Formal Ontology, Patterns and Anti-Patterns for Next-Generation Conceptual Modeling

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*"**Conceptual Modeling** is the activity of describing aspects of the physical and social world for the purpose of **understanding and communication**… the adequacy of a conceptual modeling notation rests in its ability to **promote understanding about a shared reality among its human users**"*

(John Mylopoulos, Conceptual Modeling and Telos,1992)

The **Taxonomy** of Animals in *The Celestial Emporium of Benevolent Knowledge (Borges)*

- Those that belong to the emperor
- Those that resemble flies from a distance
- Those that have just broken a flower vase
- Embalmed ones
- Fabulous ones

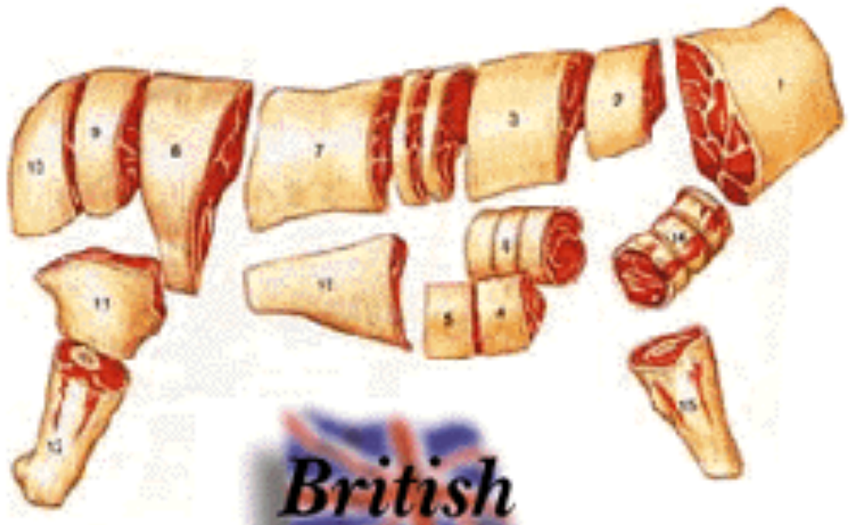
“Those that resemble flies from a distance” is a logically possible way to group objects, but it’s not how we naturally make sense of the world. No real language would have a noun for such a category…Real nouns capture something deep; they refer to **kinds** of things that are thought to share deep properties…”

(Paul Bloom, How Pleasure Works, 2010)

"...As the evolutionary theorist Stephen Jay Gould put it, our classifications don't just exist to avoid chaos, they are ***"theories about the basis of natural order."***

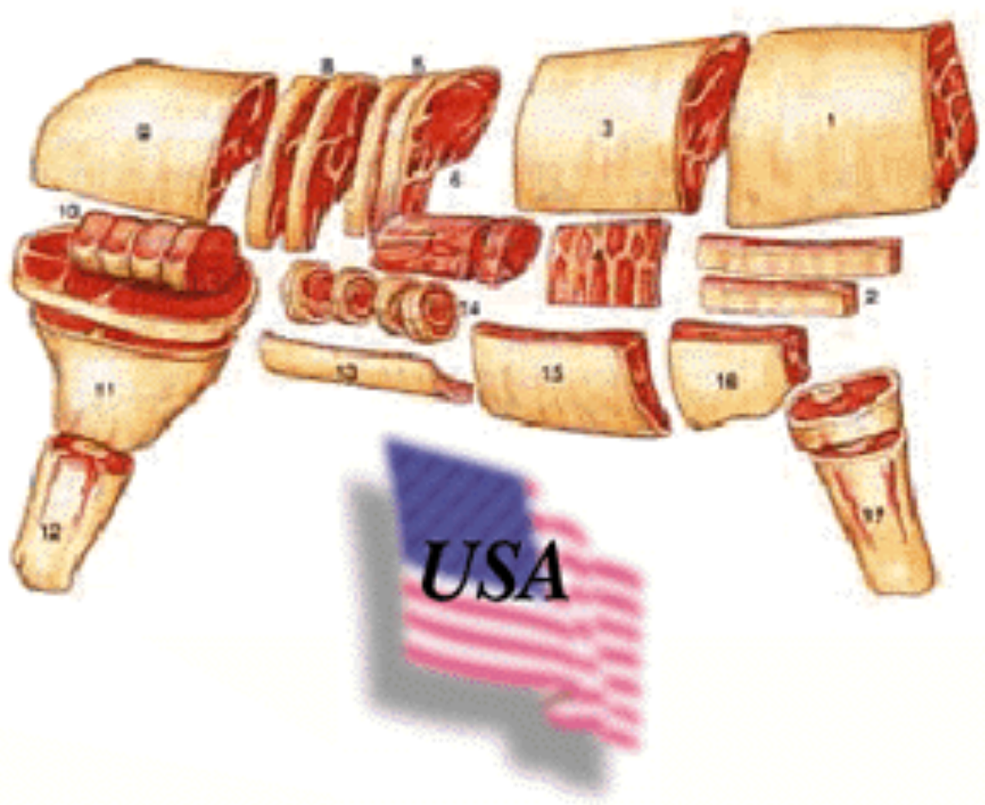
(Paul Bloom, How Pleasure Works, 2010)

Carving reality at its joints [Plato]:



British

French



USA

CTSciNet
Clinical and Translational Science Network

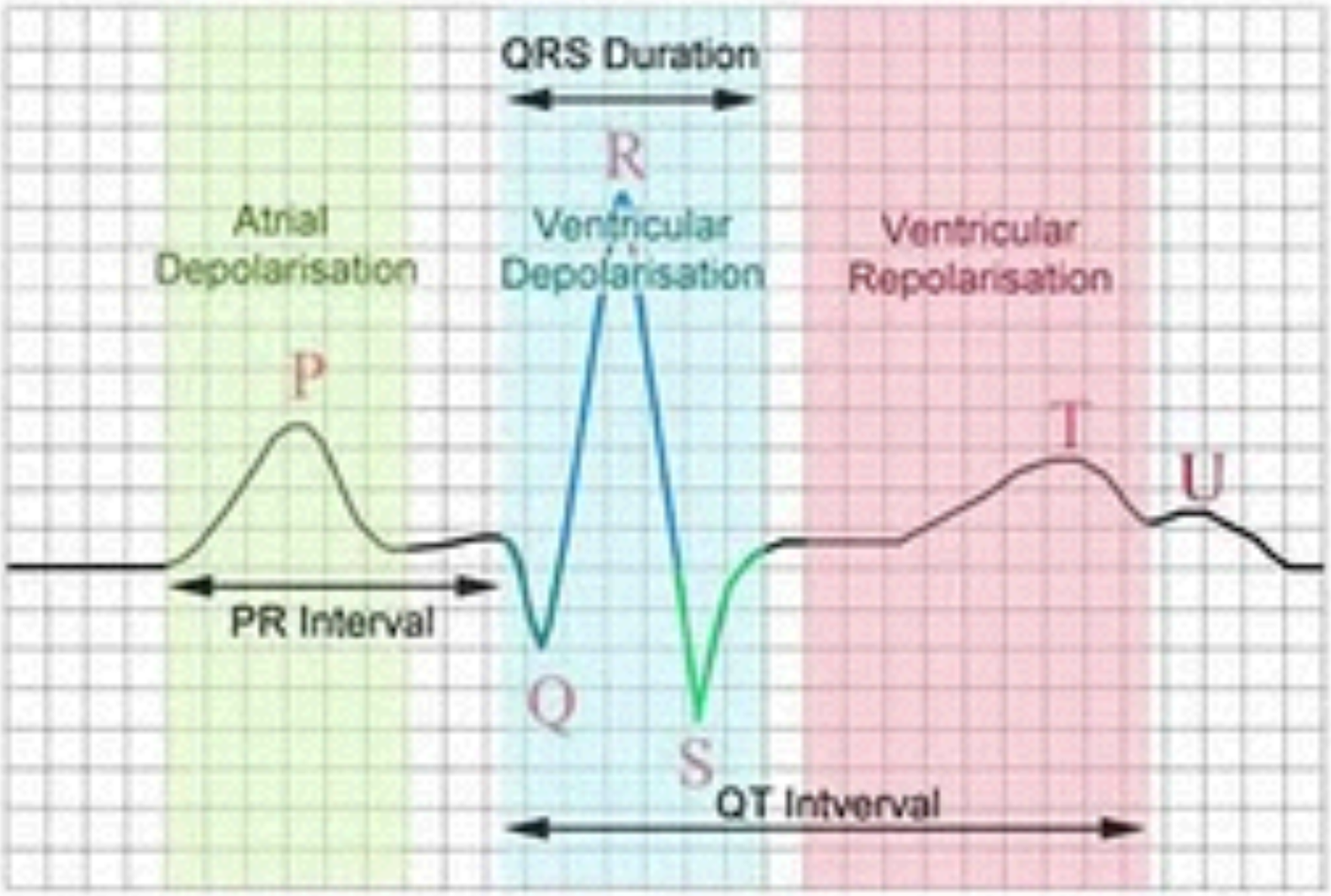
CTSciNet

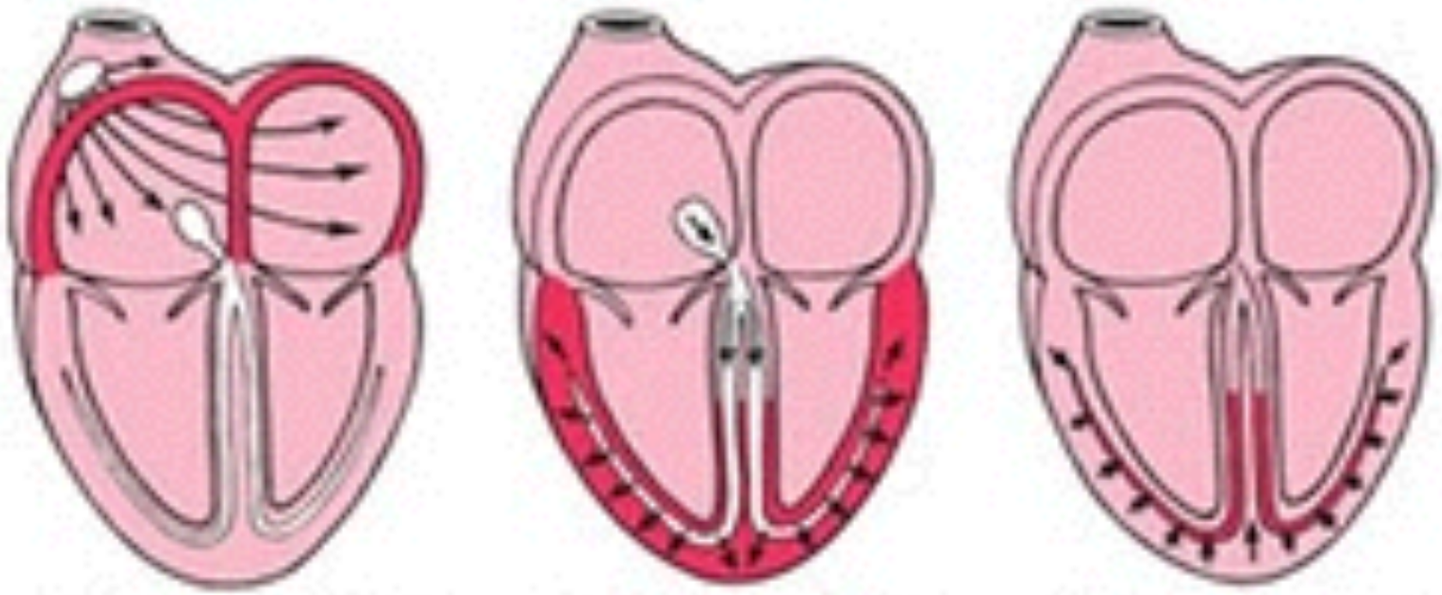
More Than Words

By Chelsea Wald
February 11, 2011

Most biomedical research laboratories make up their own private language to describe their particular techniques, materials, and measurements. Even medical practitioners have more than a hundred ways to describe a simple fact such as a patient's blood glucose. Talking to other scientists about data

"It's getting to be impossible to do work in bioinformatics without knowledge of biomedical ontology." -- Mark Musen



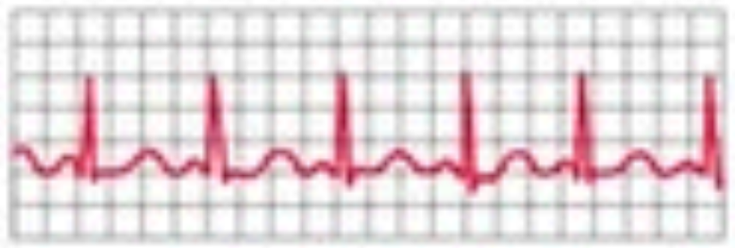


Activation of the atria

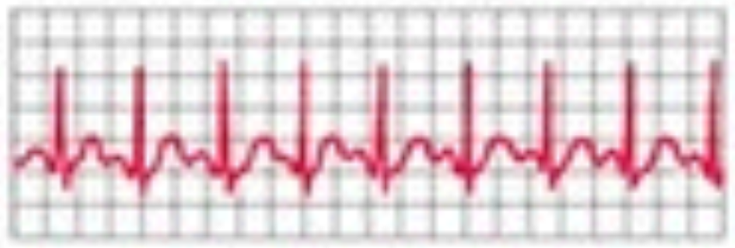
Activation of the ventricles

Recovery wave

Normal Heartbeat



Fast Heartbeat



Slow Heartbeat

Irregular Heartbeat

“Carving up Reality”

We need to guarantee

Intra-worldview Consistency

and

Inter-worldview Interoperability

Ontology

- 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

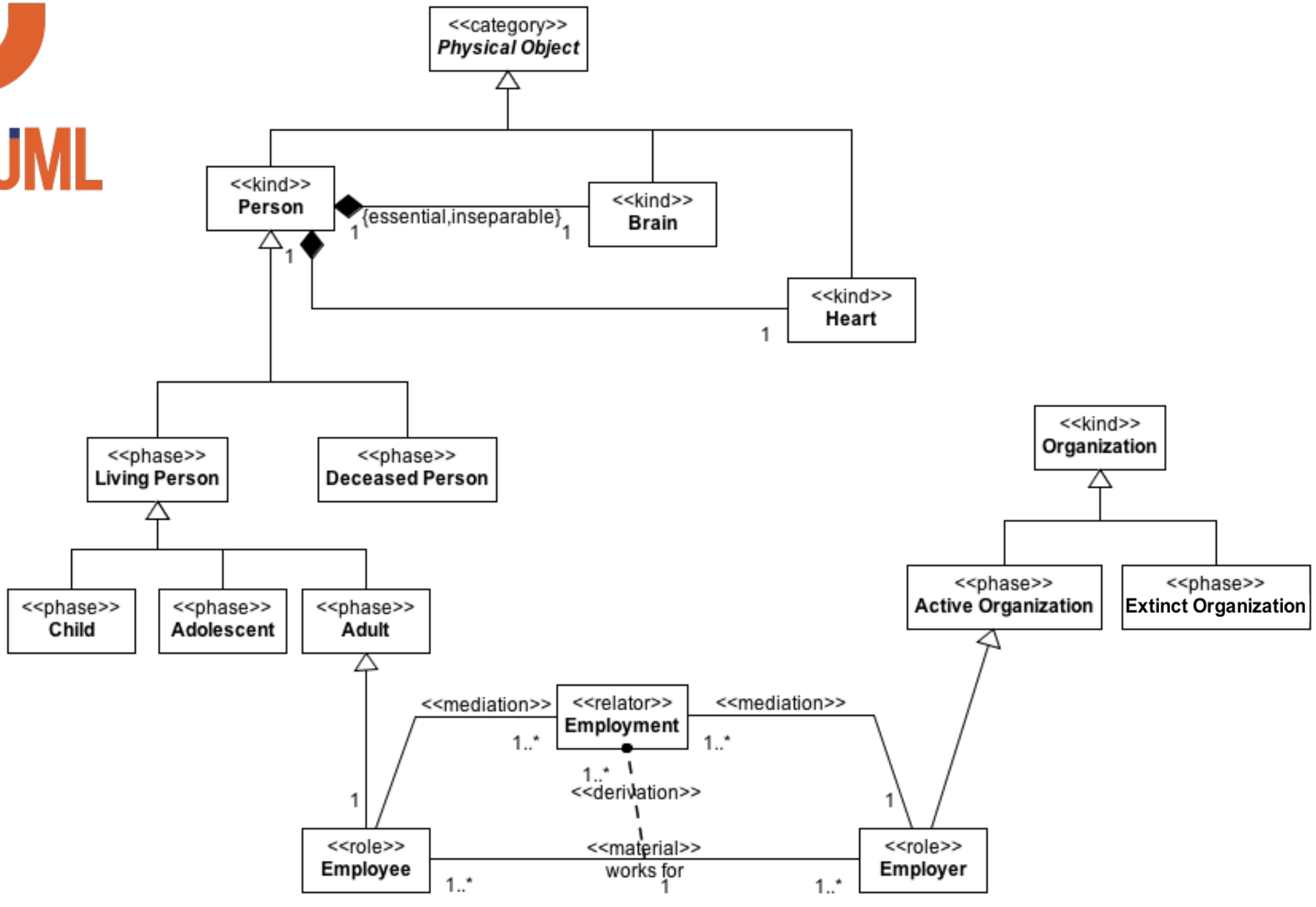
A discipline aiming at developing ontology-based methodologies, computational tools and **modeling languages** for the area of Conceptual Modeling

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 and Taxonomic Structures (CAISE 2004, CAISE 2007, CAISE 2012), Part-Whole Relations (CAISE 2007, CAISE 2009, FOIS2010, CAISE 2011), Intrinsic and Relational Properties (ER 2006, ER 2008, ER 2011, CAISE 2015), Weak Entities, Attributes and Datatypes (ER 2006), Events (ER 2013), Services (EDOC 2013), Capabilities (EDOC 2013), Goals, Communities, Organizational Structures, etc…

