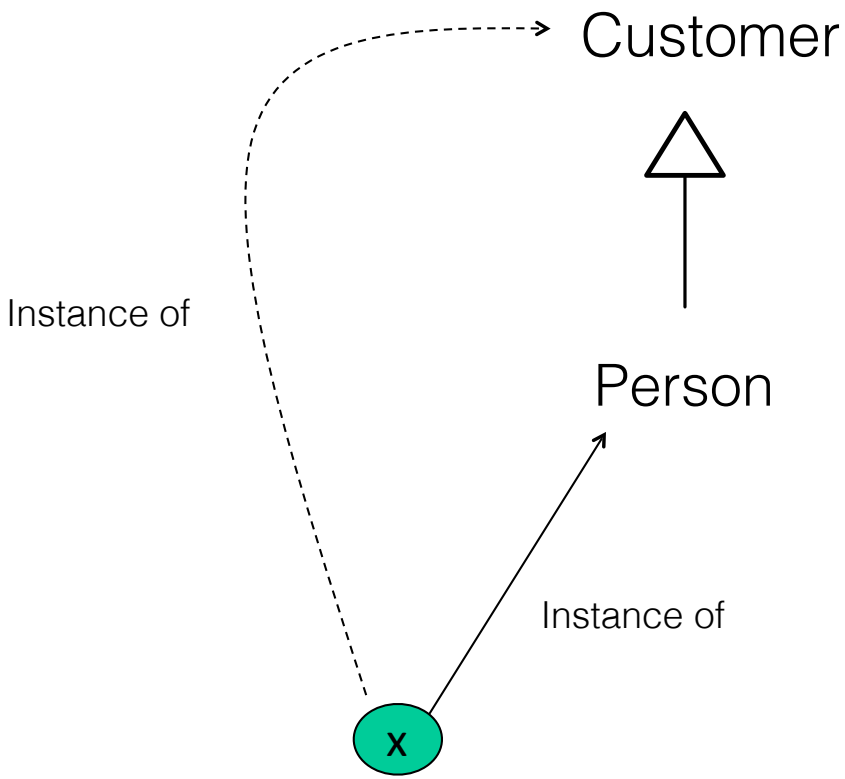

«role»
Customer
«kind»
Person


«role»
Customer
«kind»
Person
«kind»
Organization

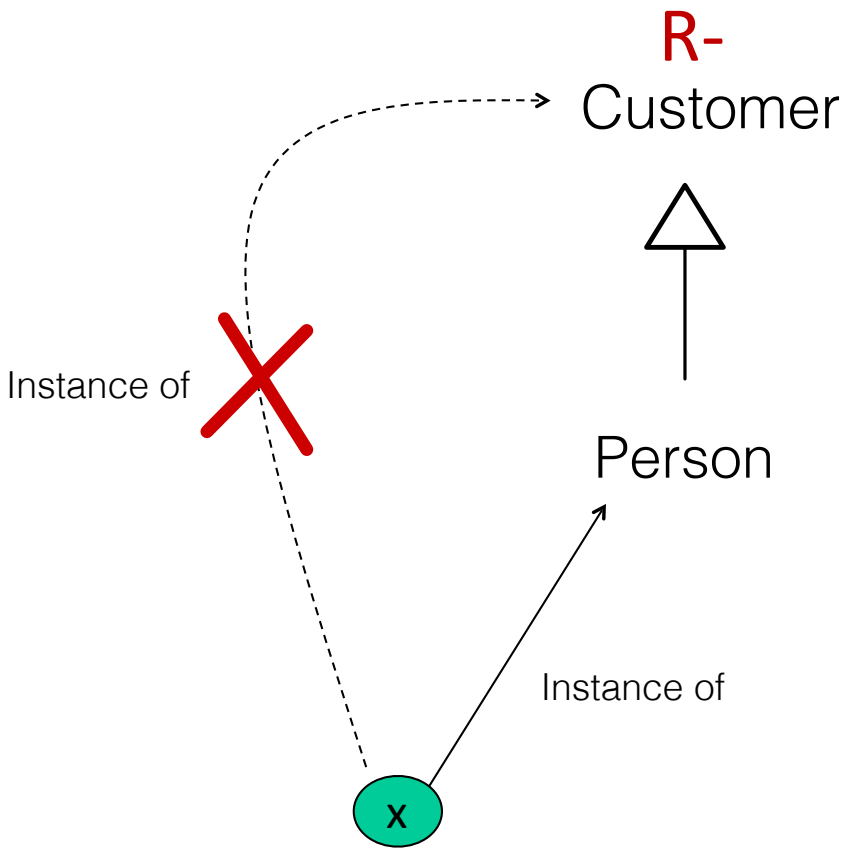
WORLD W



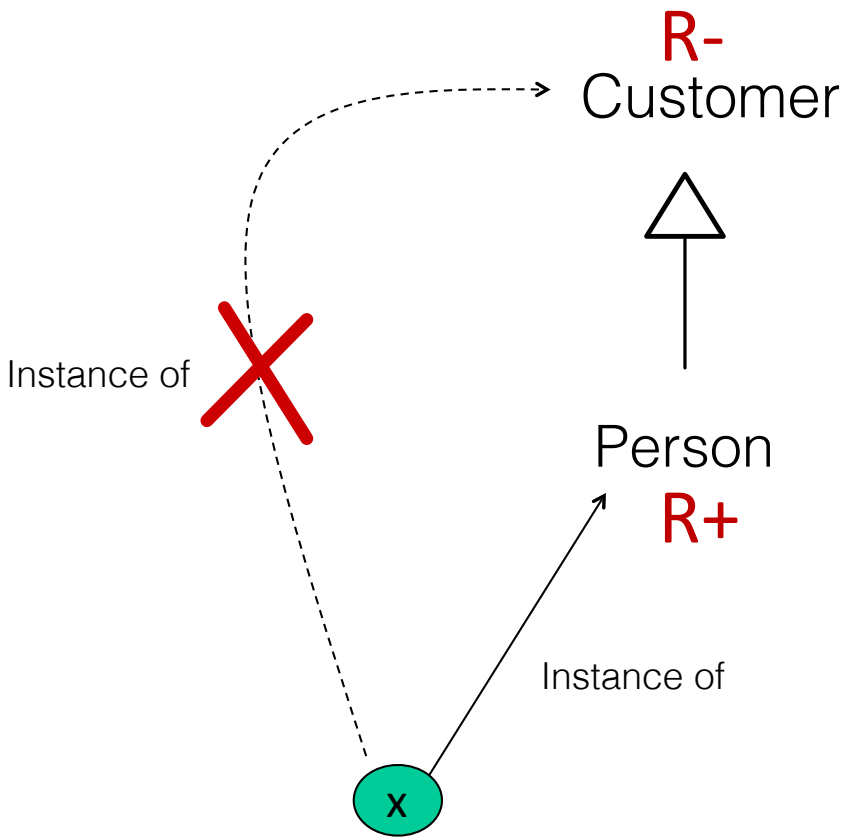
WORLD W



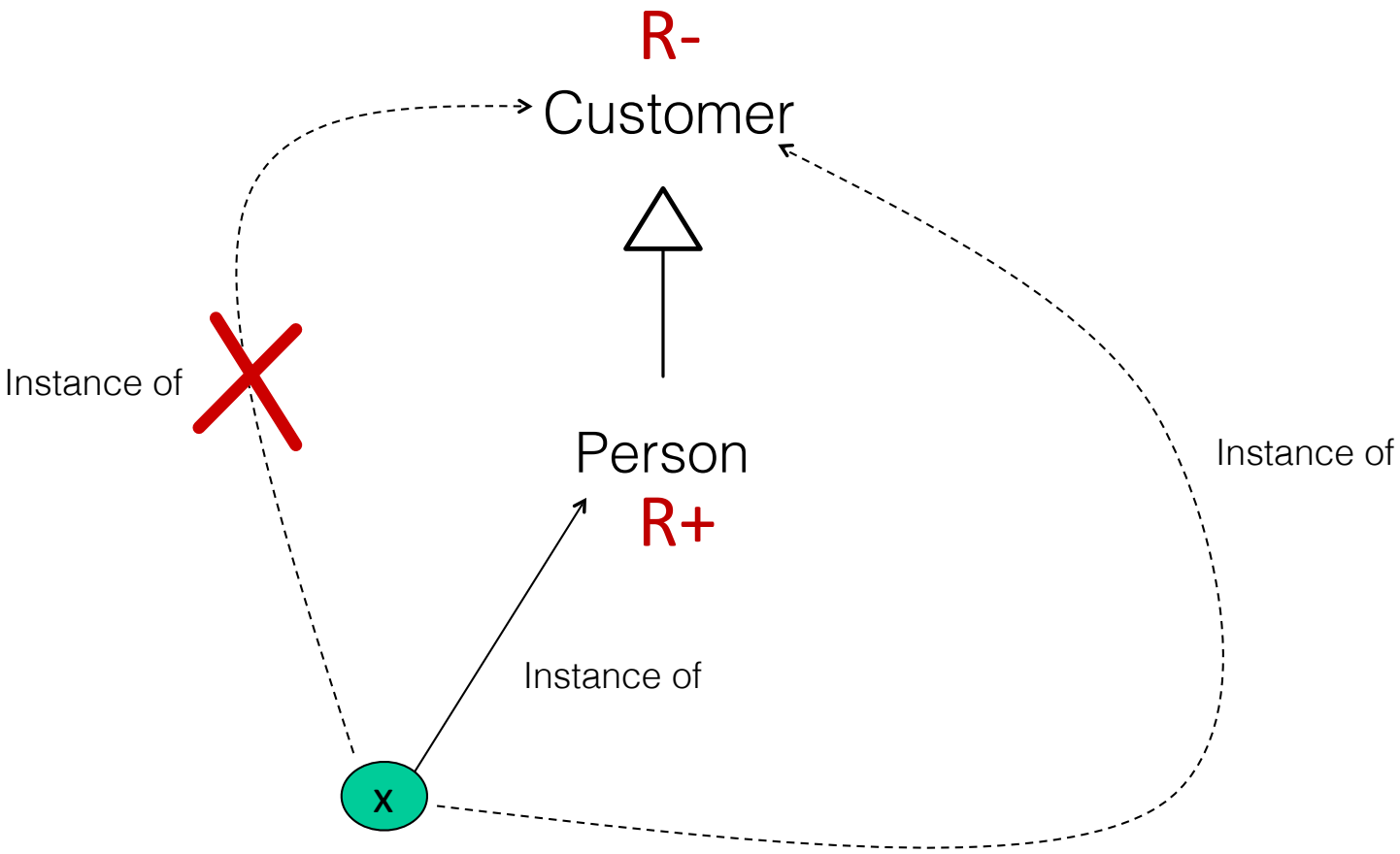
WORLD W’



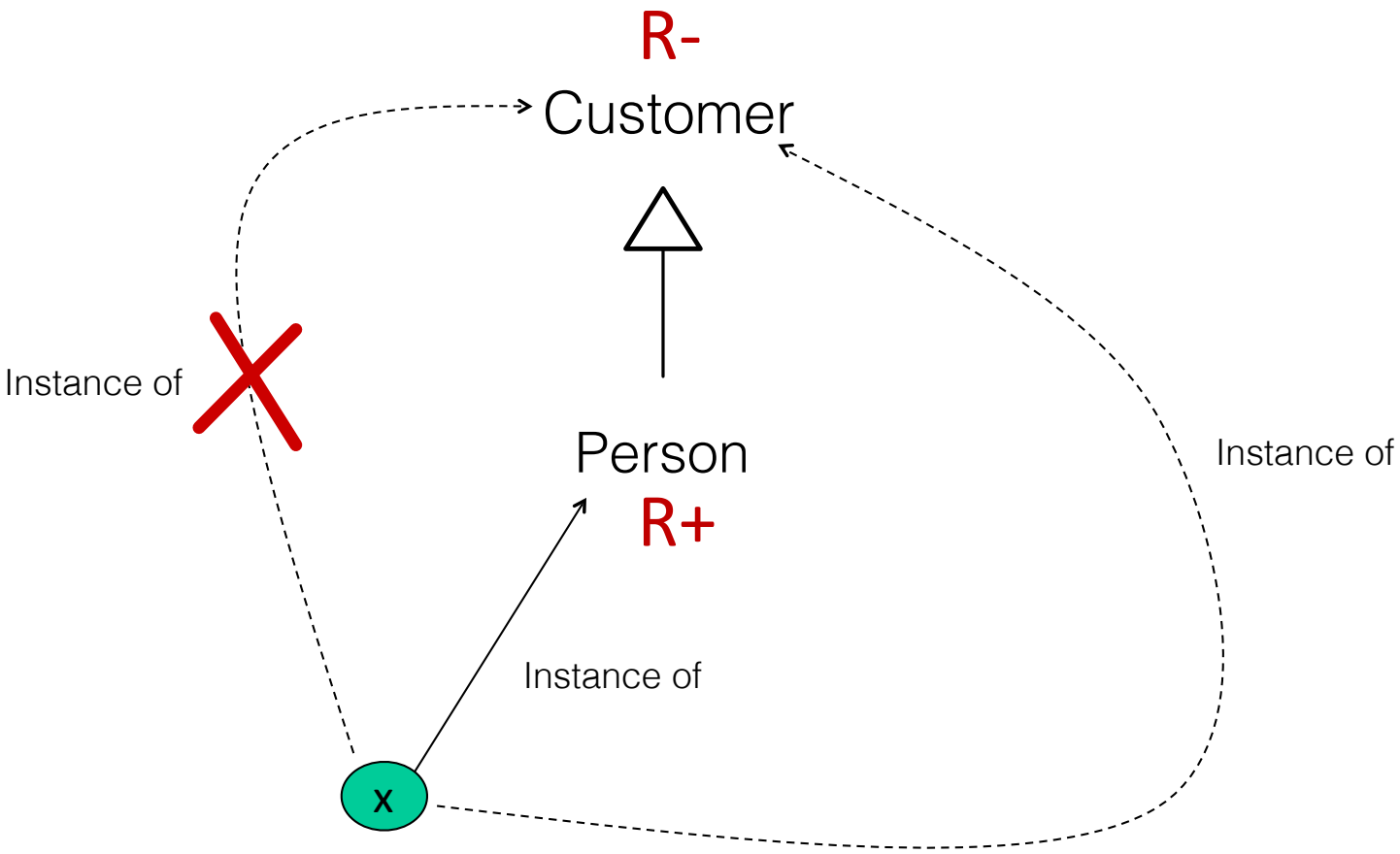
WORLD W’



WORLD W'



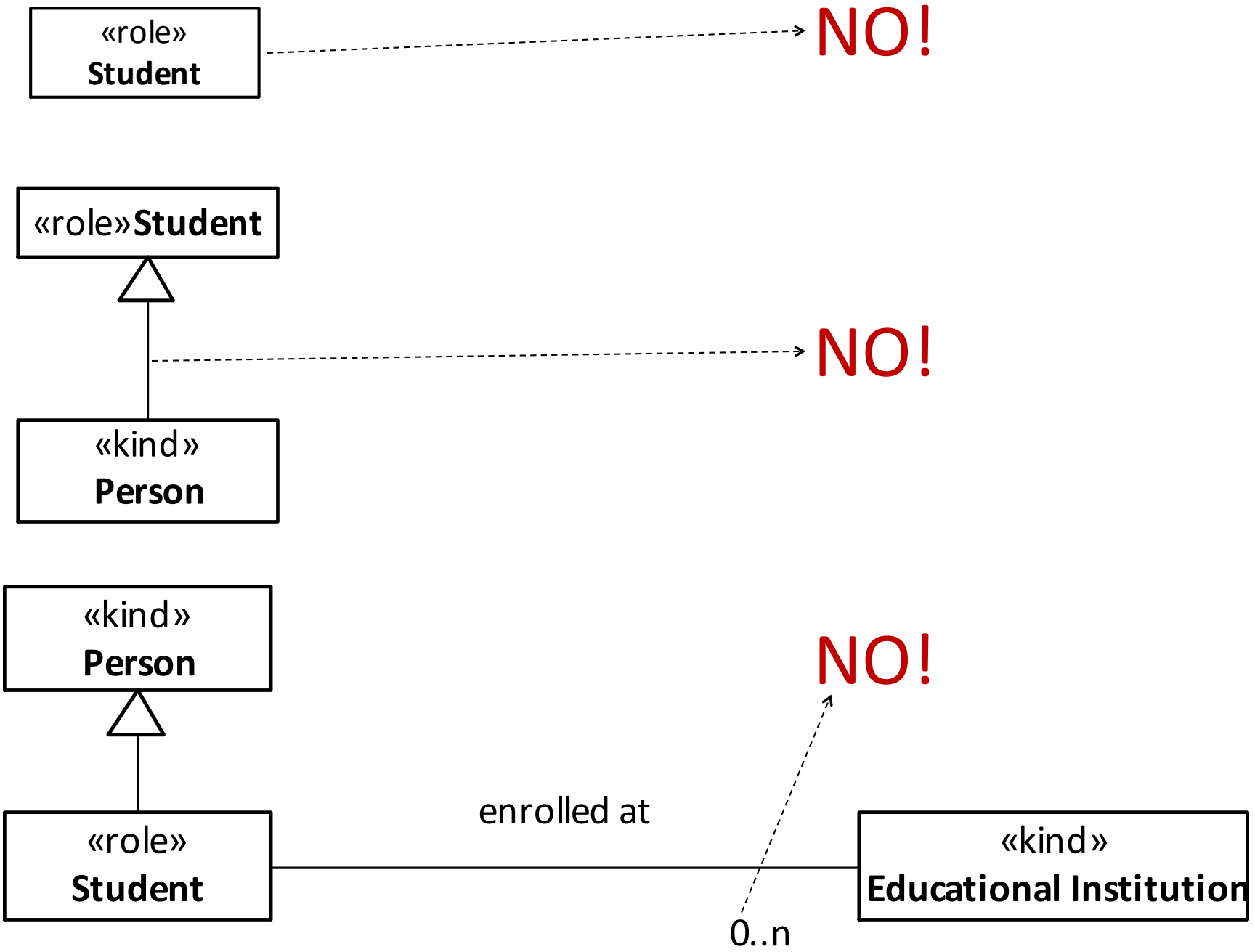
WORLD W'