ONTOUML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works for
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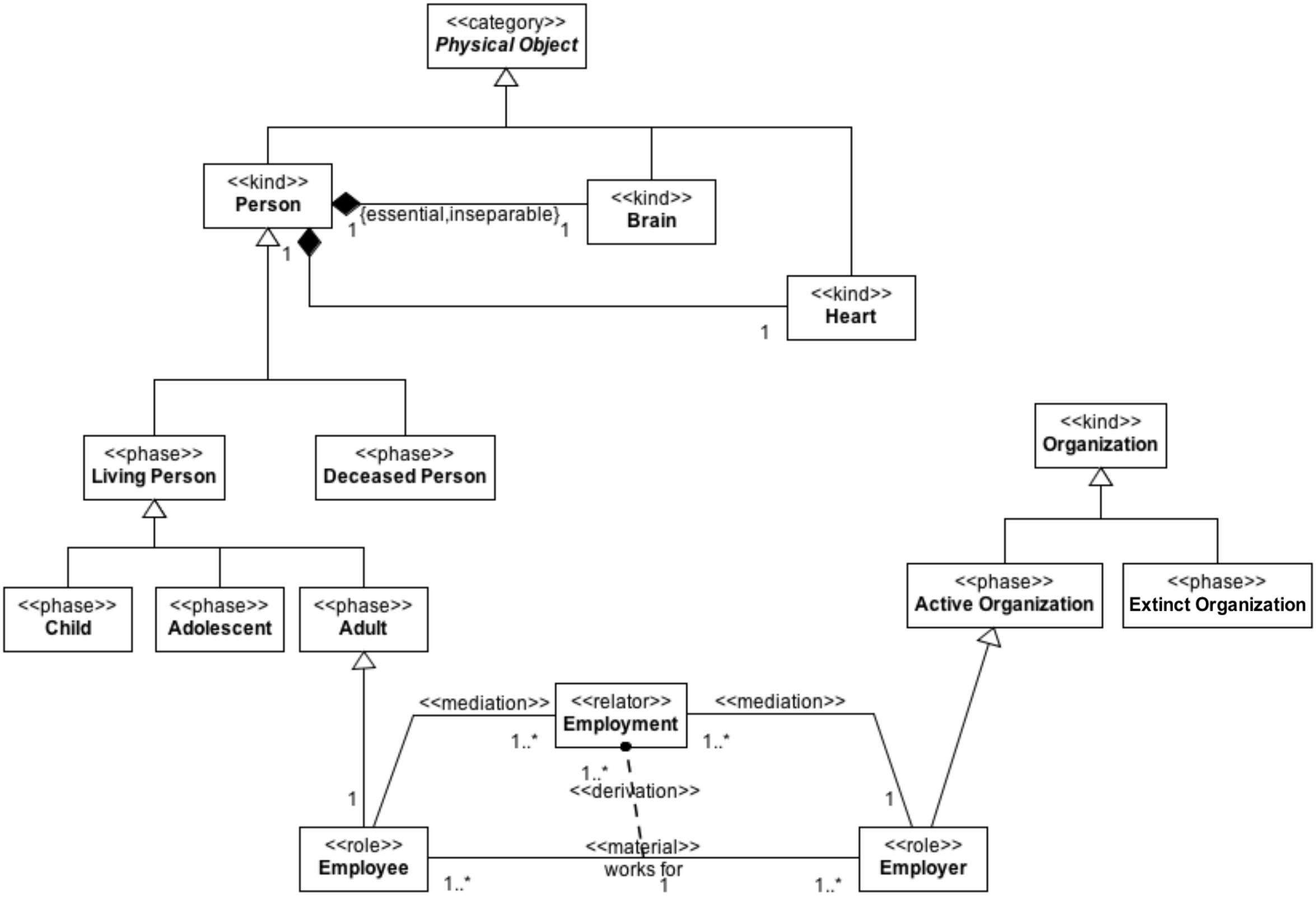
Employer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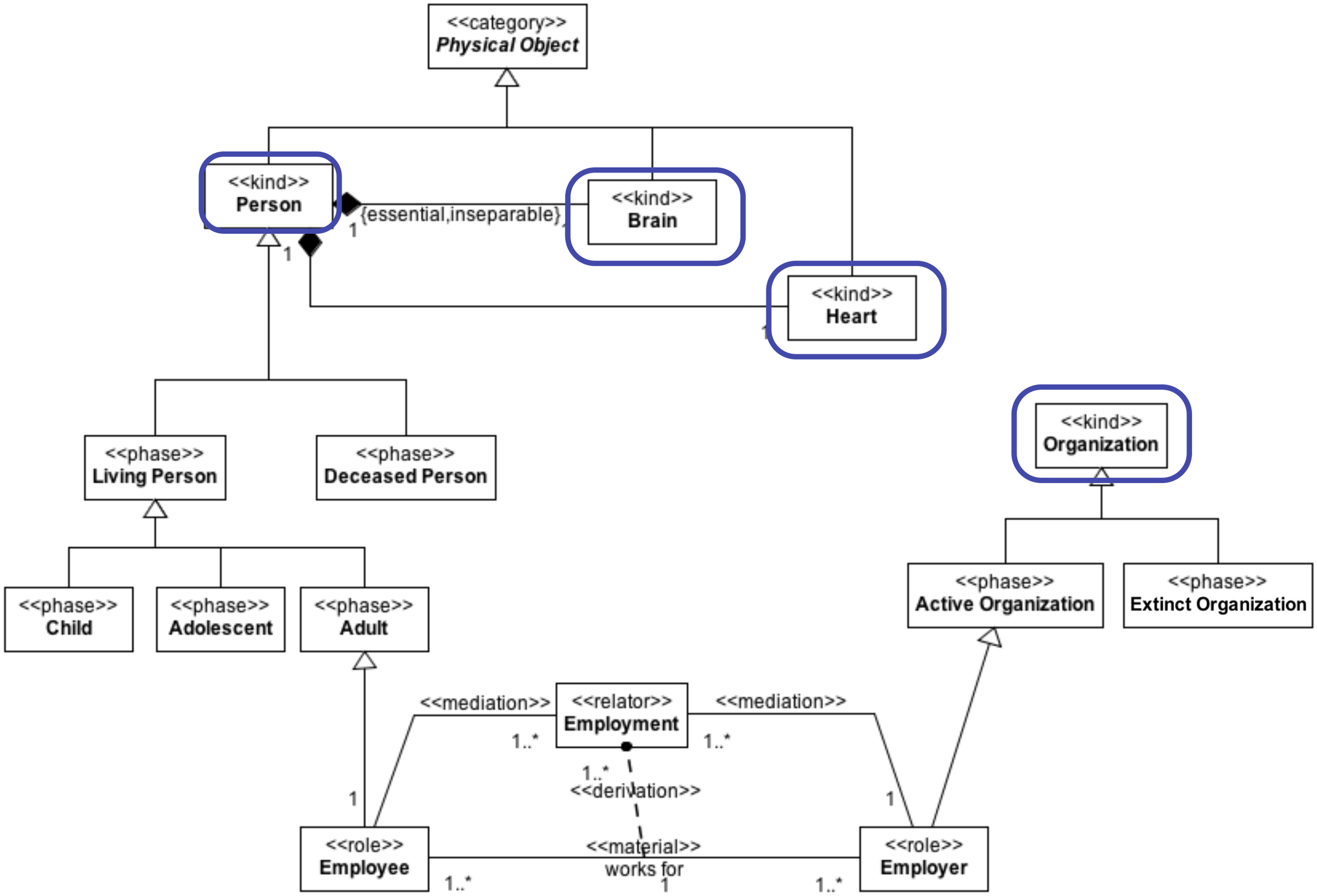
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works for
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1..*