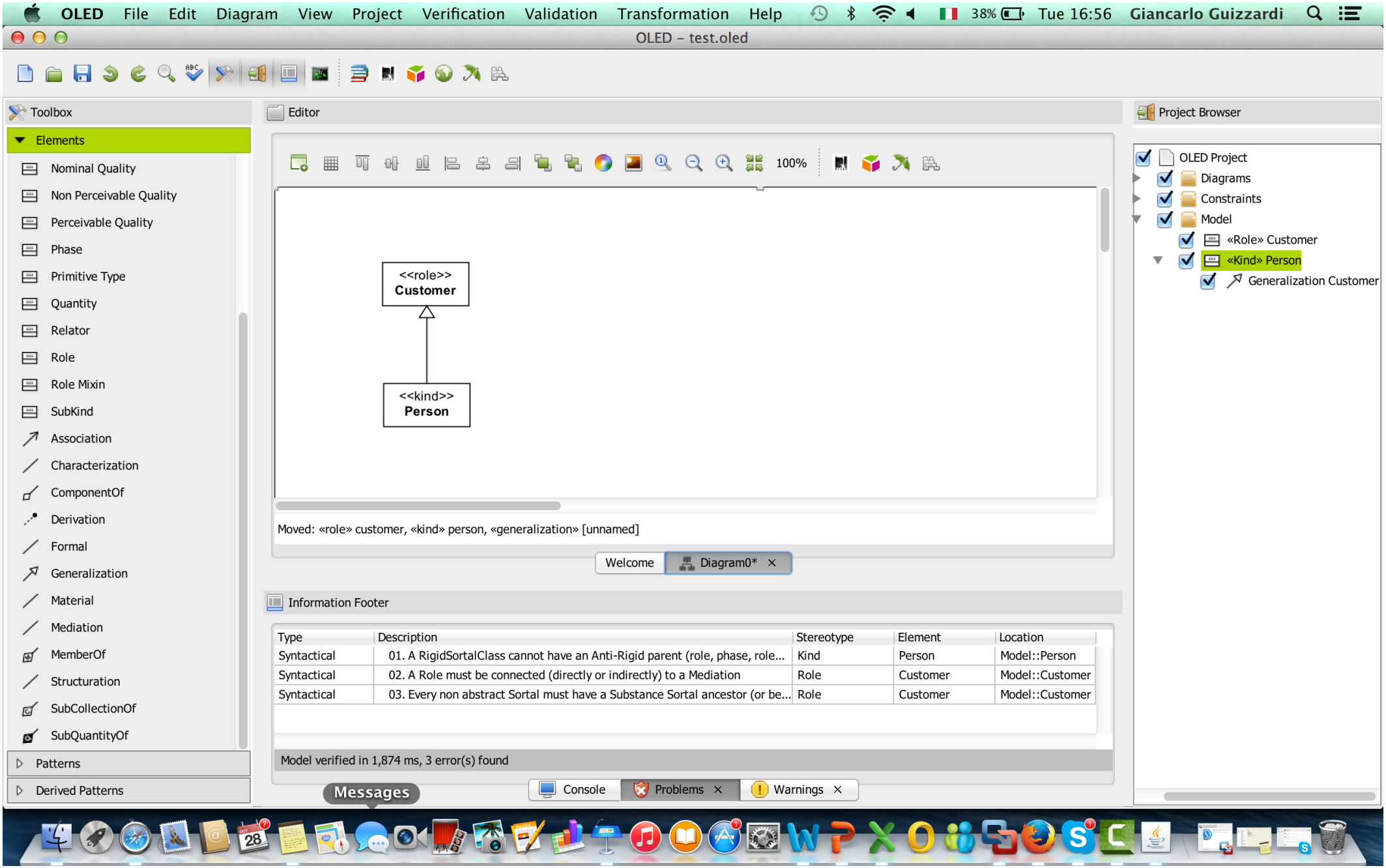


We run into a logical contradiction!

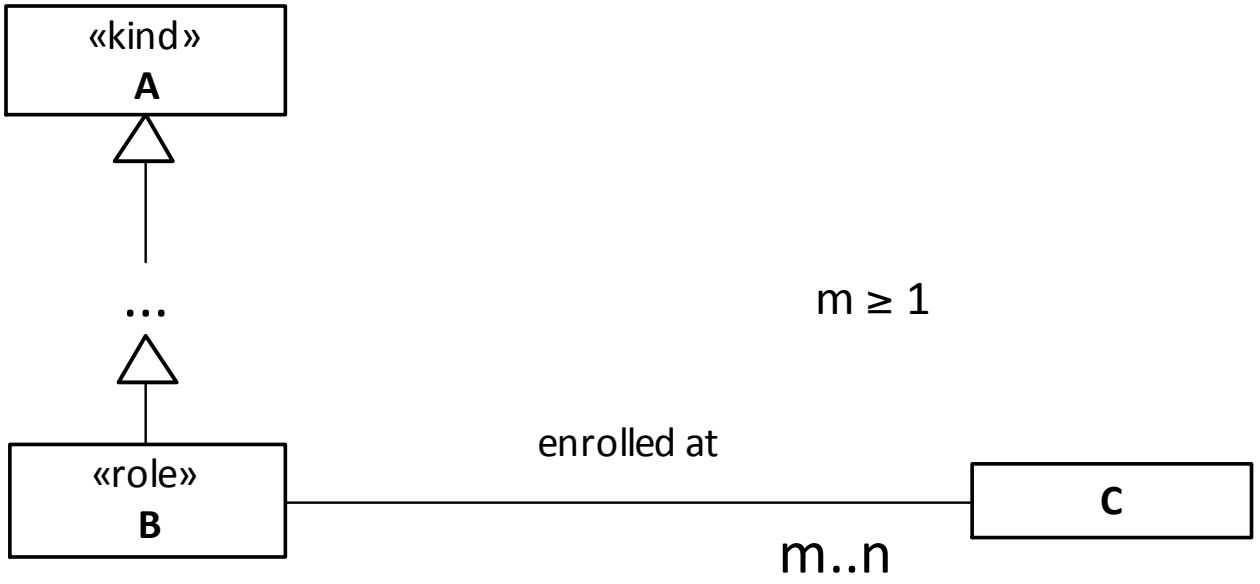
Role

- All instances of a given ROLE are of the same KIND (e.g., all Students are Person)
- All instances of a ROLE instantiate that type only contingently (e.g., no Student is necessarily a Student)
- Instances of a KIND instantiate that ROLE when participating in a certain RELATIONAL CONTEXT (e.g., instances of Person instantiate the Role Student when enrolled in na Educational Institution)
- A ROLE cannot be a supertype of a Rigid Type

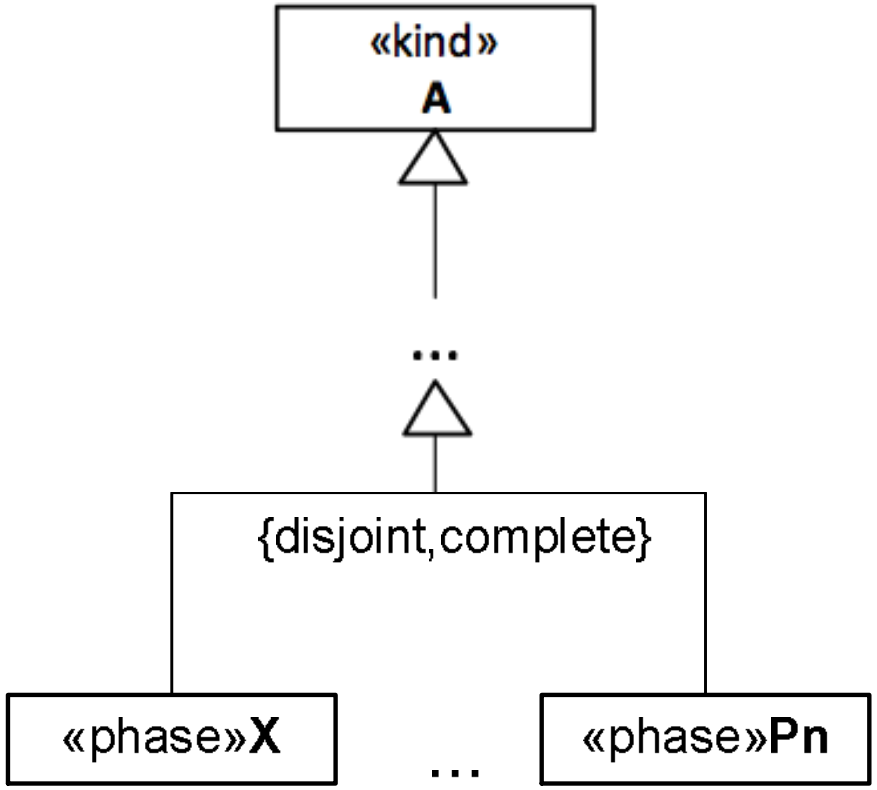

«role»
Student
NO!
«role»Student
NO!
«kind»
Person
«kind»
Person
NO!
enrolled at
«role»
Student
«kind»
Educational Institution
0..n


OLED File Edit Diagram View Project Verification Validation Transformation Help 38% Tue 16:56 Giancarlo Guizzardi
OLED – test.oled
Toolbox
Elements
Nominal Quality
Non Perceivable Quality
Perceivable Quality
Phase
Primitive Type
Quantity
Relator
Role
Role Mixin
SubKind
Association
Characterization
ComponentOf
Derivation
Formal
Generalization
Material
Mediation
MemberOf
Structuration
SubCollectionOf
SubQuantityOf
Patterns
Derived Patterns
Editor
100%
<<role>>
Customer
<<kind>>
Person
Moved: «role» customer, «kind» person, «generalization» [unnamed]
Welcome
Diagram0*
Information Footer
Type
Description
Stereotype
Element
Location
Syntactical
01. A RigidSortalClass cannot have an Anti-Rigid parent (role, phase, role...
Kind
Person
Model::Person
Syntactical
02. A Role must be connected (directly or indirectly) to a Mediation
Role
Customer
Model::Customer
Syntactical
03. Every non abstract Sortal must have a Substance Sortal ancestor (or be...
Role
Customer
Model::Customer
Model verified in 1,874 ms, 3 error(s) found
Messages
Console
Problems
Warnings
Project Browser
OLED Project
Diagrams
Constraints
Model
«Role» Customer
«Kind» Person
Generalization Customer

The Emerging **Role** Pattern



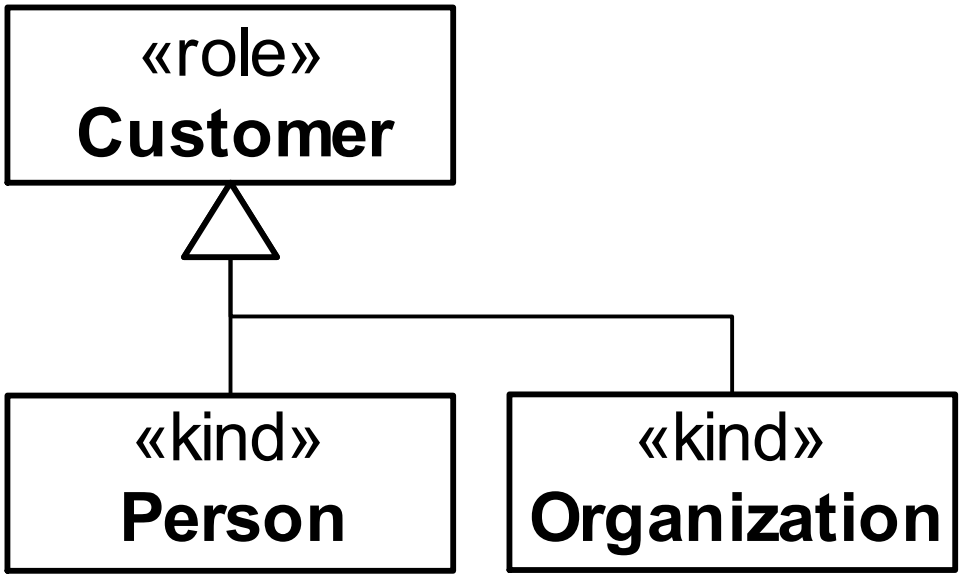
The Emerging **Phase** Pattern

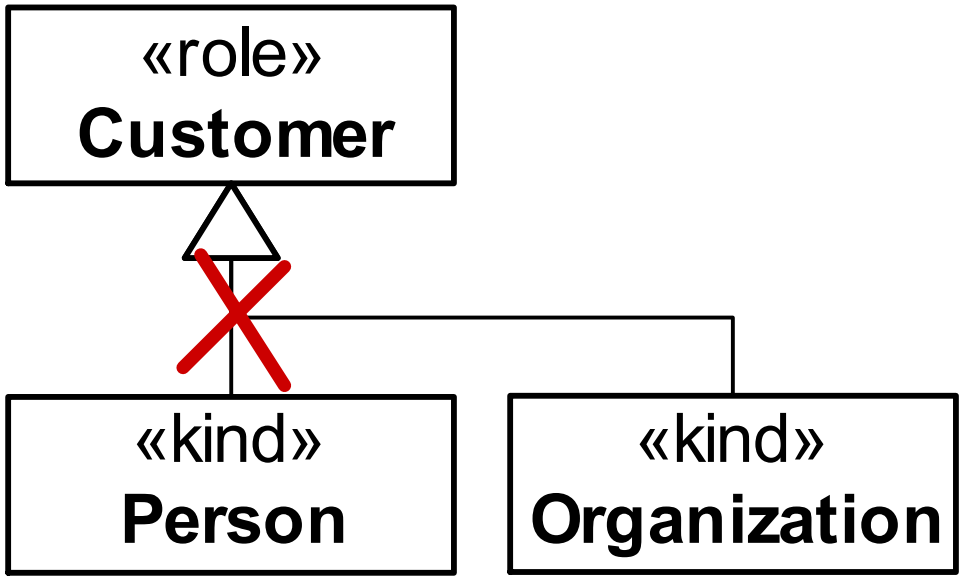


Problem (2)

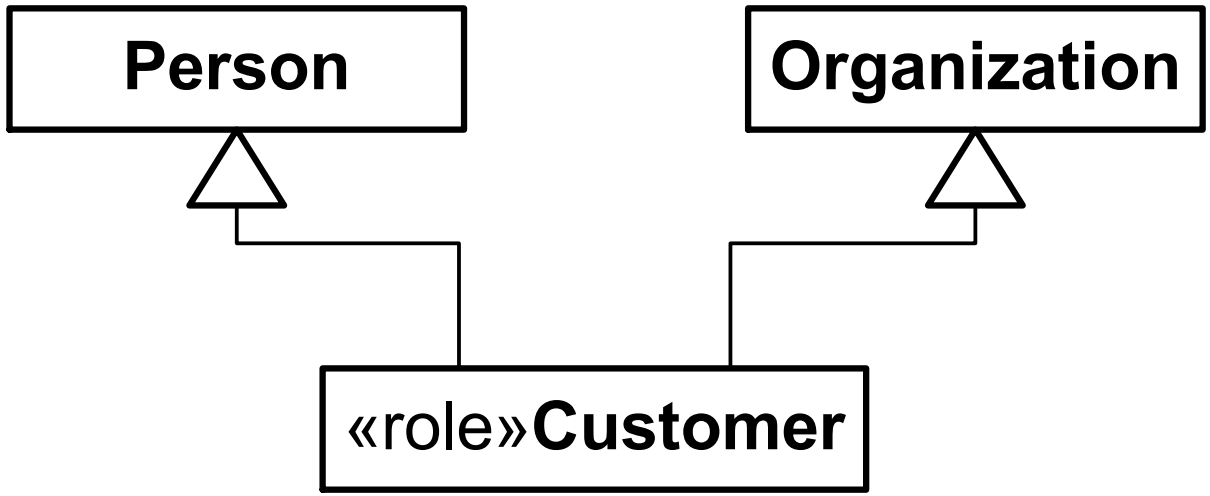
1. Suppose that I want to represent that the ROLE Customer can be played by entities of different KINDS, namely, People and Organizations. How to relate the ROLE and its *allowed types* using subtyping relations?