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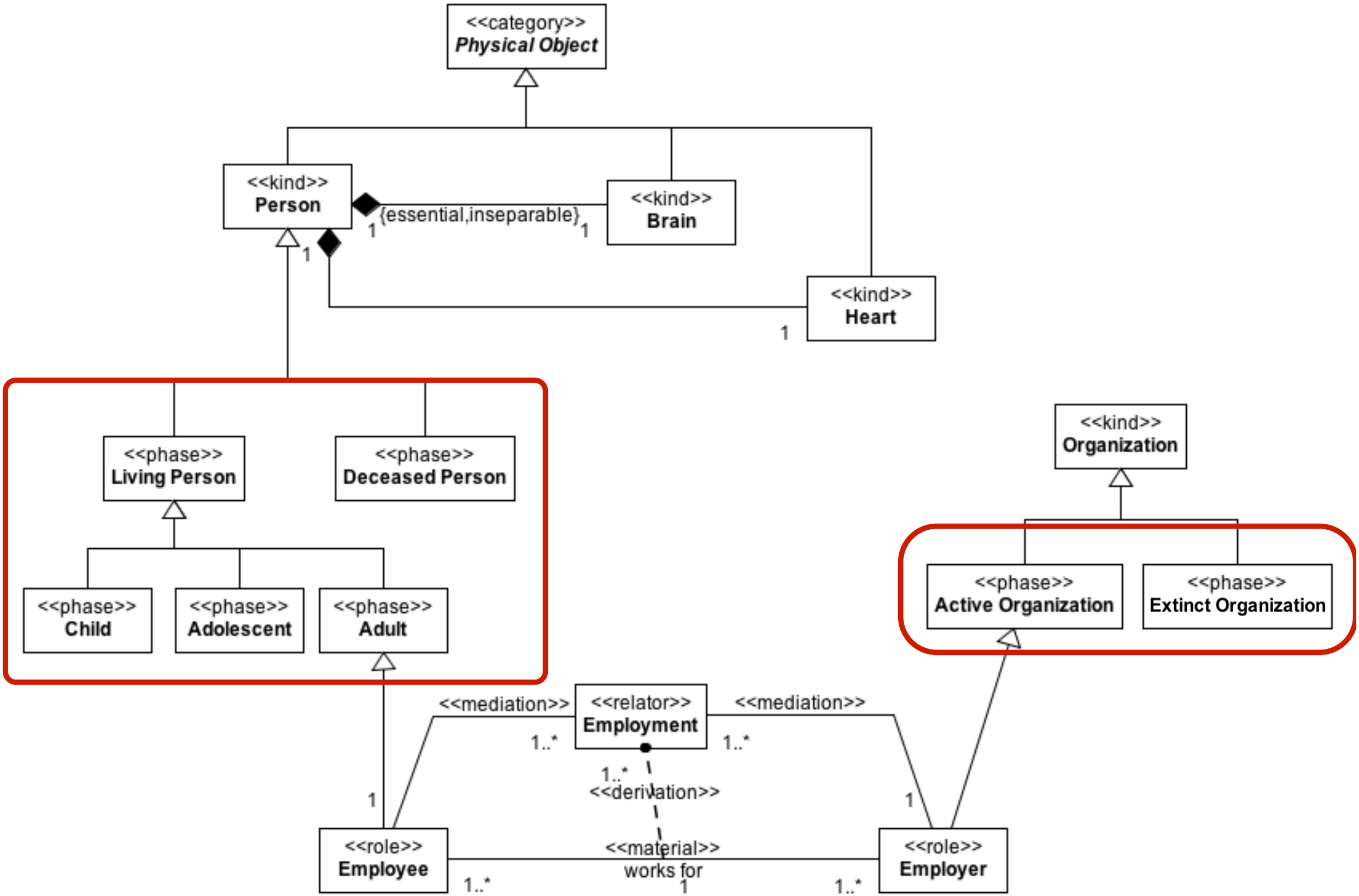
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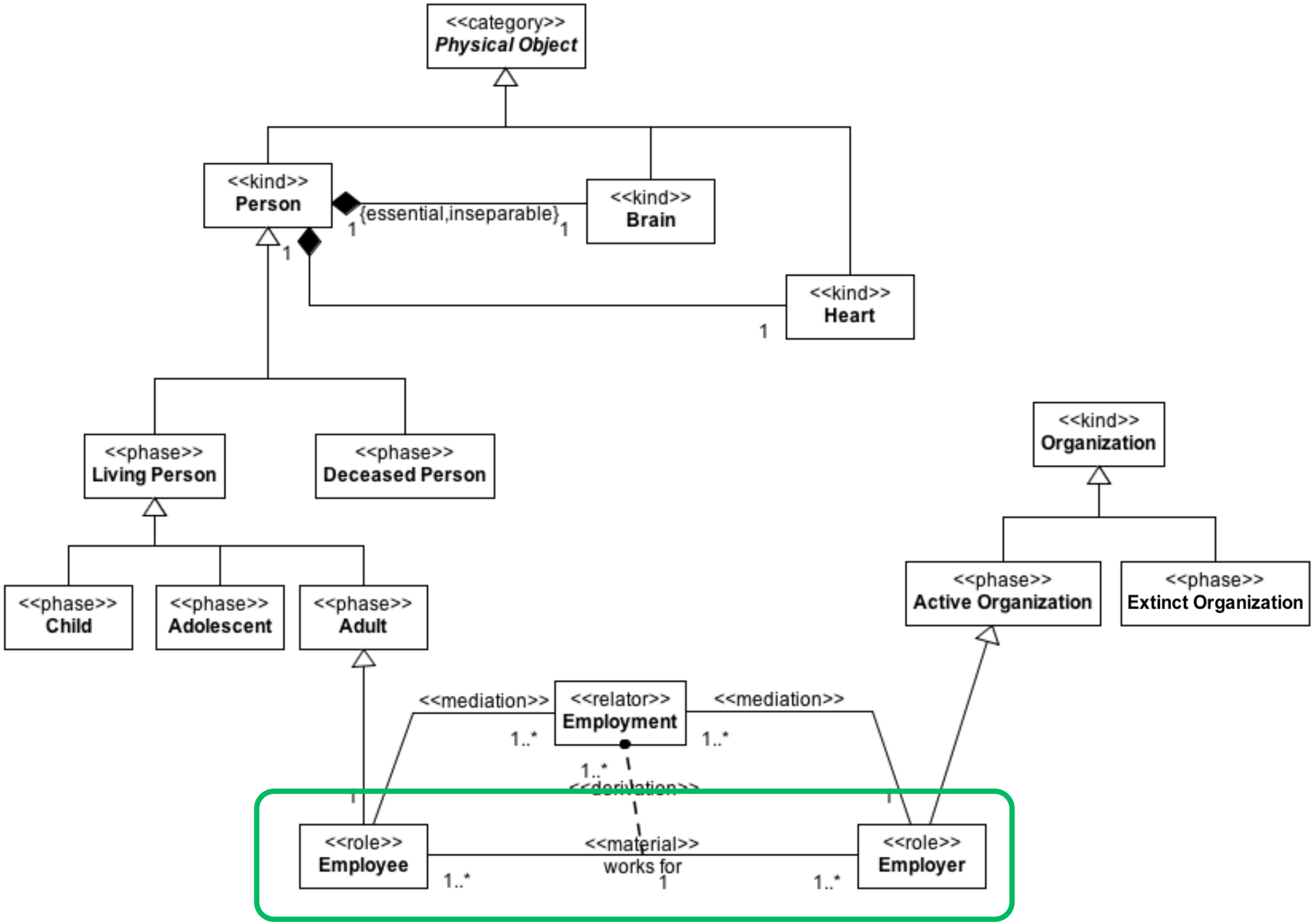
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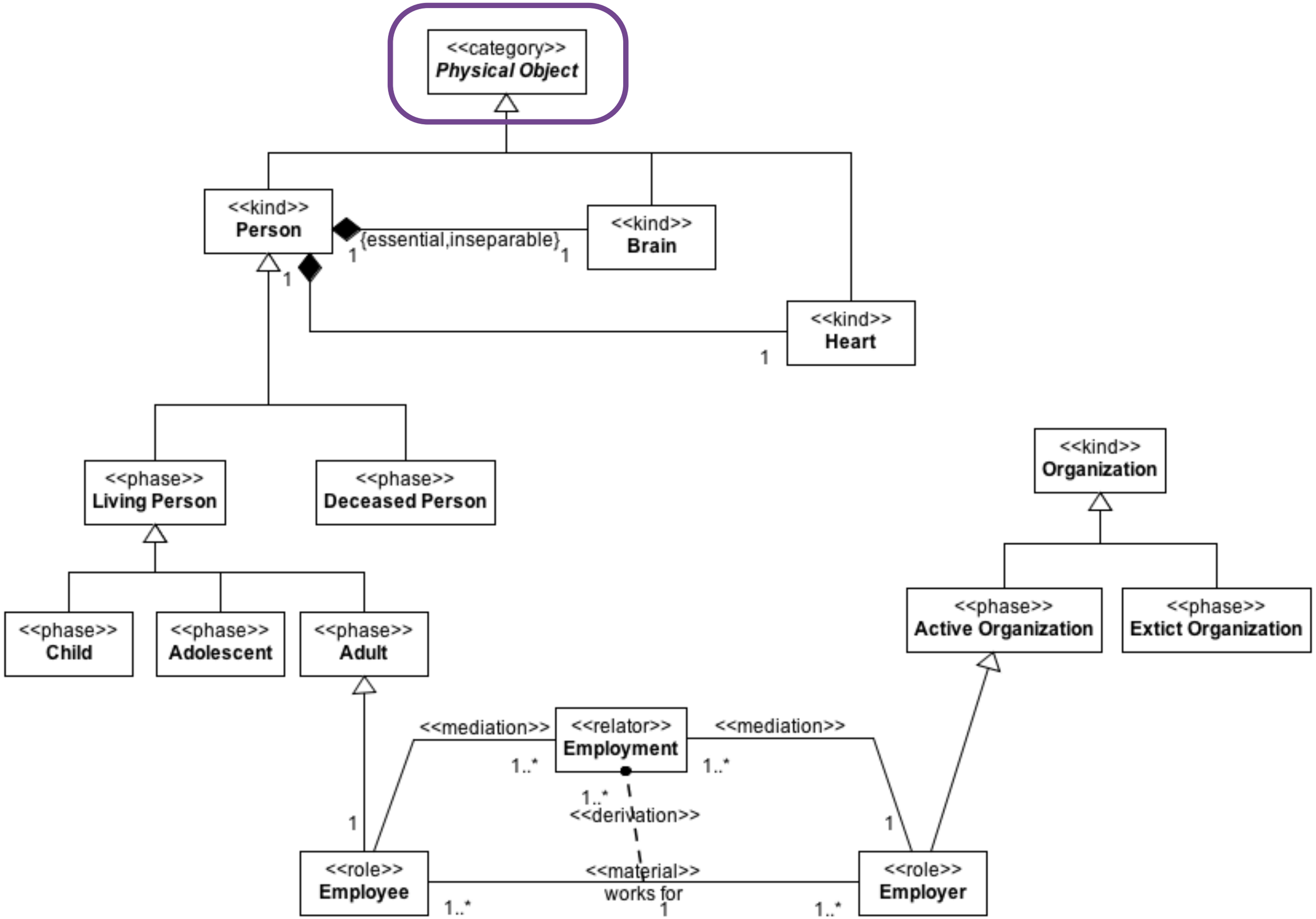
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Brain
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Heart