A Classic Problem

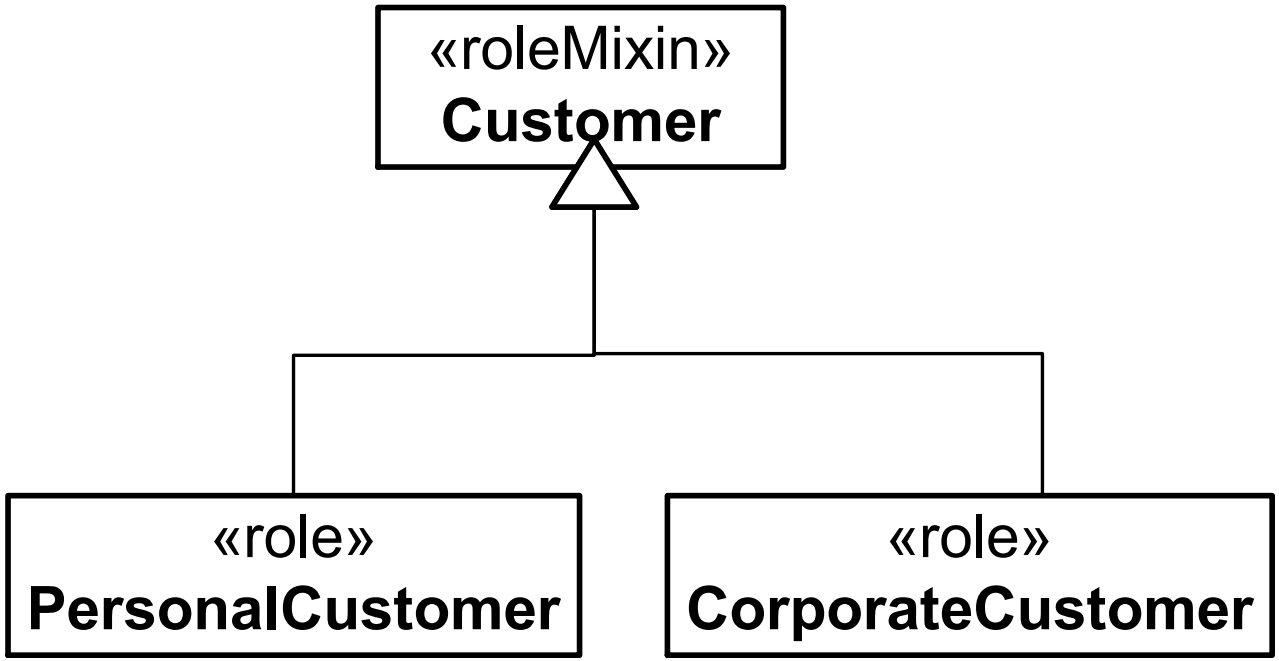


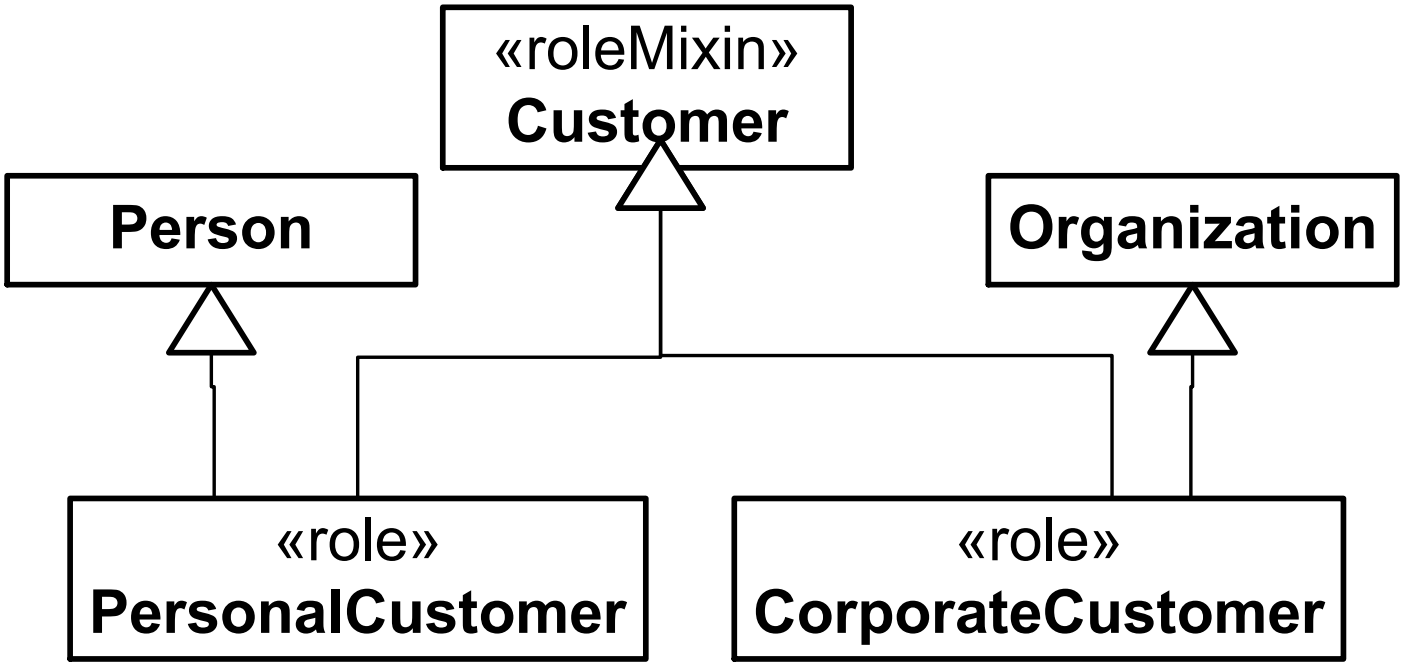

«role»
Customer
«kind»
Person
«kind»
Organization

A Possible Alternative?

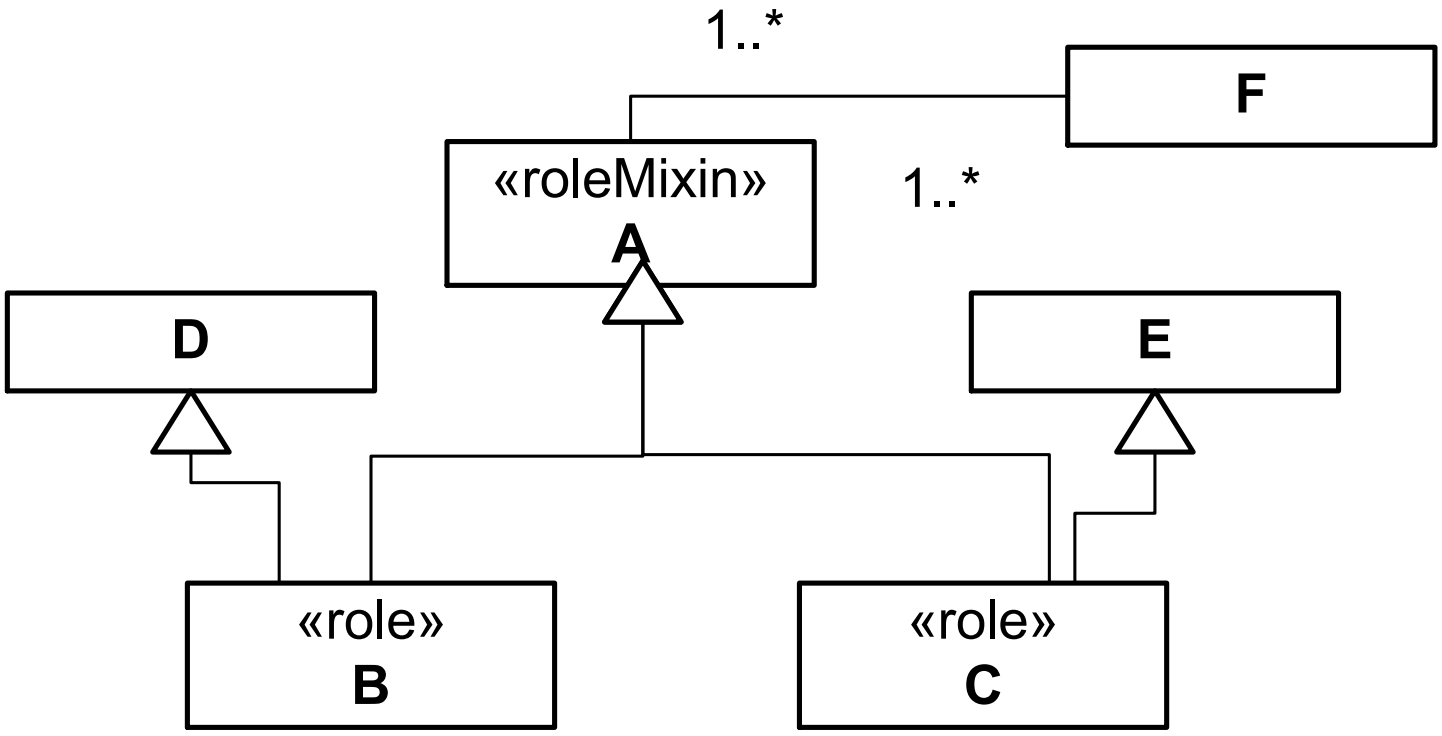


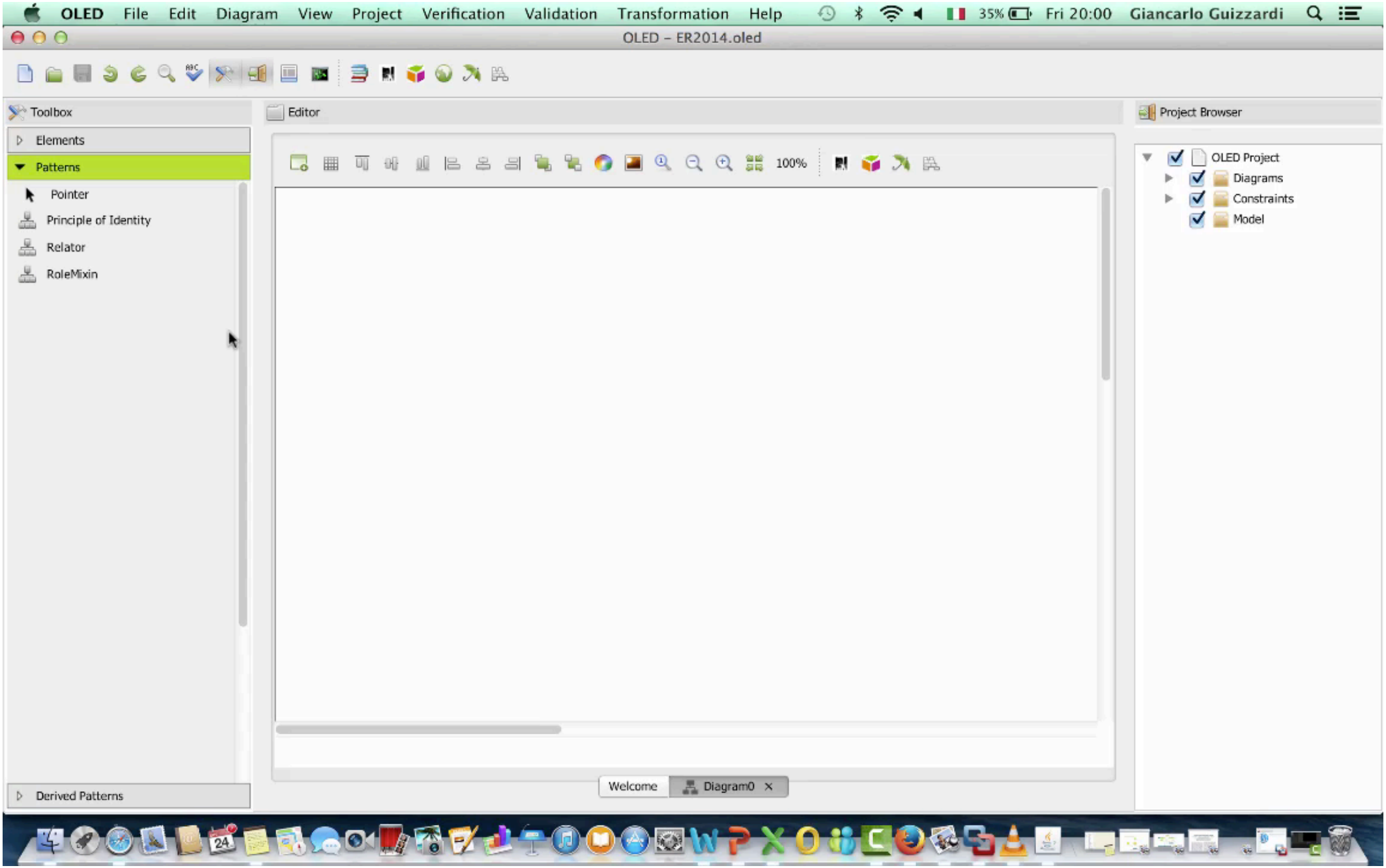

«roleMixin»
Customer

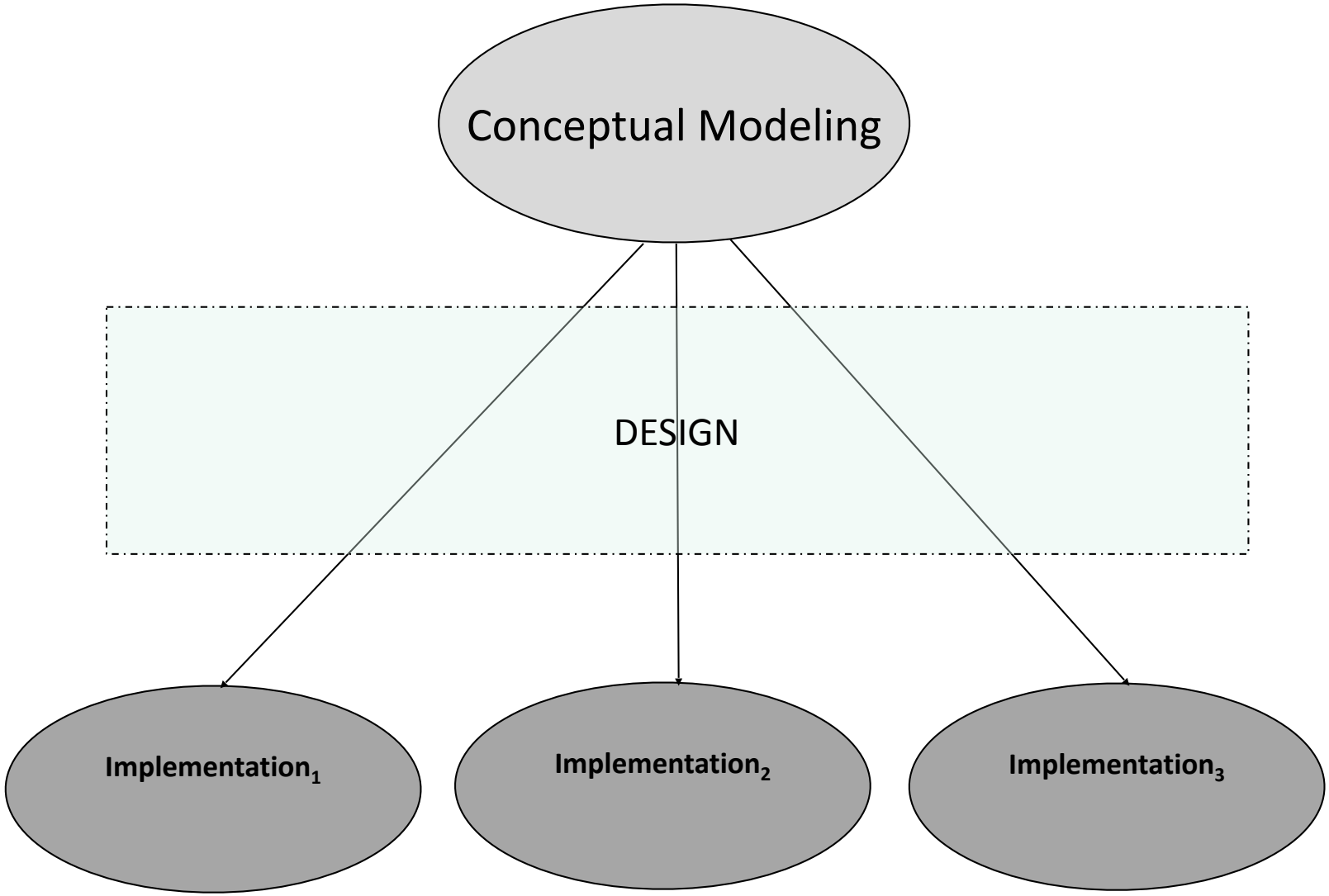

«roleMixin»
Customer
«role»
PersonalCustomer
«role»
CorporateCustomer

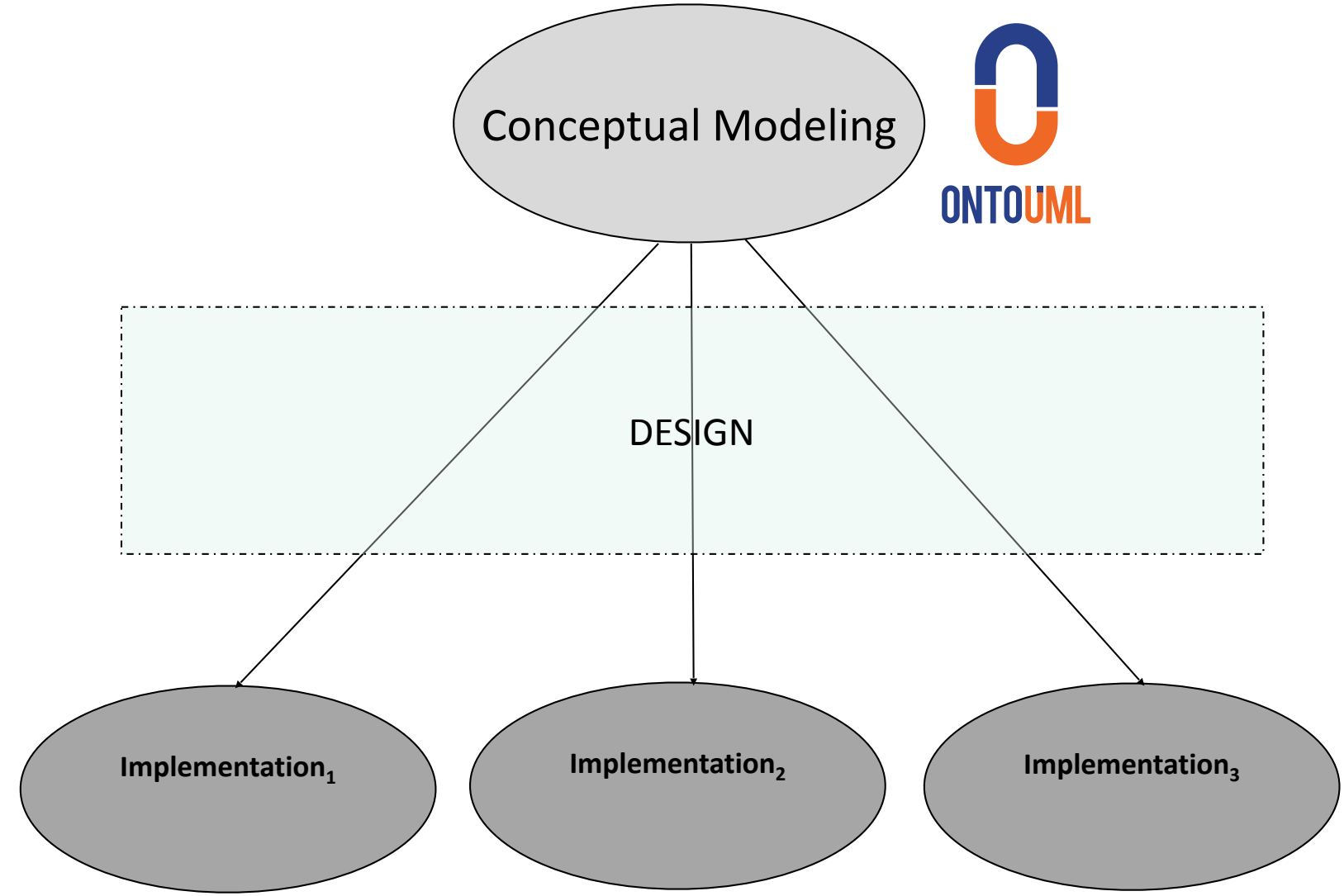

«roleMixin»
Customer
Person
Organization
«role»
PersonalCustomer
«role»
CorporateCustomer

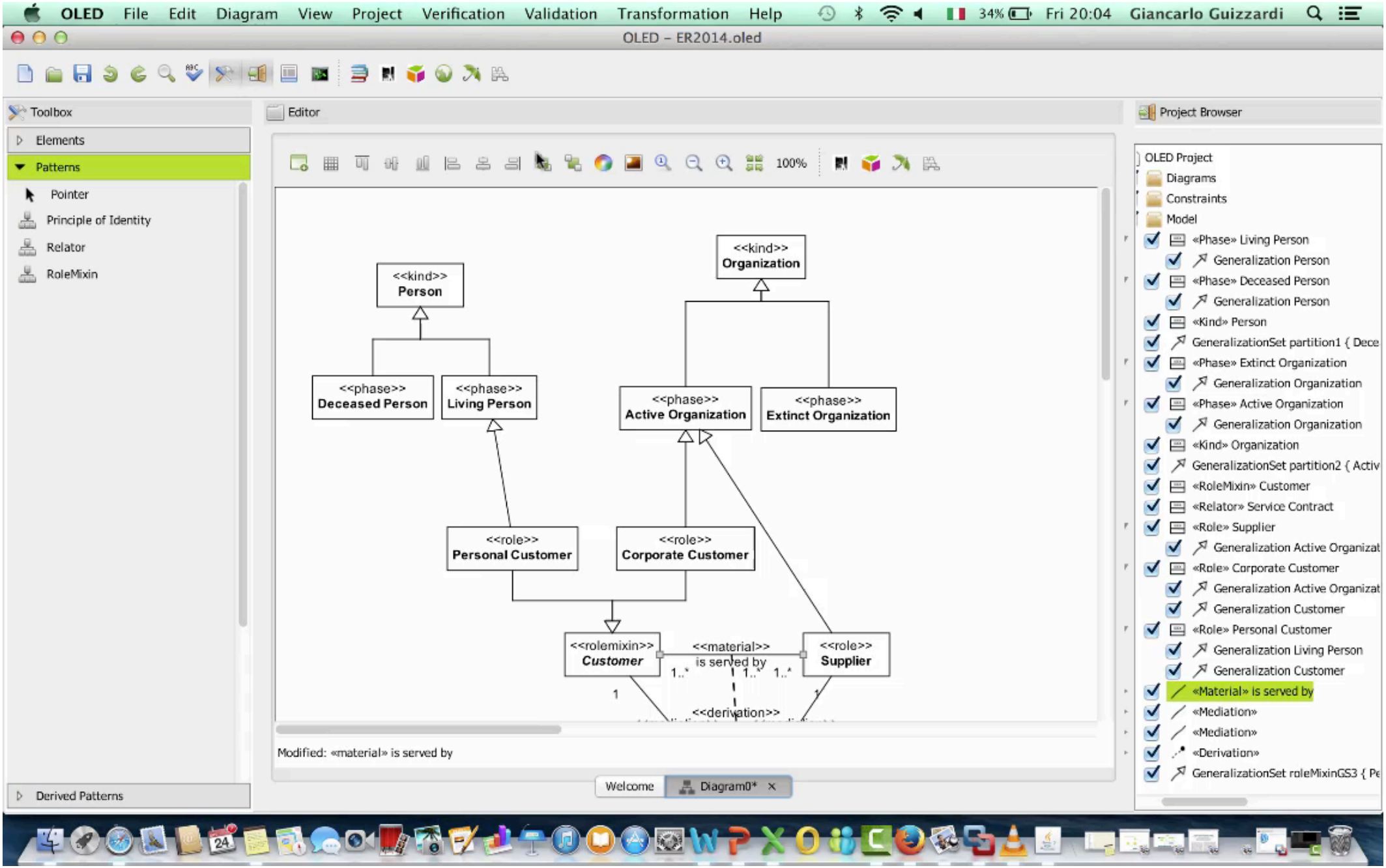
The emerging **RoleMixin** Pattern



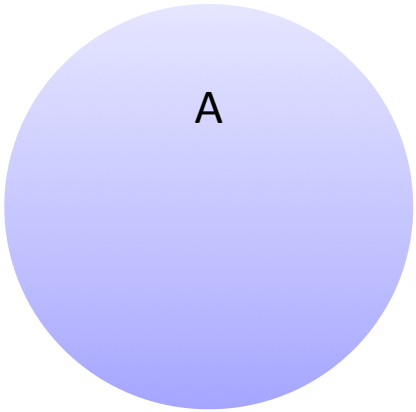

OLED File Edit Diagram View Project Verification Validation Transformation Help 35% Fri 20:00 Giancarlo Guizzardi
OLED – ER2014.oled
Toolbox
Elements
Patterns
Pointer
Principle of Identity
Relator
RoleMixin
Derived Patterns
Editor
100%
Welcome
Diagram0
Project Browser
OLED Project
Diagrams
Constraints
Model


Conceptual Modeling
DESIGN
Implementation1
Implementation2
Implementation3

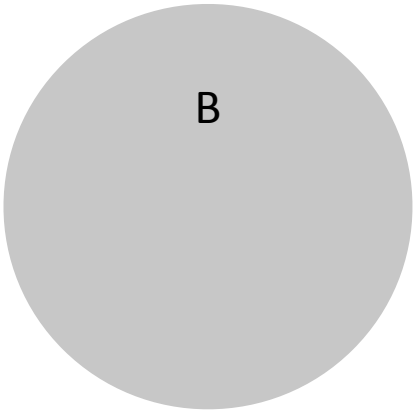

Conceptual Modeling
ONTOUML
DESIGN
Implementation1
Implementation2
Implementation3
W3C
OWL2


OLED File Edit Diagram View Project Verification Validation Transformation Help
OLED – ER2014.oled
Toolbox
Elements
Patterns
Pointer
Principle of Identity
Relator
RoleMixin
Derived Patterns
Editor
100%
<<kind>> Person
<<kind>> Organization
<<phase>> Deceased Person
<<phase>> Living Person
<<phase>> Active Organization
<<phase>> Extinct Organization
<<role>> Personal Customer
<<role>> Corporate Customer
<<rolemixin>> Customer
<<material>> is served by
<<role>> Supplier
<<derivation>>
Modified: «material» is served by
Welcome
Diagram0*
Project Browser
OLED Project
Diagrams
Constraints
Model
«Phase» Living Person
Generalization Person
«Phase» Deceased Person
Generalization Person
«Kind» Person
«Phase» Extinct Organization
Generalization Organization
«Phase» Active Organization
Generalization Organization
«Kind» Organization
«RoleMixin» Customer
«Relator» Service Contract
«Role» Supplier
Generalization Customer
«Role» Corporate Customer
Generalization Customer
«Role» Personal Customer
Generalization Living Person
Generalization Customer
«Material» is served by
«Mediation»
«Mediation»
«Derivation»

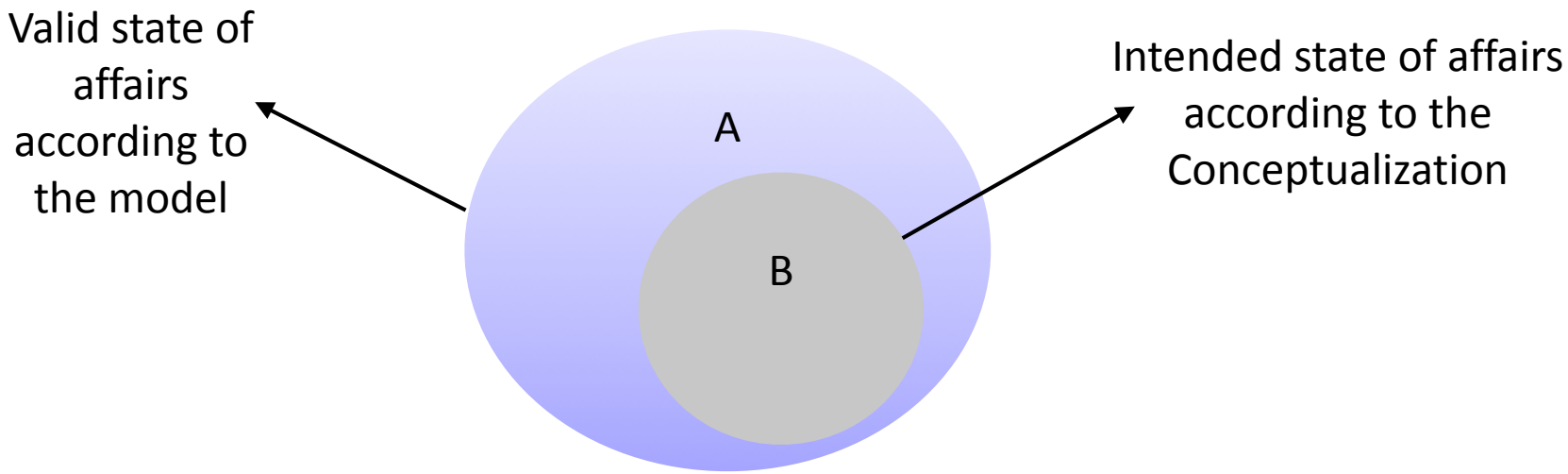
Complexity Management:
Viewpoint Extraction,
Modularization and Abstraction



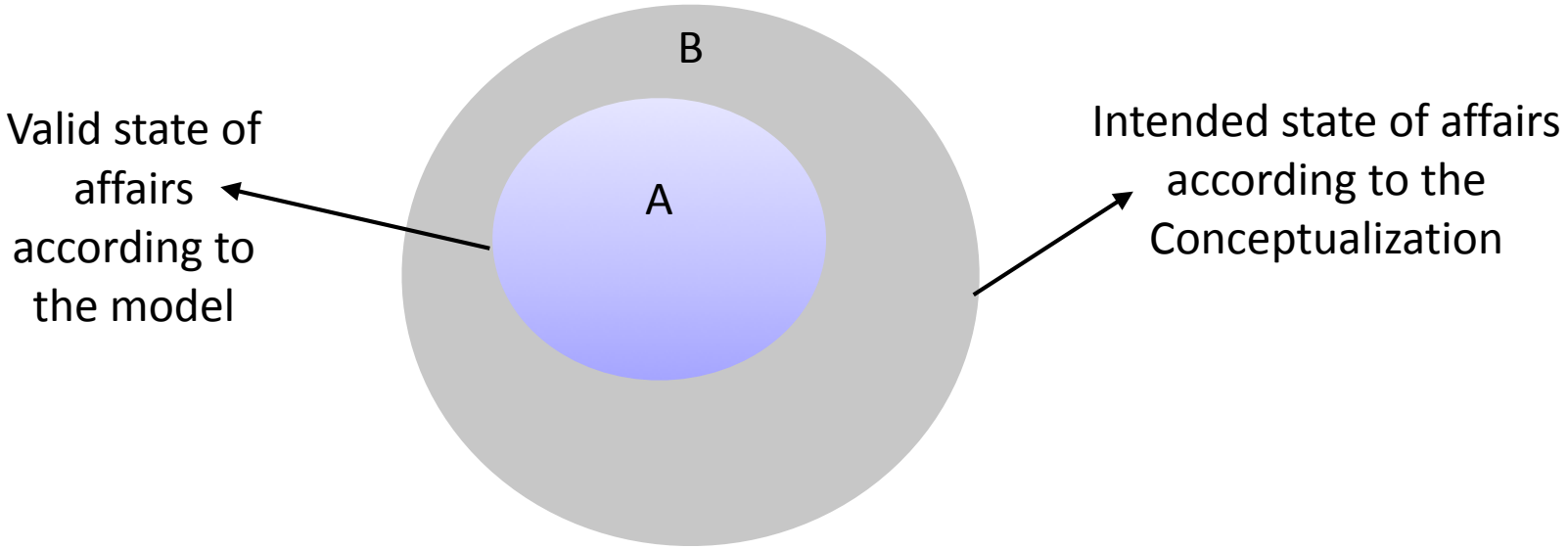
Valid state of affairs
according to the representation