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Living Person
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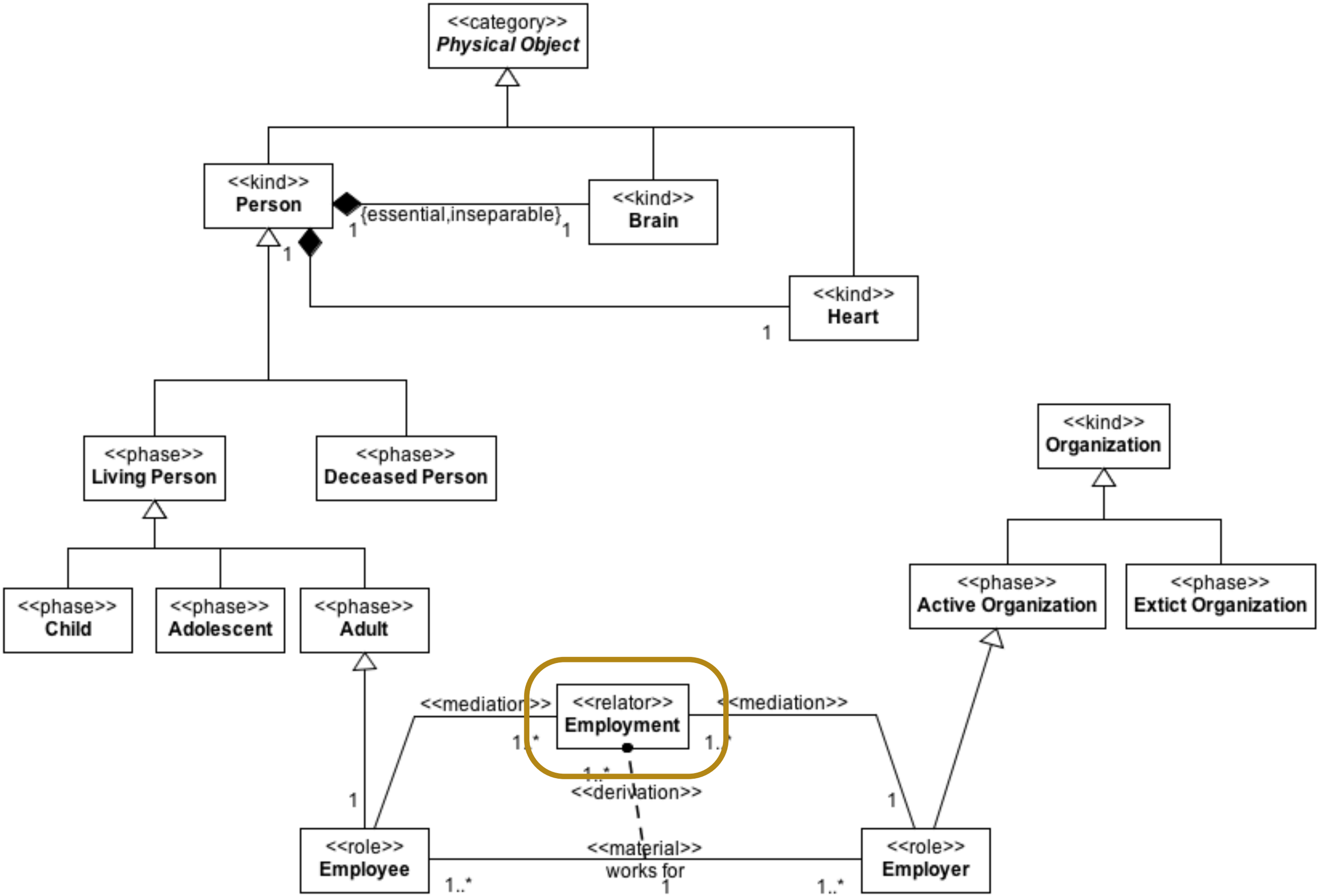
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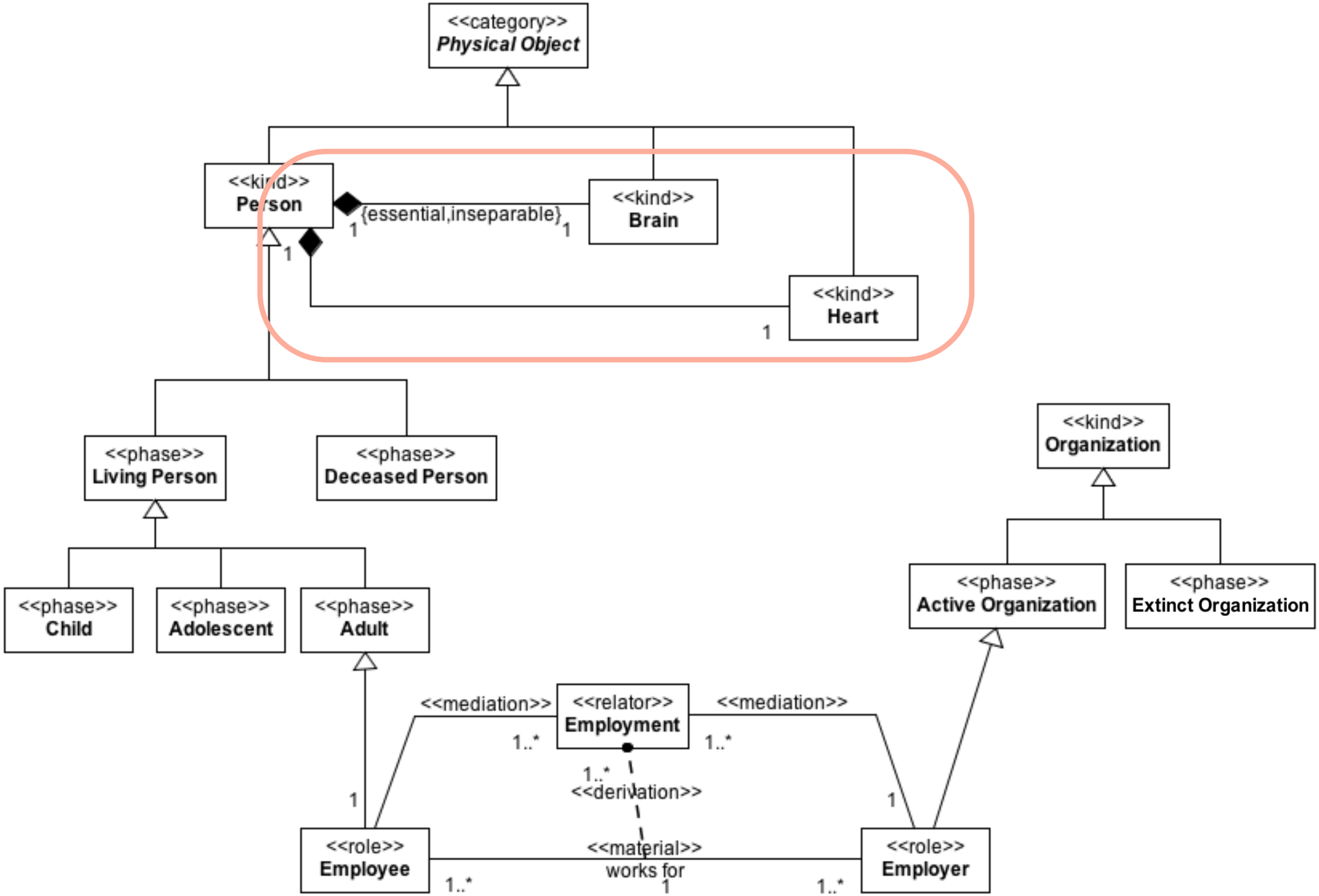
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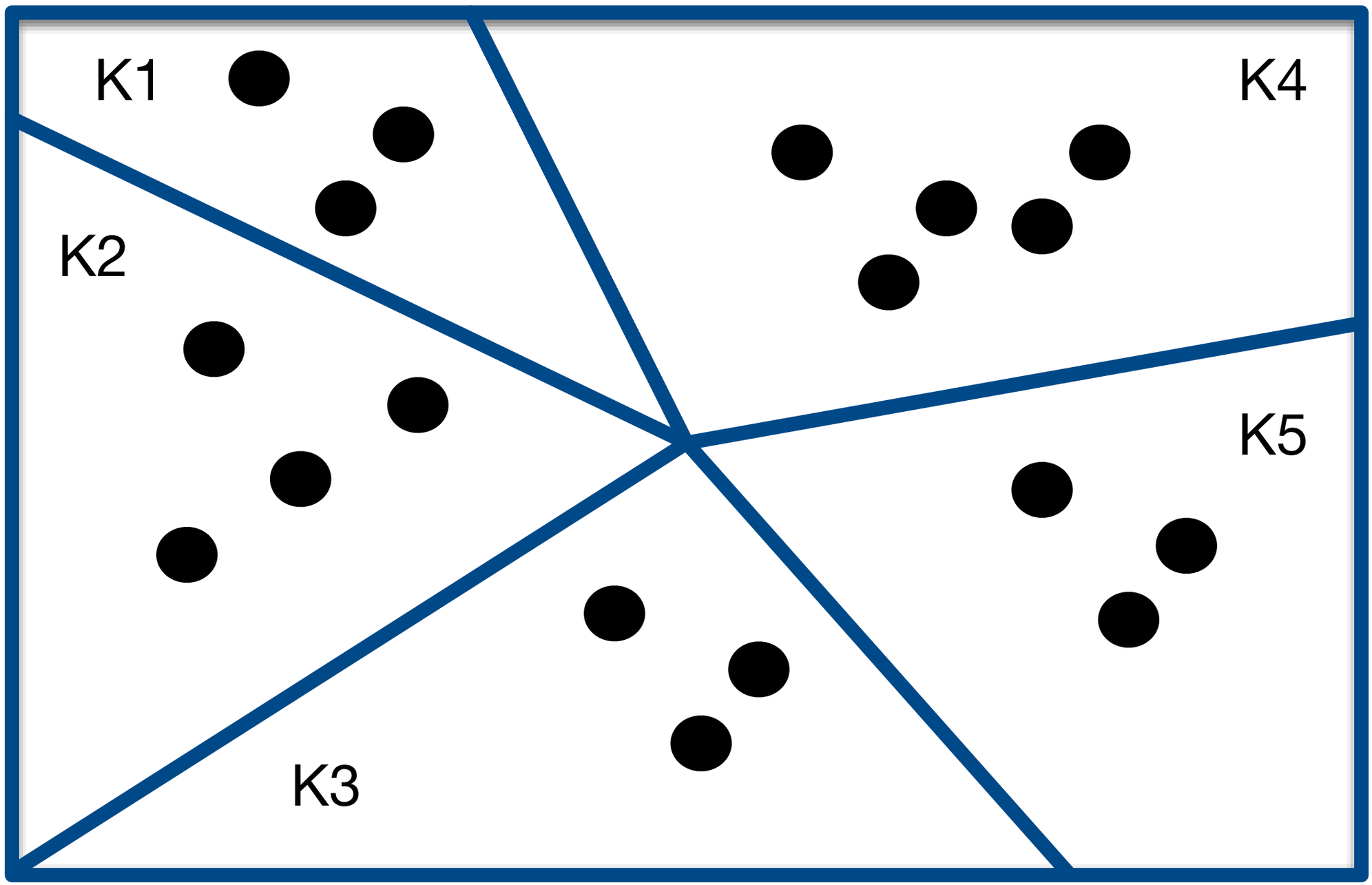
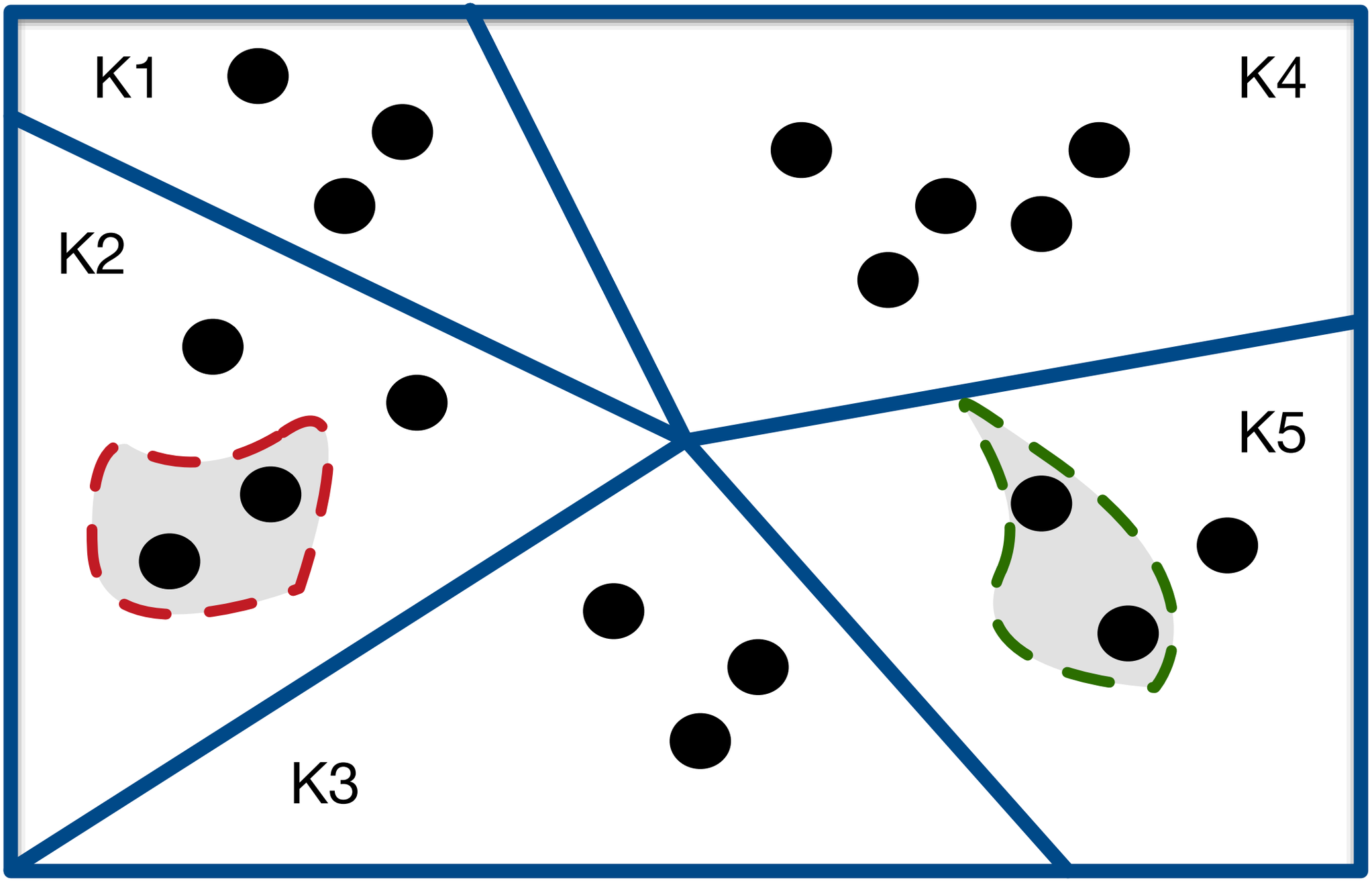
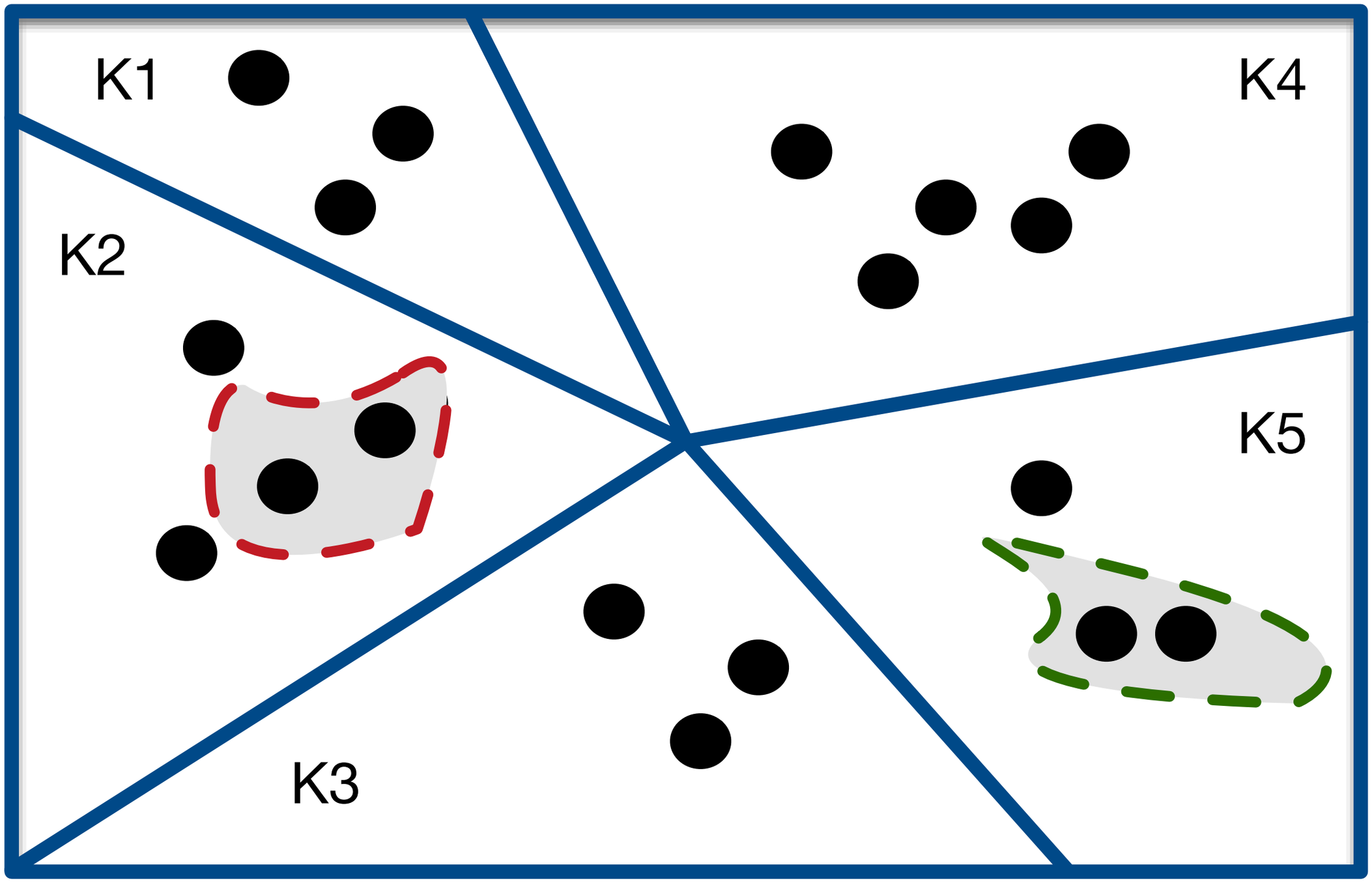
Kinds