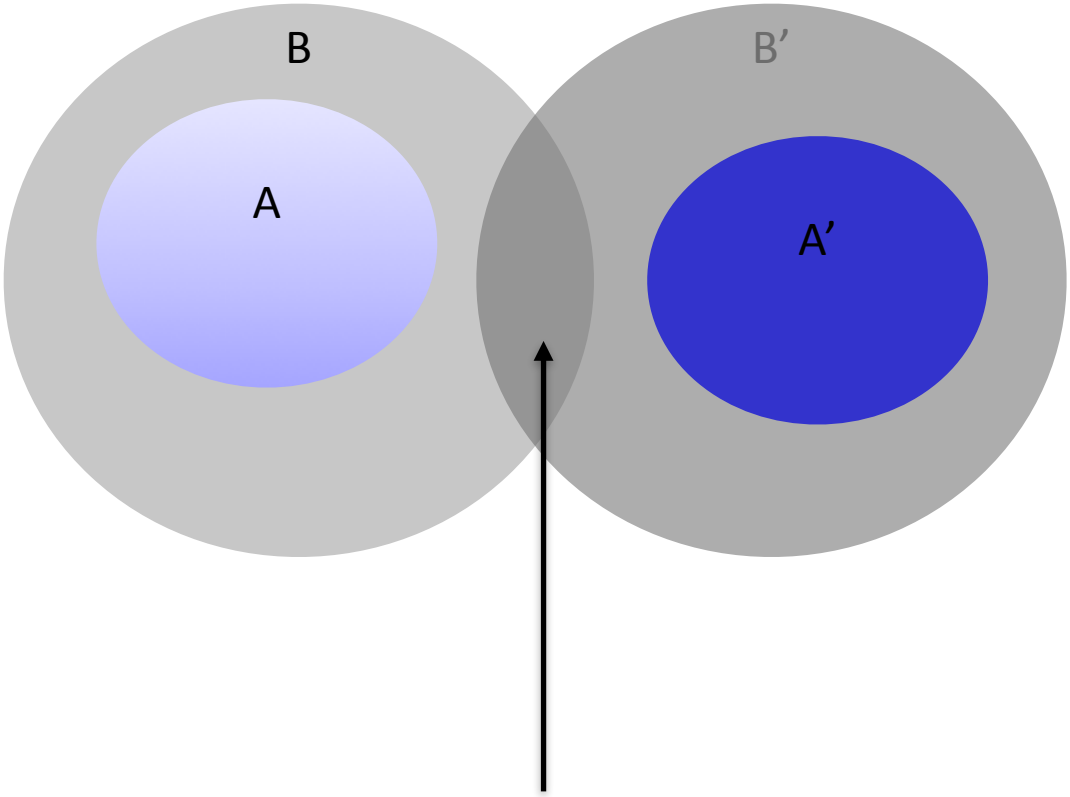
Intended state of affairs
according to the Conceptualization



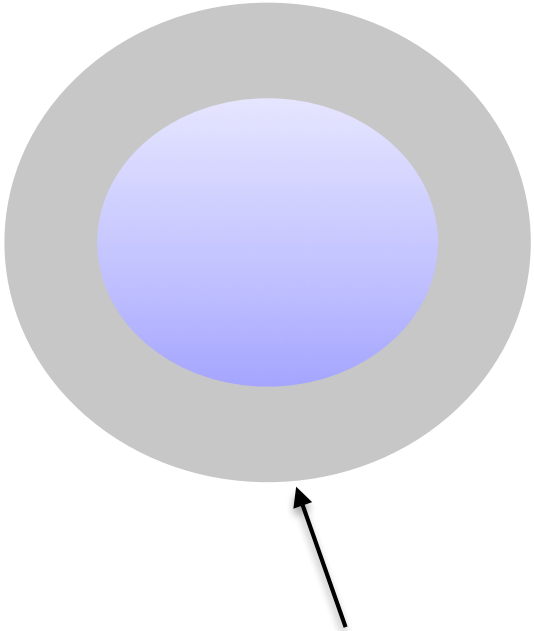
Under-constraining

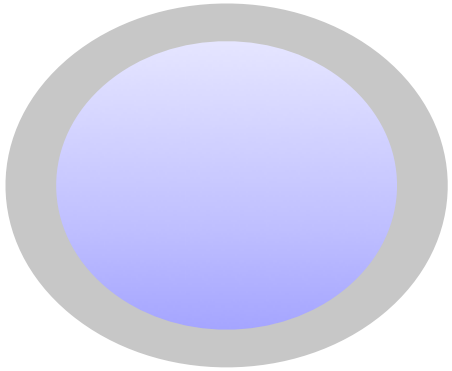


Over-constraining



False Agreement


Constraints



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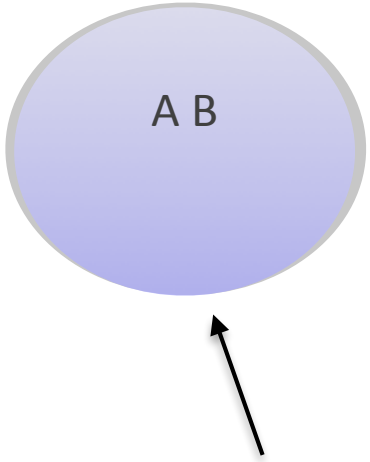
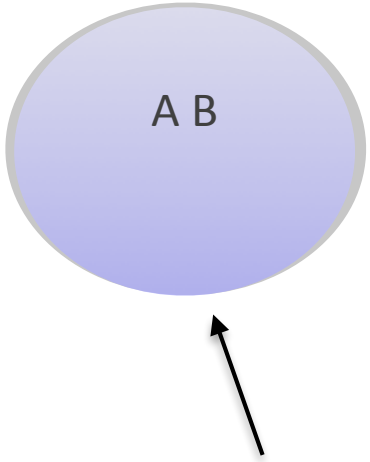
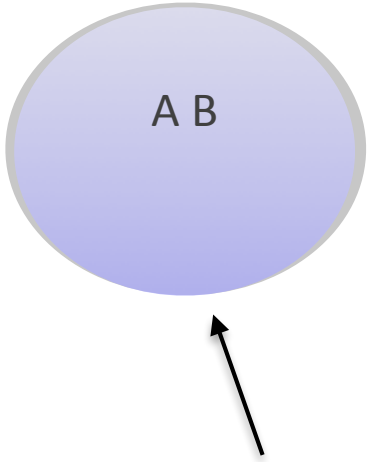


Constraints

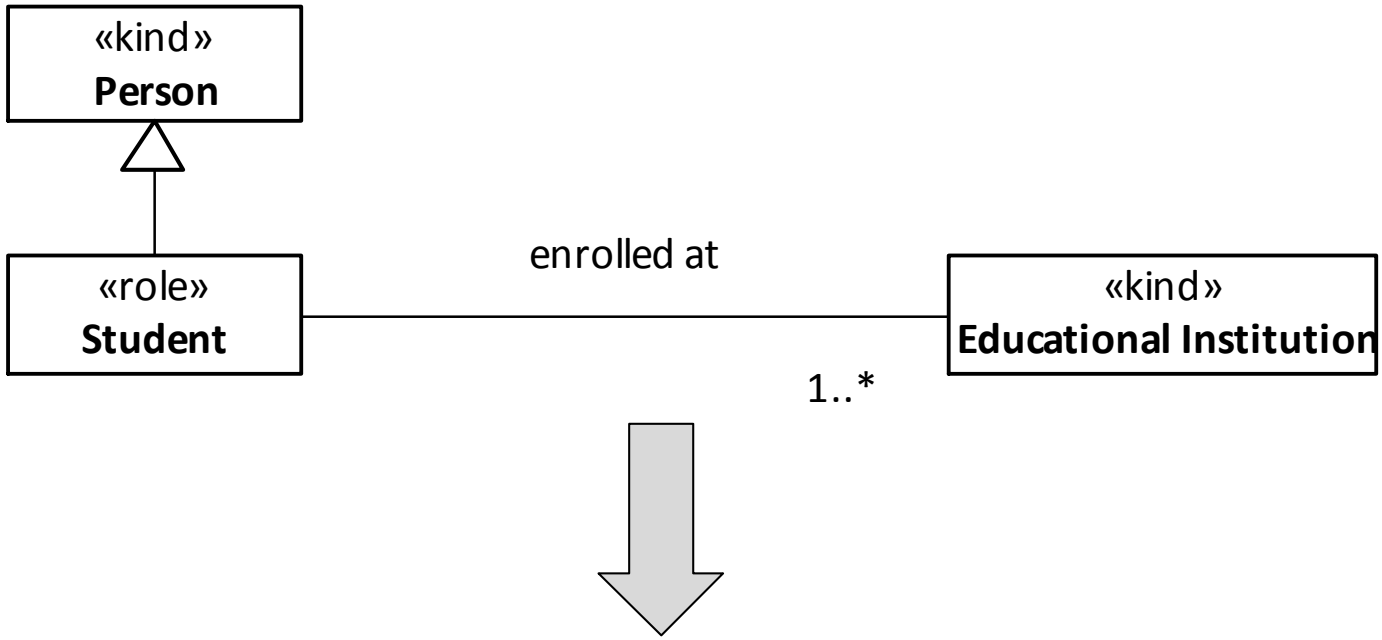


Conceptual Model = Structure + Axiomatization



Conceptual Model = Structure + Axiomatization

(**Ontological Commitment**)



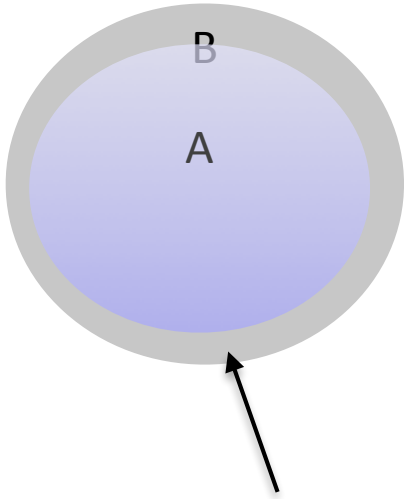
□(∀x Person(x) → □(Person(x)))

□(∀x Student(x) → ◊(¬Student(x)))

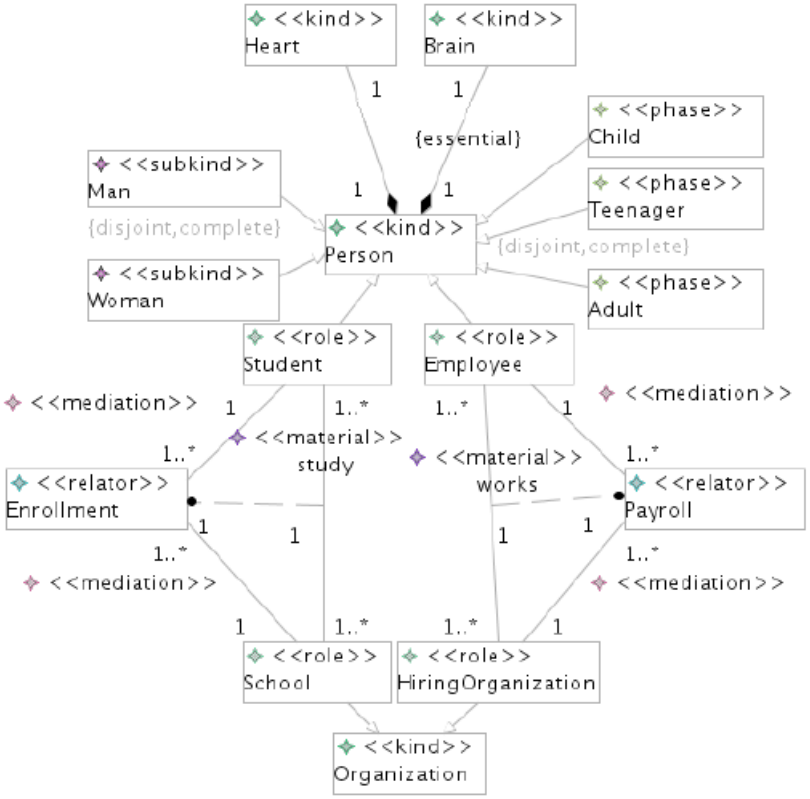
□(∀x Student(x) → Person(x))

□(∀x Student(x) → ∃y Educational Institution(y) ∧ Enrolled-at(x,y))

…



Conceptual Model =
Structure + Domain-Independent Axioms +
Domain-Specific Axioms

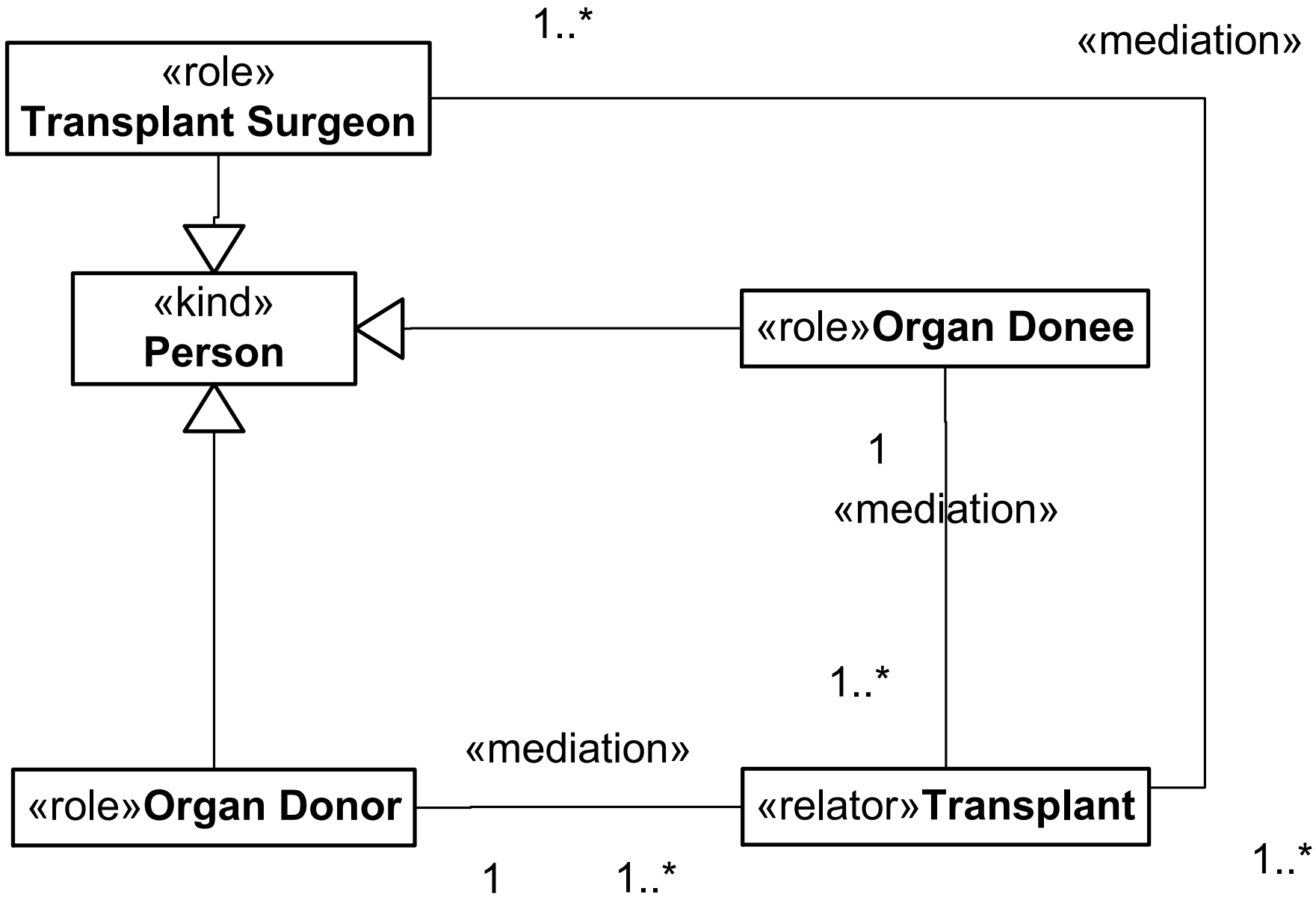


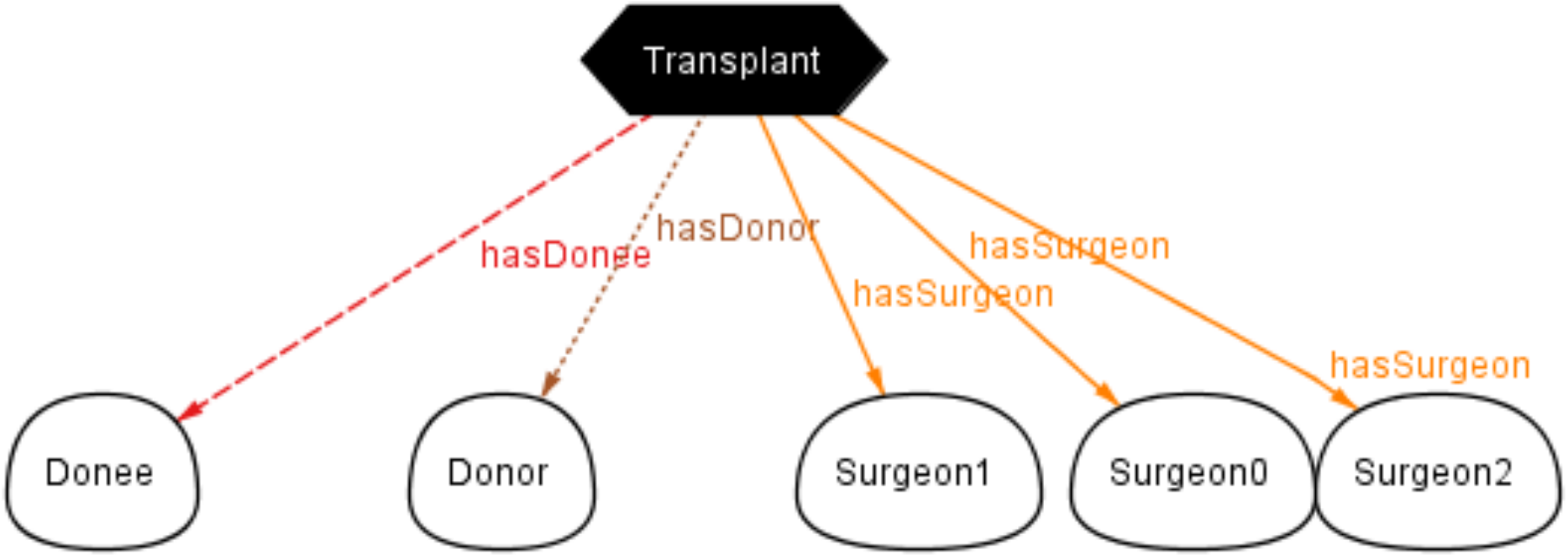
ATL Transformation

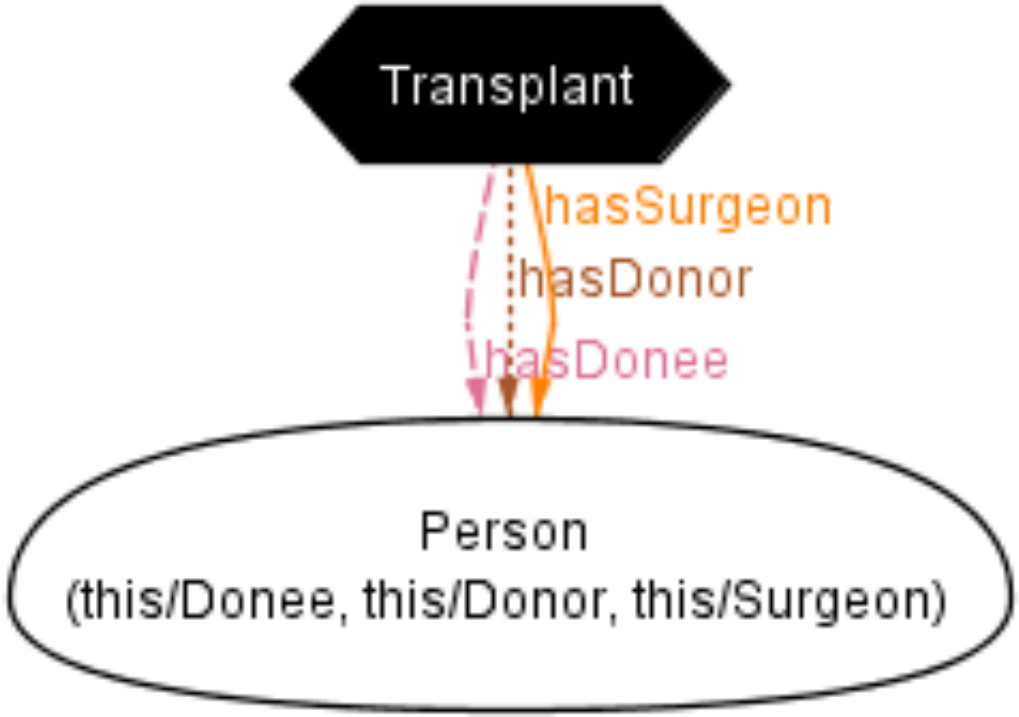
```
1 sig Person_Set in Concept { Person: some World }
2 {
3   Person in existsIn
4   all w1: World | w1 in Person => (all w2:
        w1.access | (w2 in existsIn) => (w2 in
        Person)) -- Rigidity
5   some w: World | w in this.Child -- Phase
6   some w: World | w in this.Teenager -- Phase
7   some w: World | w in this.Adult -- Phase
8   ⋮
9 }
```

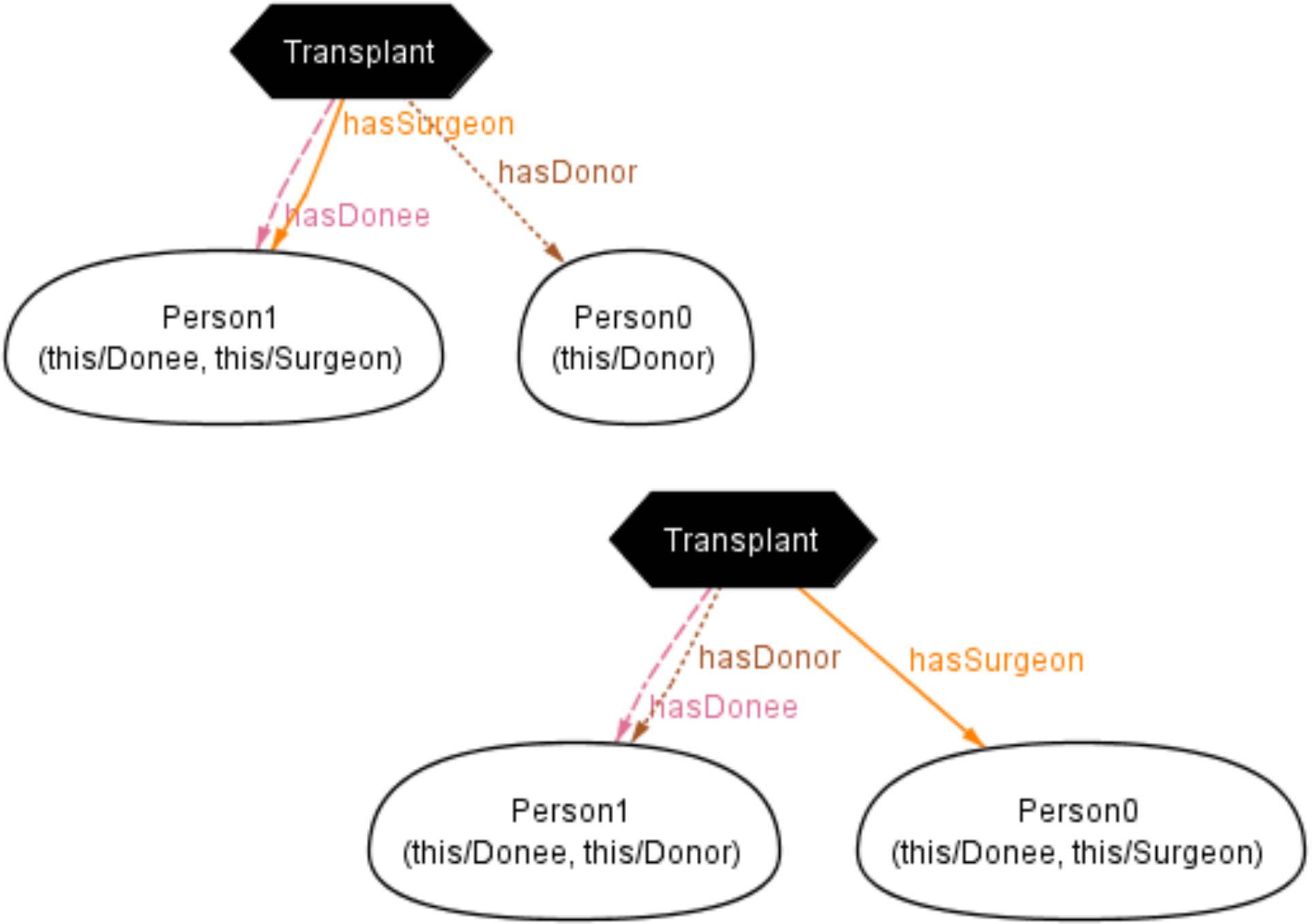
Simulation and Visualization

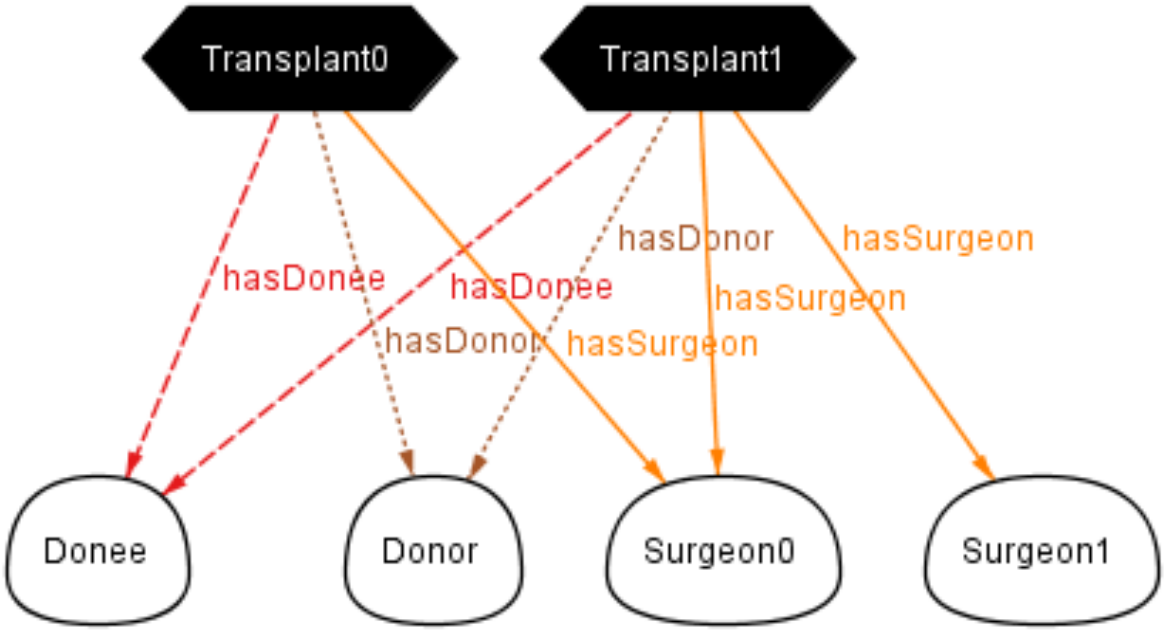
Alloy Analyzer + OntoUML visual Plugin


1..*
«mediation»
«role»
Transplant Surgeon
«kind»
Person
«role»Organ Donee
1
«mediation»
1..*
«mediation»
«role»Organ Donor
«relator»Transplant
1
1..*
1..*

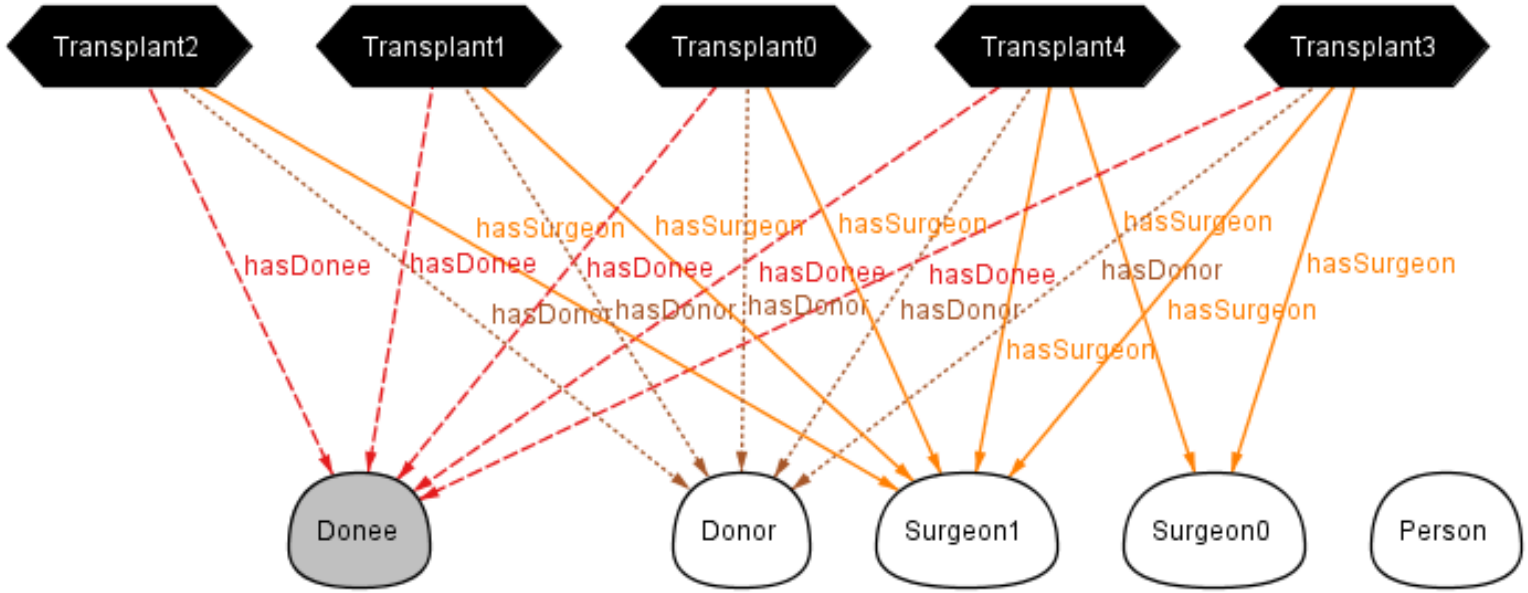

Transplant
hasDonee
hasDonor
hasSurgeon
hasSurgeon
hasSurgeon
Donee
Donor
Surgeon1
Surgeon0
Surgeon2


Transplant
hasSurgeon
hasDonor
hasDonee
Person
(this/Donee, this/Donor, this/Surgeon)


Transplant
hasSurgeon
hasDonor
hasDonee
Person1
(this/Donee, this/Surgeon)
Person0
(this/Donor)
Transplant
hasDonor
hasSurgeon
hasDonee
Person1
(this/Donee, this/Donor)
Person0
(this/Donee, this/Surgeon)



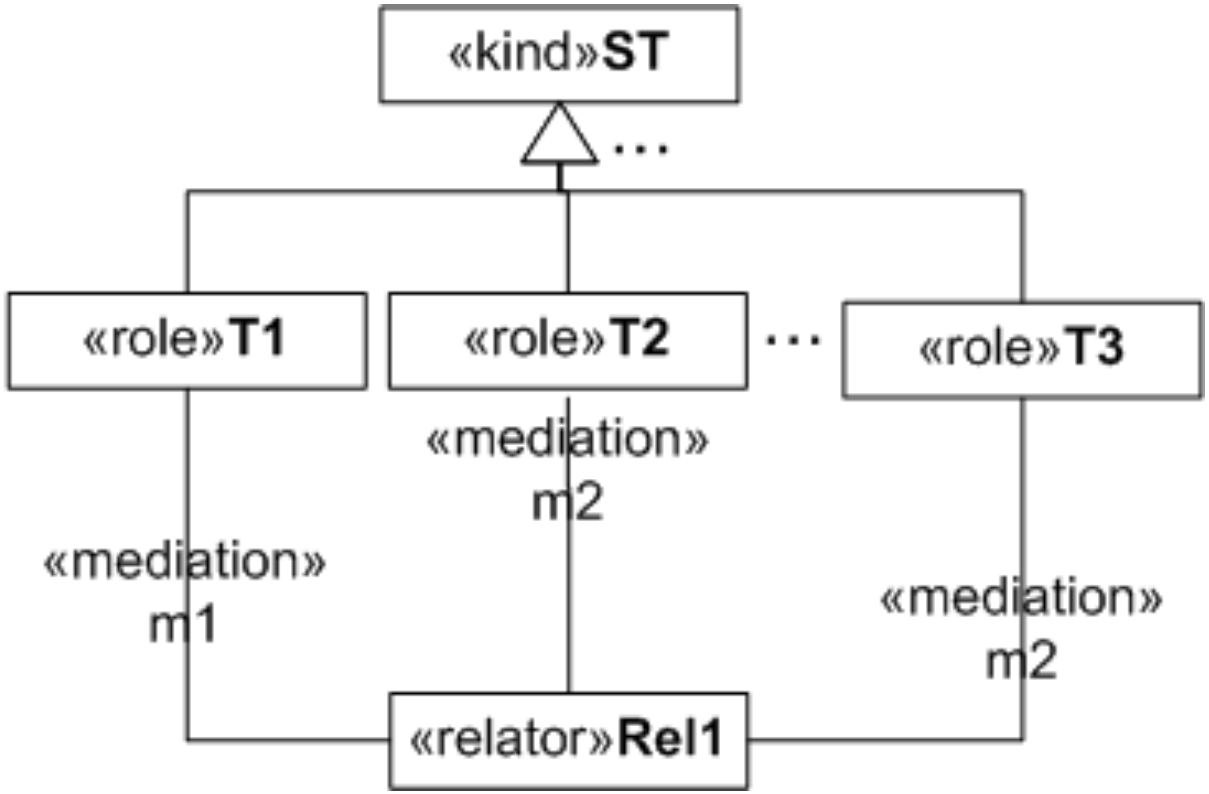
Real-Word Semantics



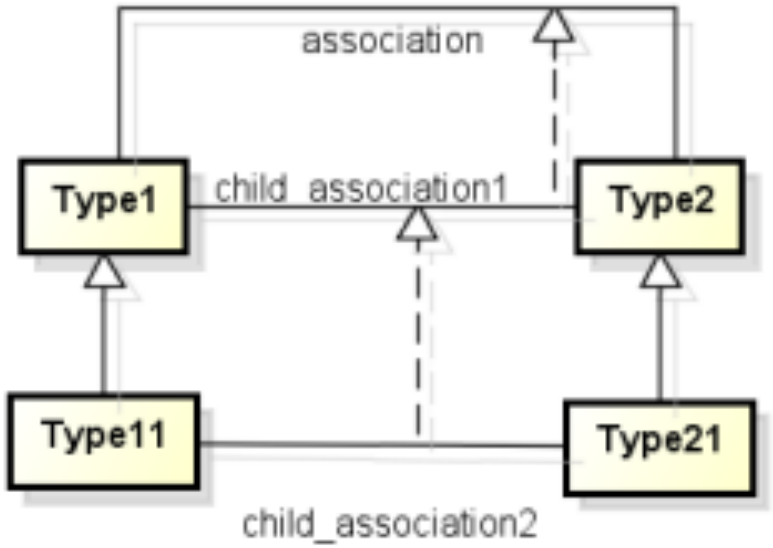
OntoUML Model Benchmark

- Model benchmark with 56 models
- Models in domains such as Provenance in Scientific Workflow, Public Cloud Vulnerability, Software Configuration Management, Emergency Management, Services, IT Governance, Organizational Structures, Software Requirements, Heart Electrophisiology, Amazonian Biodiversity Management, Human Genome, Optical Transport Networks, Federal Government Organizational Structures, Normative Acts, and Ground Transportation Regulation