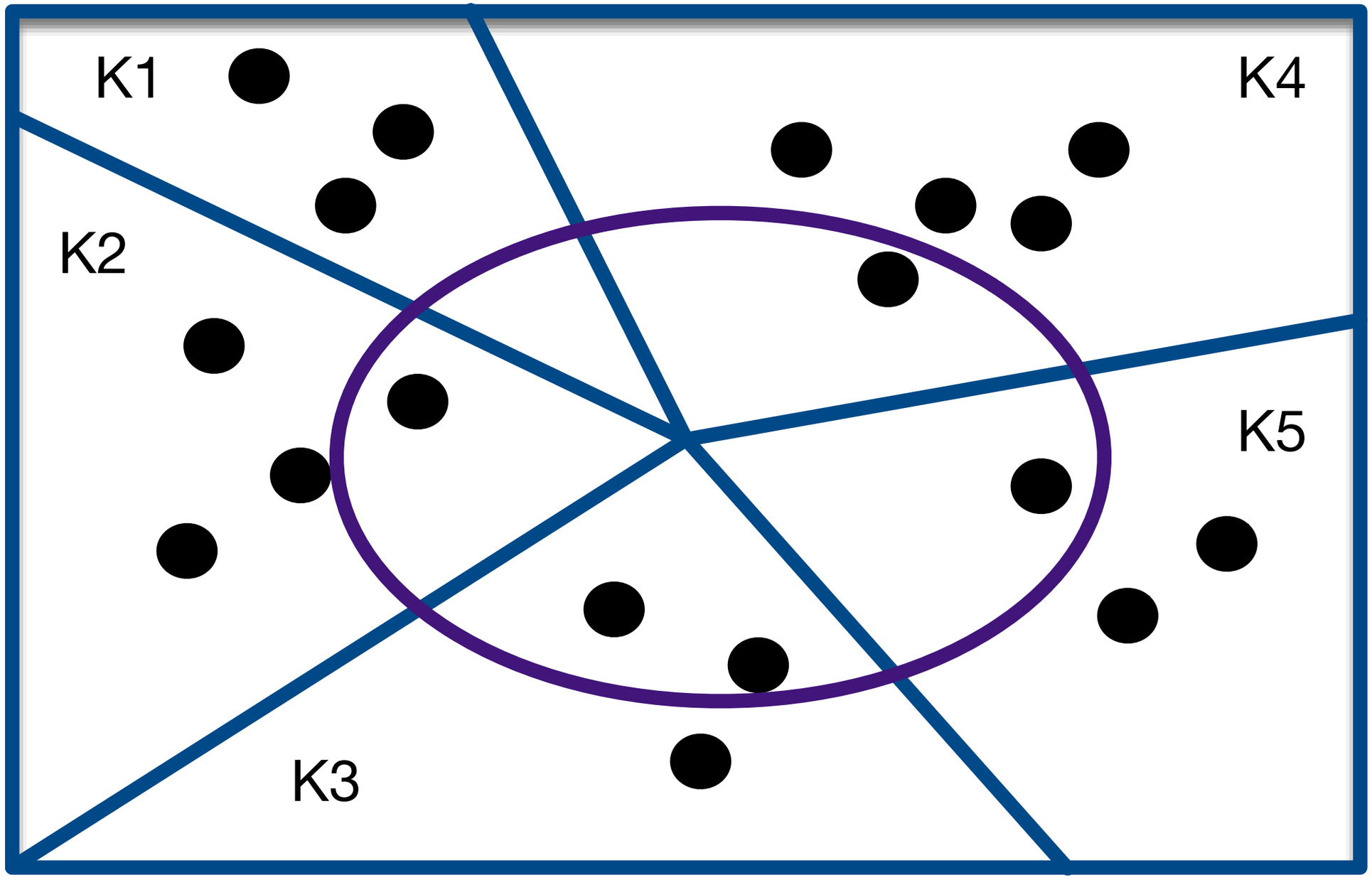
Anti-Rigid Sortals (**Roles** and **Phases**)