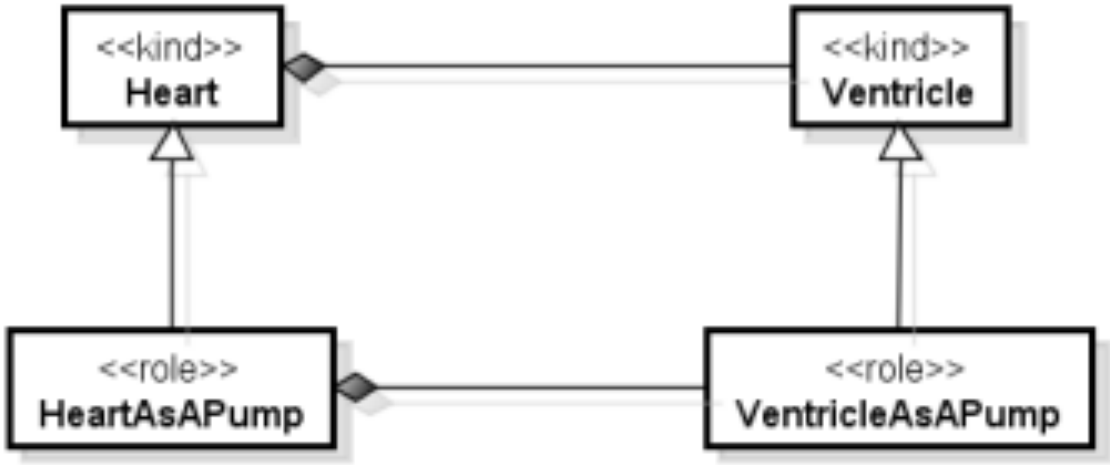
The Emerging Anti-Pattern: Relation Between Overlapping Types (**RelOver**)



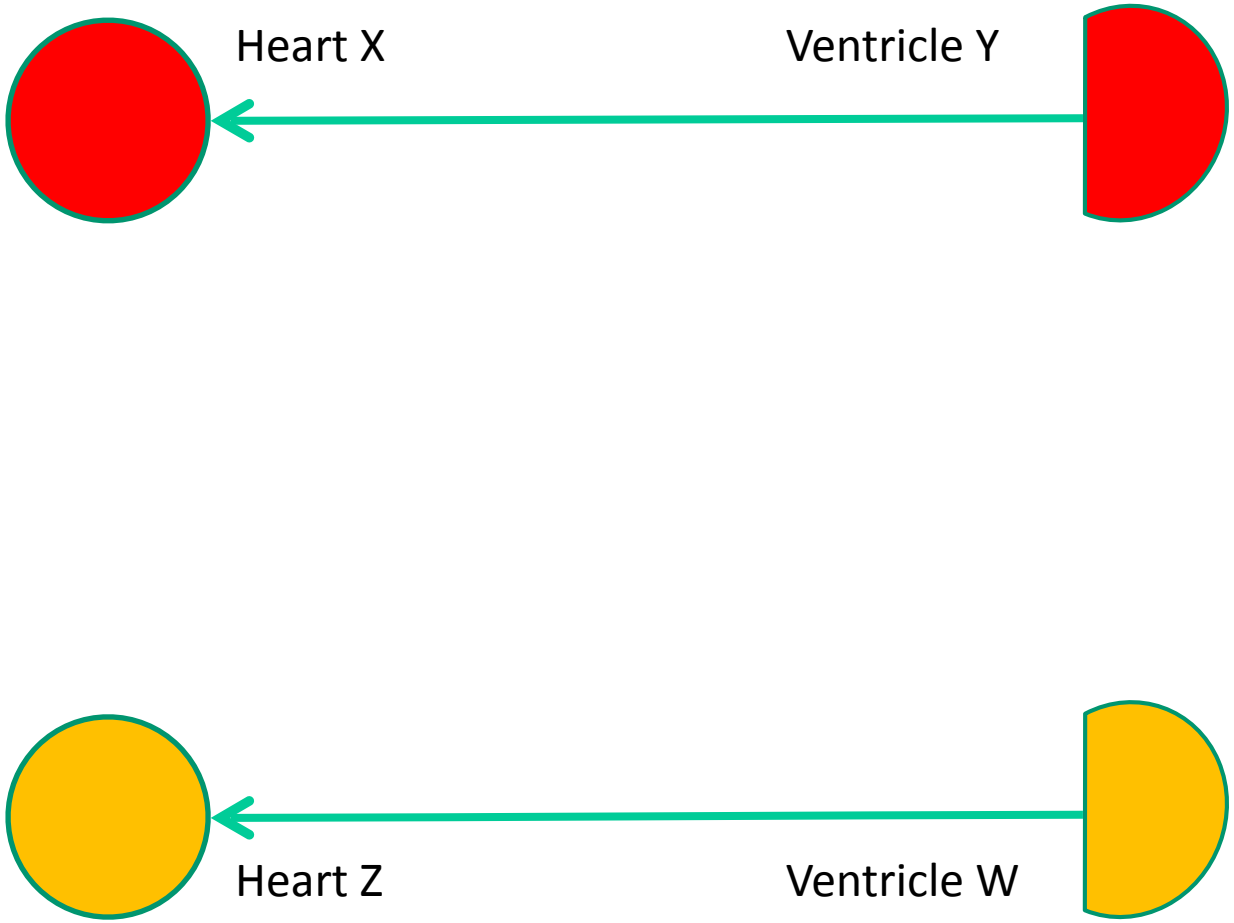
The Emerging Anti-Pattern: Relation Specialization (**RelSpec**)

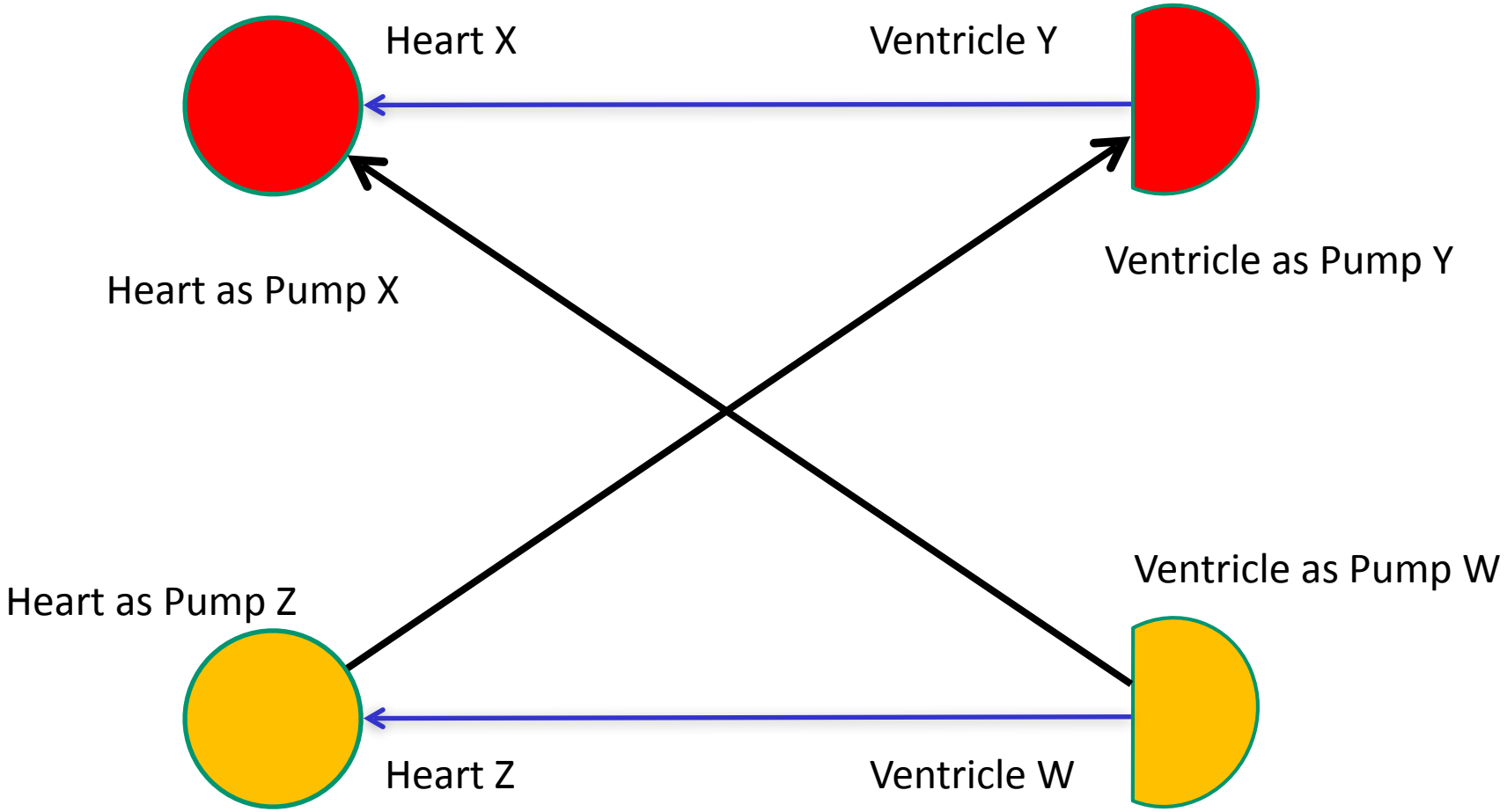


(a)



(b)


Heart X
Ventricle Y
Heart Z
Ventricle W


Heart X
Ventricle Y
Heart as Pump X
Ventricle as Pump Y
Heart as Pump Z
Ventricle as Pump W
Heart Z
Ventricle W

Anti-Pattern Catalogue

- Association Cycle
- Binary Relation Between Over. Types
- Deceiving Intersection
- Free Role Specialization
- Imprecise Abstraction
- Multiple Relational Dependency
- Part Composing Over. Roles
- Whole Composed by Over. Parts
- Relator Mediating Over. Types
- Relation Composition
- Relator Mediating Rigid Types
- Relation Specialization
- Repeatable Relator Instances
- Relationally Dependent Phase
- Generalization Set With Mixed Rigidity
- Heterogeneous Collective
- Homogeneous Functional Complex
- Mixin With Same Identity
- Mixin With Same Rigidity
- Undefined Formal Association
- Undefined Phase Partition

Anti-Patterns (AP)	AP Occurrences	Relevant Model Construct (RMC)	RMC /AP Ratio	% of Qualified Models with AP Occurrence
RelSpec	817	Association	4.92	48.15%
ImpAbs	758	Association	5.30	72.22%
AssCyc	1809	Association	2.22	92.59%
RelOver	149	Relator	8.08	25%
RepRel	319	Relator	3.77	64.58%
BinOver	224	Association	17.93	48.15%

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Anti-Pattern	#Occ.	#Error	#Error / #Occ.	#Refac. /#Error
RelSpec	315	279	88.6%	97.1%
RepRel	221	57	25.8%	84.2%
RelOver	124	70	56.5%	77.1%
BinOver	74	31	41.9%	74.2%
AssCyc	20	14	70.0%	71.4%
ImpAbs	125	11	8.8%	27.3%
Total	879	462	52.56%	88.53%

Anti-Pattern	#Occ.	#Error	#Error / #Occ.	#Refac. /#Error
RelSpec	315	279	88.6%	97.1%
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RelOver	124	70	56.5%	77.1%
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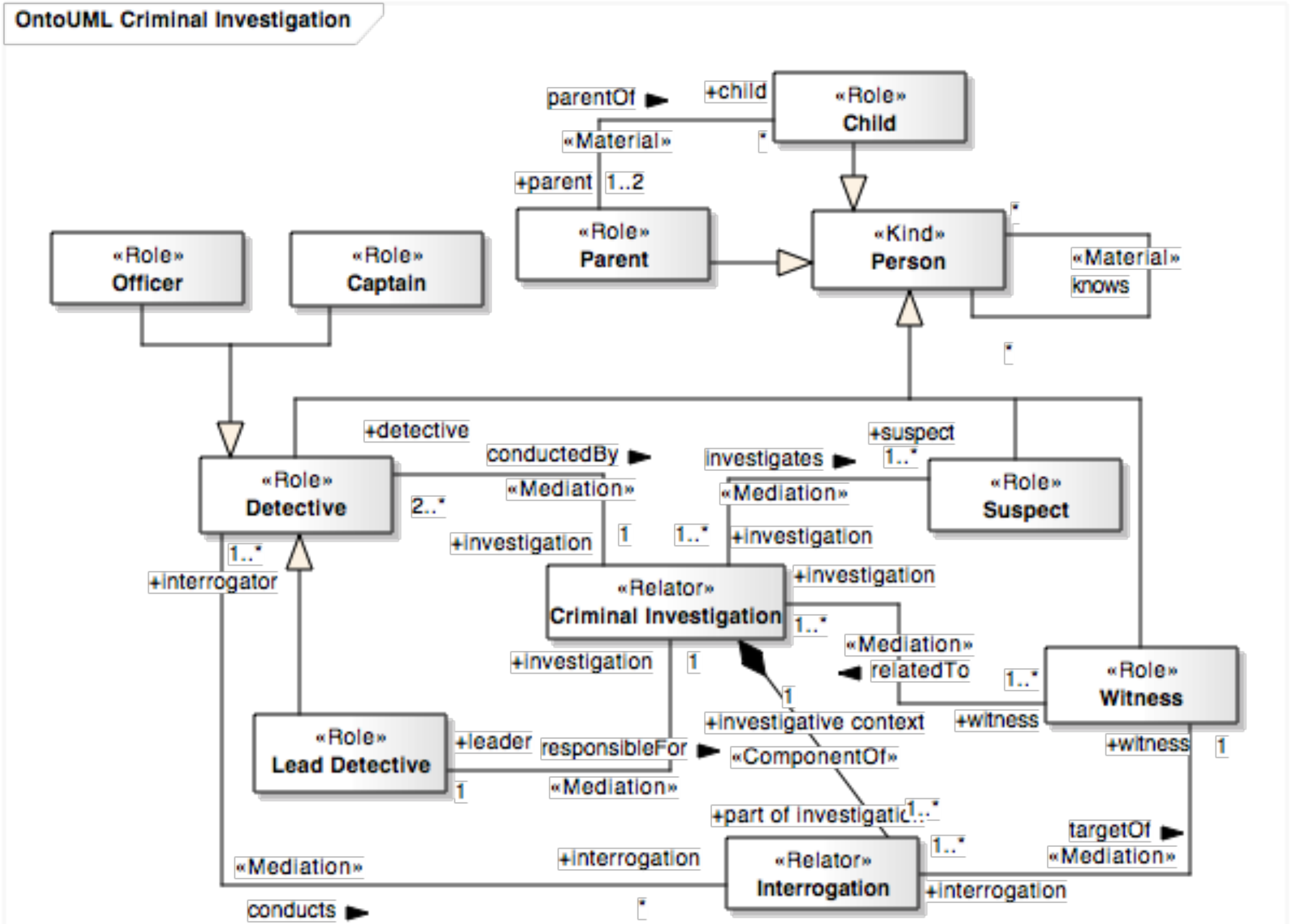
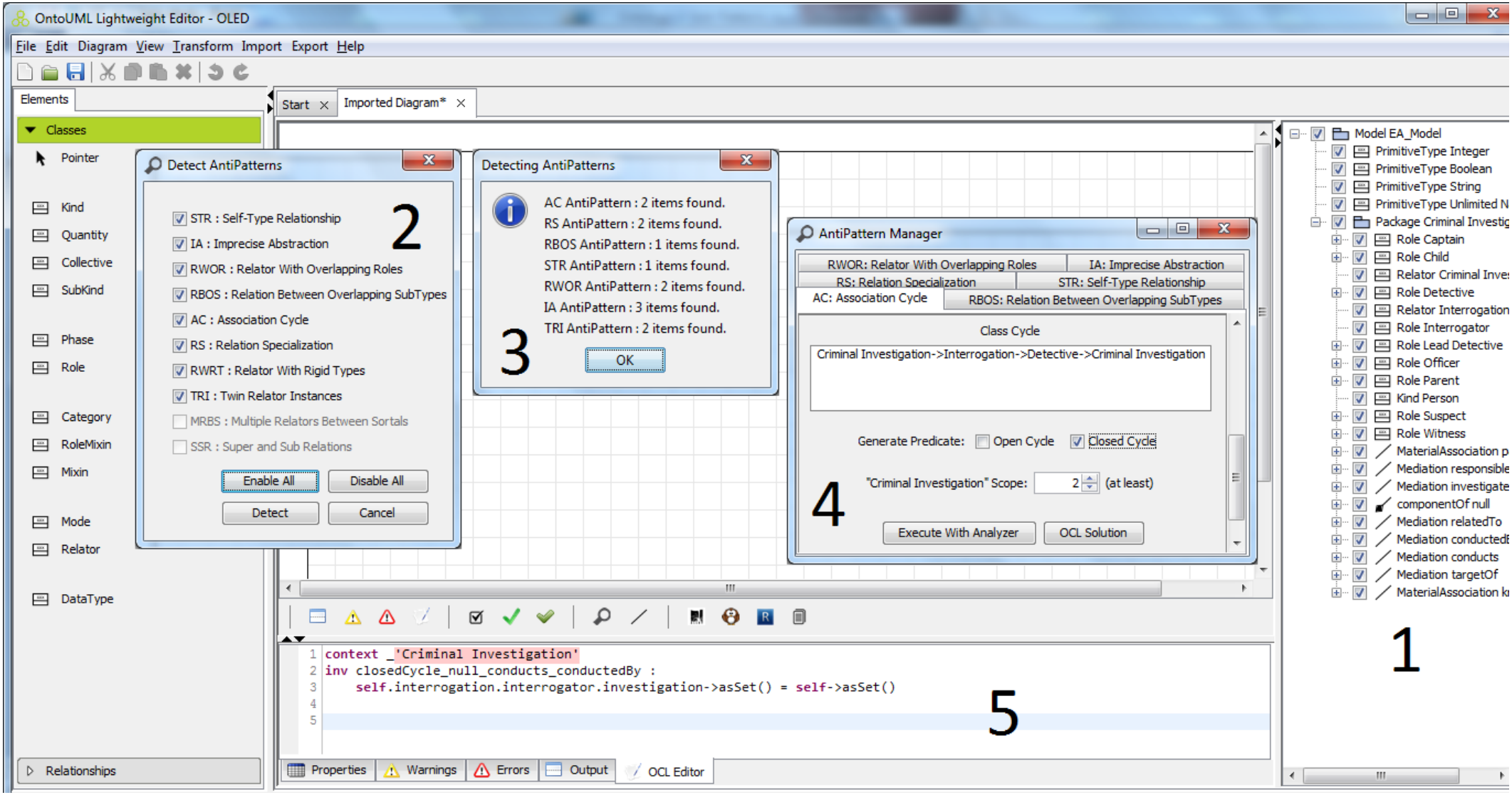
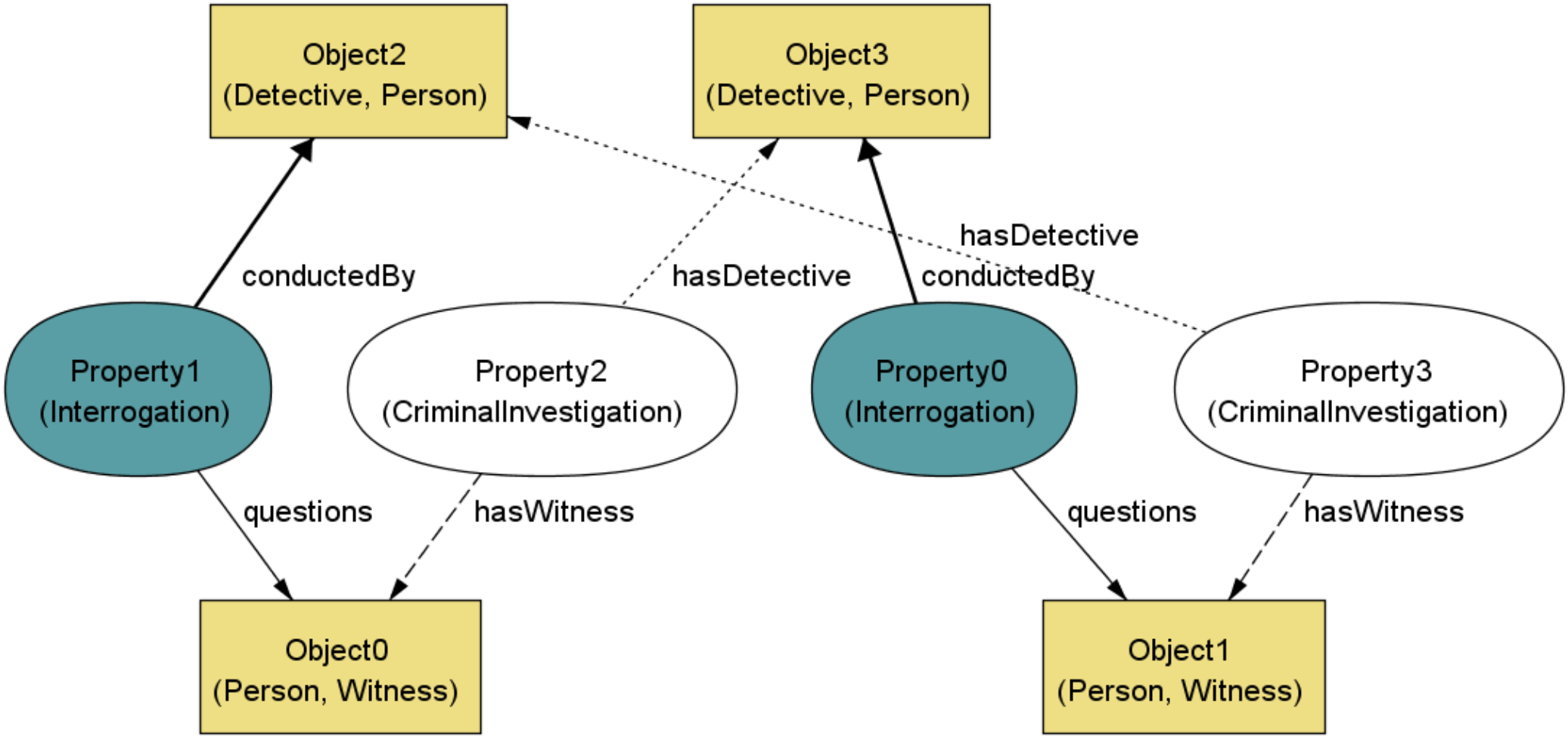
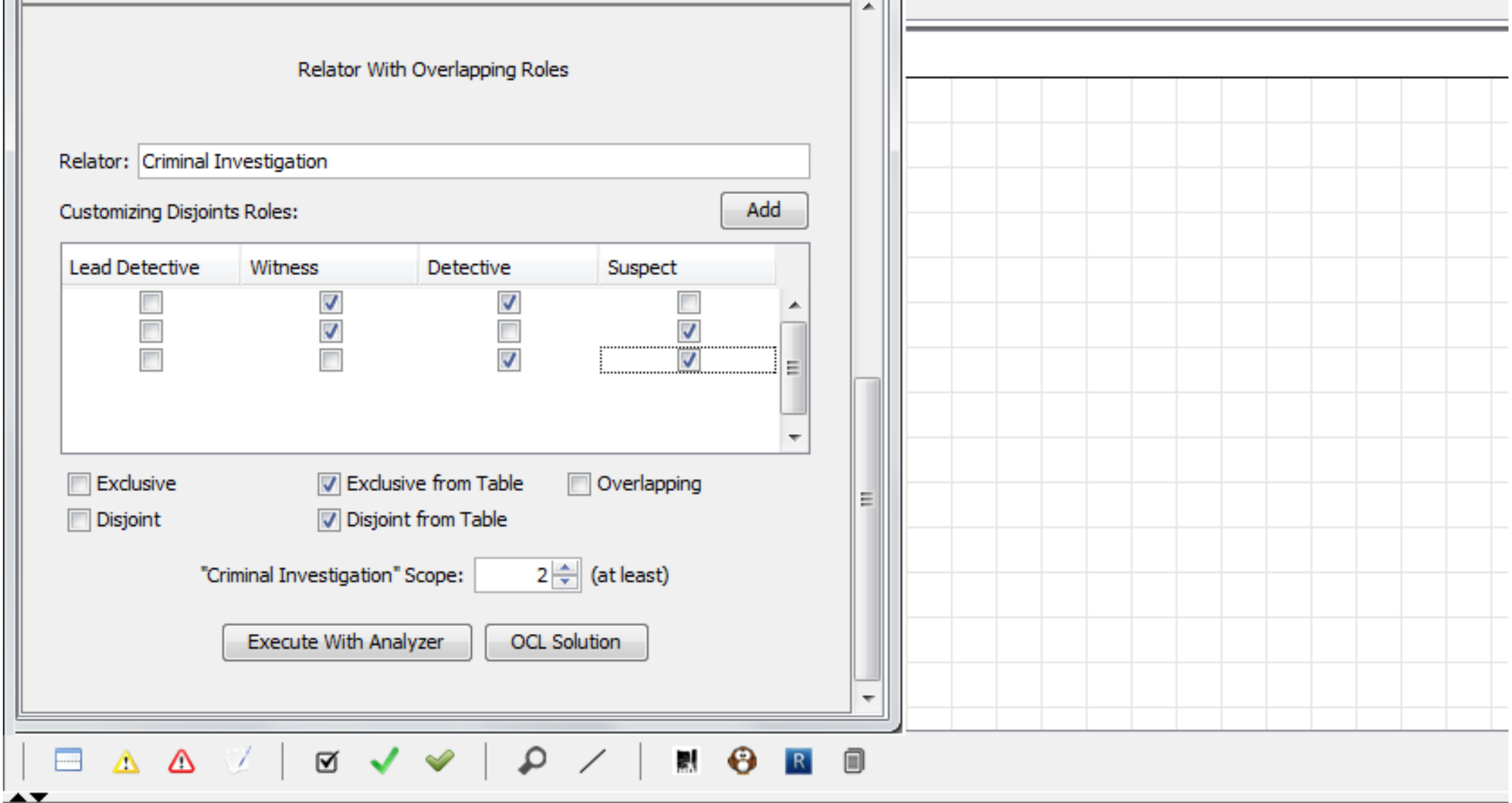

OntoUML Criminal Investigation
parentOf
+child
«Role»
Child
«Material»
*
+parent
1..2
«Role»
Parent
«Kind»
Person
*
«Material»
knows
*
«Role»
Officer
«Role»
Captain
+detective
conductedBy
investigates
+suspect
1..*
«Role»
Detective
«Mediation»
«Mediation»
«Role»
Suspect
2..*
+investigation
1
1..*
+investigation
1..*
+interrogator
«Relator»
Criminal Investigation
+investigation
1..*
«Mediation»
relatedTo
+investigation
1
1..*
«Role»
Witness
+investigative context
+witness
«Role»
Lead Detective
+leader
responsibleFor
«ComponentOf»
+witness
1
1
«Mediation»
+part of investigatic...
1..*
targetOf
1..*
«Mediation»
+interrogation
«Relator»
Interrogation
«Mediation»
+interrogation
conducts
*


OntoUML Lightweight Editor - OLED
File Edit Diagram View Transform Import Export Help
Elements
Classes
Pointer
Kind
Quantity
Collective
SubKind
Phase
Role
Category
RoleMixin
Mixin
Mode
Relator
DataType
Relationships
Start
Imported Diagram*
Detect AntiPatterns
STR : Self-Type Relationship
IA : Imprecise Abstraction
RWOR : Relator With Overlapping Roles
RBOS : Relation Between Overlapping SubTypes
AC : Association Cycle
RS : Relation Specialization
RWRT : Relator With Rigid Types
TRI : Twin Relator Instances
MRBS : Multiple Relators Between Sortals
SSR : Super and Sub Relations
Enable All
Disable All
Detect
Cancel
2
Detecting AntiPatterns
AC AntiPattern : 2 items found.
RS AntiPattern : 2 items found.
RBOS AntiPattern : 1 items found.
STR AntiPattern : 1 items found.
RWOR AntiPattern : 2 items found.
IA AntiPattern : 3 items found.
TRI AntiPattern : 2 items found.
OK
3
AntiPattern Manager
RWOR: Relator With Overlapping Roles
IA: Imprecise Abstraction
RS: Relation Specialization
STR: Self-Type Relationship
AC: Association Cycle
RBOS: Relation Between Overlapping SubTypes
Class Cycle
Criminal Investigation->Interrogation->Detective->Criminal Investigation
Generate Predicate:
Open Cycle
Closed Cycle
"Criminal Investigation" Scope:
2
(at least)
Execute With Analyzer
OCL Solution
4
context _'Criminal Investigation'
inv closedCycle_null_conducts_conductedBy :
self.interrogation.interrogator.investigation->asSet() = self->asSet()
5
Properties
Warnings
Errors
Output
OCL Editor
Model EA_Model
PrimitiveType Integer
PrimitiveType Boolean
PrimitiveType String
PrimitiveType Unlimited N
Package Criminal Investig
Role Captain
Role Child
Relator Criminal Inves
Role Detective
Relator Interrogation
Role Interrogator
Role Lead Detective
Role Officer
Role Parent
Kind Person
Role Suspect
Role Witness
MaterialAssociation p
Mediation responsible
Mediation investigate
componentOf null
Mediation relatedTo
Mediation conducted
Mediation conducts
Mediation targetOf
MaterialAssociation k
1


Object2
(Detective, Person)
Object3
(Detective, Person)
conductedBy
hasDetective
hasDetective
conductedBy
Property1
(Interrogation)
Property2
(CriminalInvestigation)
Property0
(Interrogation)
Property3
(CriminalInvestigation)
questions
hasWitness
questions
hasWitness
Object0
(Person, Witness)
Object1
(Person, Witness)




```
1  context _'Criminal Investigation'
2  inv: self.witness.oclAsType(Person)->asSet()->intersection(self.detective.oclAsType(Person)->asSet())->size()=0
3
4  context _'Criminal Investigation'
5  inv: self.witness.oclAsType(Person)->asSet()->intersection(self.suspect.oclAsType(Person)->asSet())->size()=0
6
7  context _'Detective'
8  inv: not self.oclIsTypeOf(Suspect)
9
```

Properties | Warnings | Errors | Output | OCL Editor

"Few modelers, however,
have had the experience of subjecting
their models to continual, automatic review.
Building a model incrementally with an analyzer,
simulating and checking as you go along, is a very
different experience from using pencil and paper alone.
The first reaction tends to be amazement: modeling is
much more fun when you get instant, **visual feedback**.
Then the sense of **humiliation** sets in, as you discover
that **there's almost nothing you can do right**."

(Daniel Jackson, Software Abstractions : Logic,
Language, and Analysis, 2006)

The Humble **Modeler**

[What] I have chosen to stress in this talk is the following. We shall do a much better modeling job in the future, provided that we approach the task with a full appreciation of its tremendous complexity,…,provided we respect the intrinsic limitations of the human mind and approach the task a Very Humble Modelers

(paraphrasing Dijkstra's Humble Programmer, 1972)

For a primer into UFO and OntoUML…

- GUIZZARDI, G., Ontological Patterns, Anti-Patterns and Pattern Languages for Next-Generation Conceptual Modeling, 33rd International Conference on Conceptual Modeling (ER 2014), Atlanta, USA.

- GUIZZARDI, G., WAGNER, G., ALMEIDA, J.P.A., GUIZZARDI, R.S.S., Towards Ontological Foundations for Conceptual Modeling: The Unified Foundational Ontology (UFO) Story, Applied Ontology, IOS Press, 2015.

gguizzardi@unibz.it