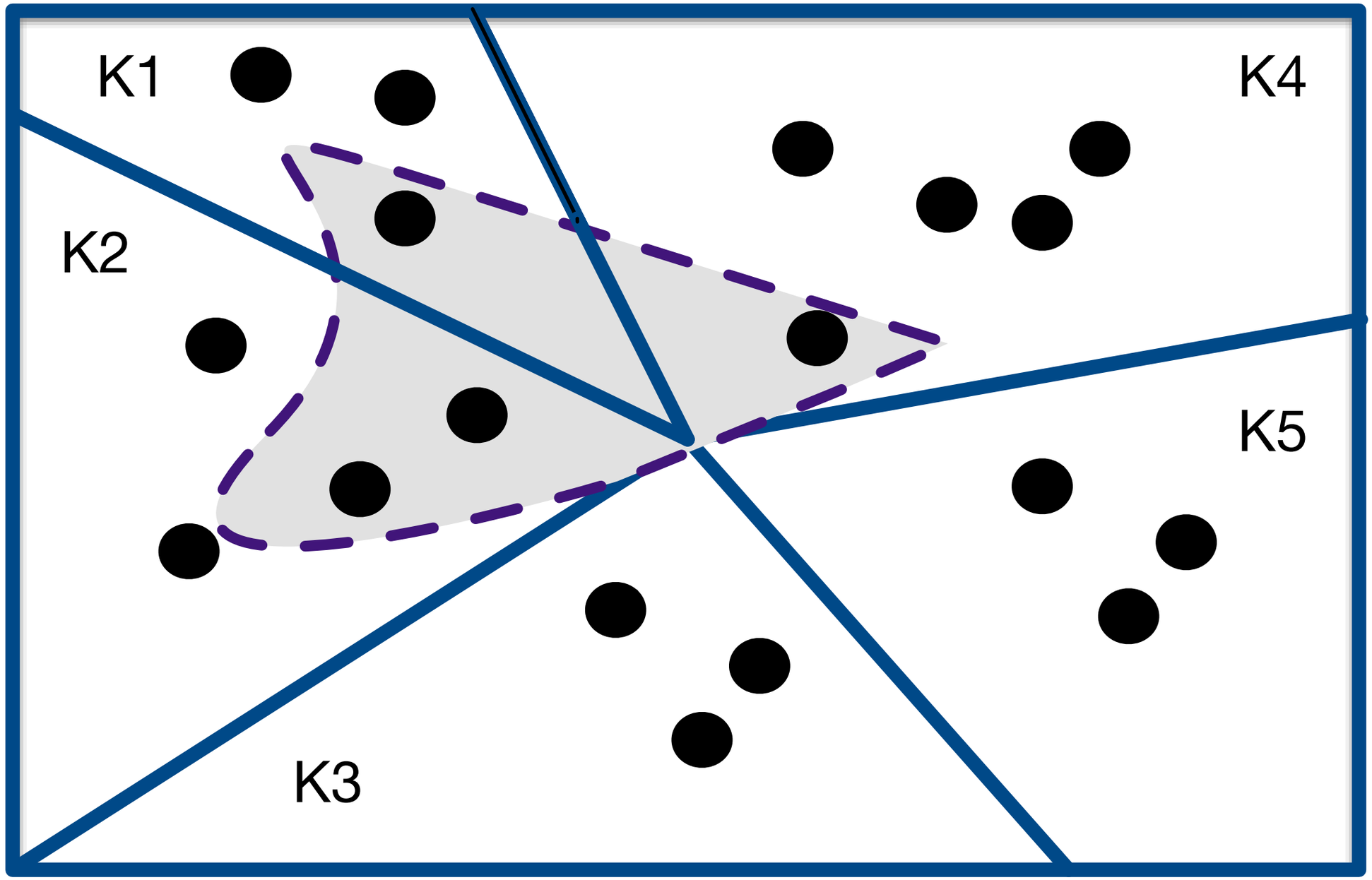
Anti-Rigid Sortals (**Roles** and **Phases**)



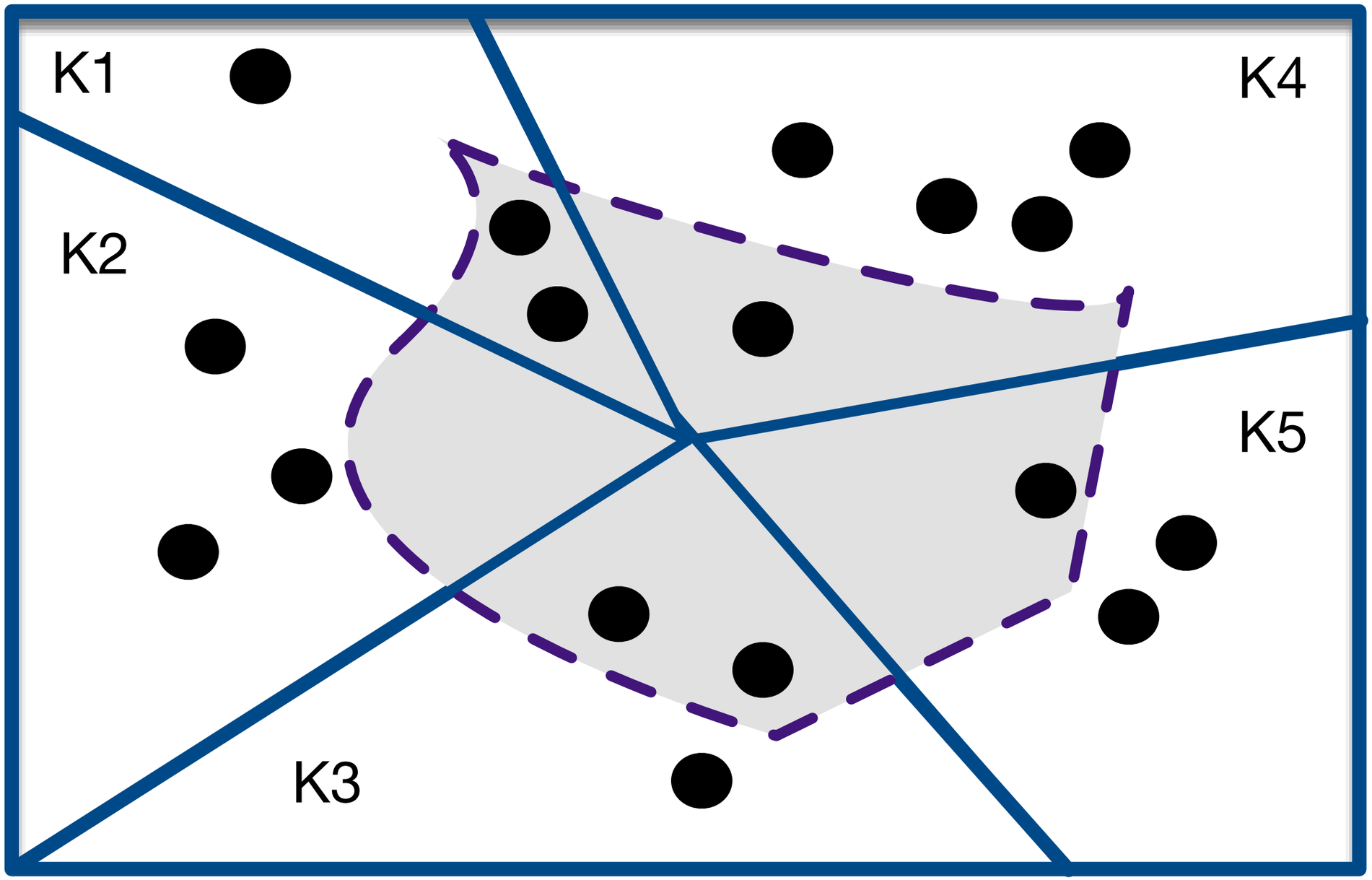
Rigid Mixins

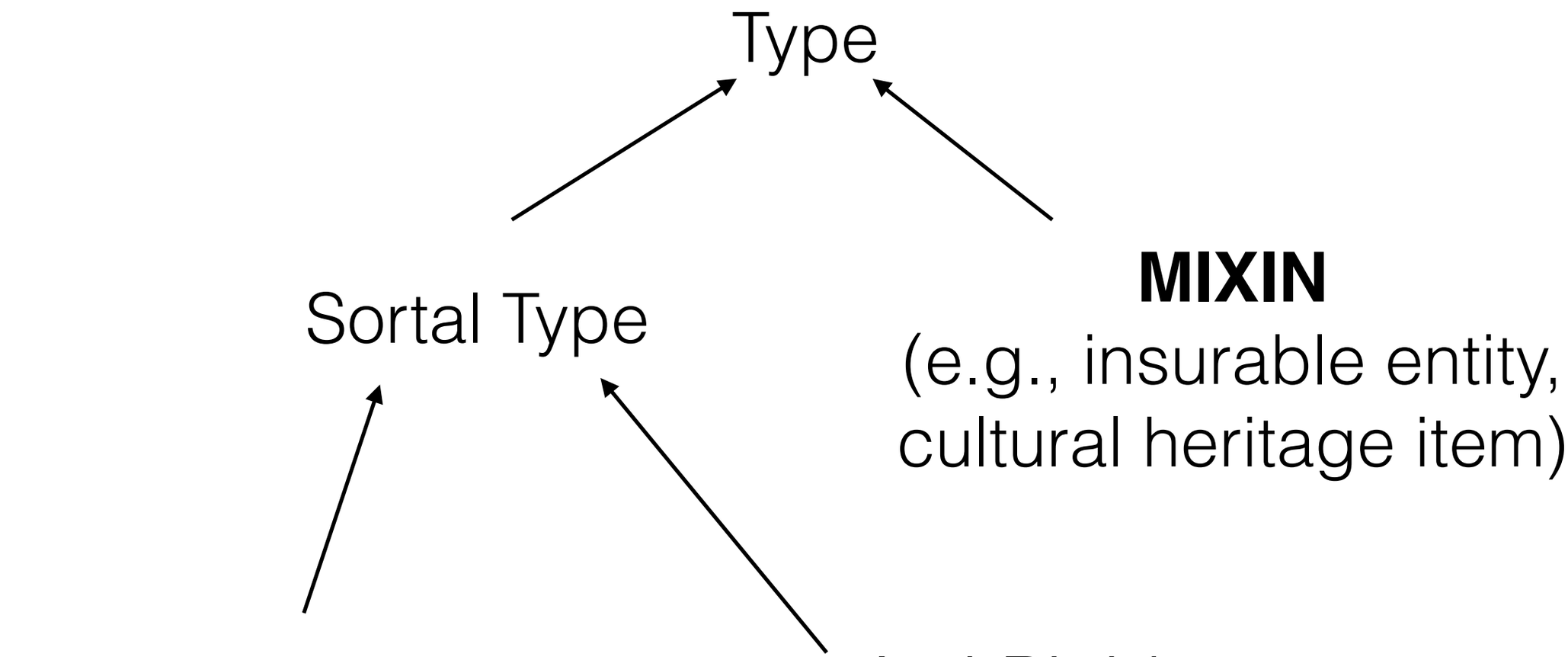


Anti-Rigid Mixins



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)

Why is this important?

1

Ontologically well-defined, formally characterized and cognitively sound systems of types

Why is this important?

2

Precise methodological guidelines for choosing how to model different elements in the universe of discourse

Problem (1)

1. Characterize the difference between the following types:

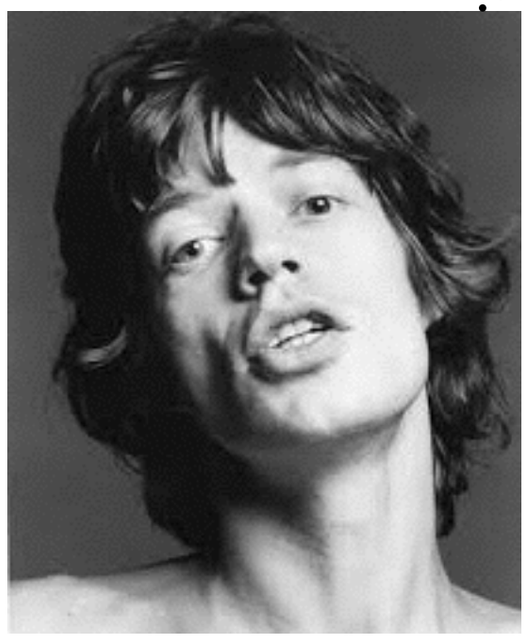
   - Person, Apple, Car, Dog, Organization
   - Student, Singer, President, Employee
   - Adult, Puppy, Metropolis
   - Crime Weapon, Insurable Item, Sharp Object, Rational Agent, Cultural Heritage Item

Person

Man

Adult Man

Living Person

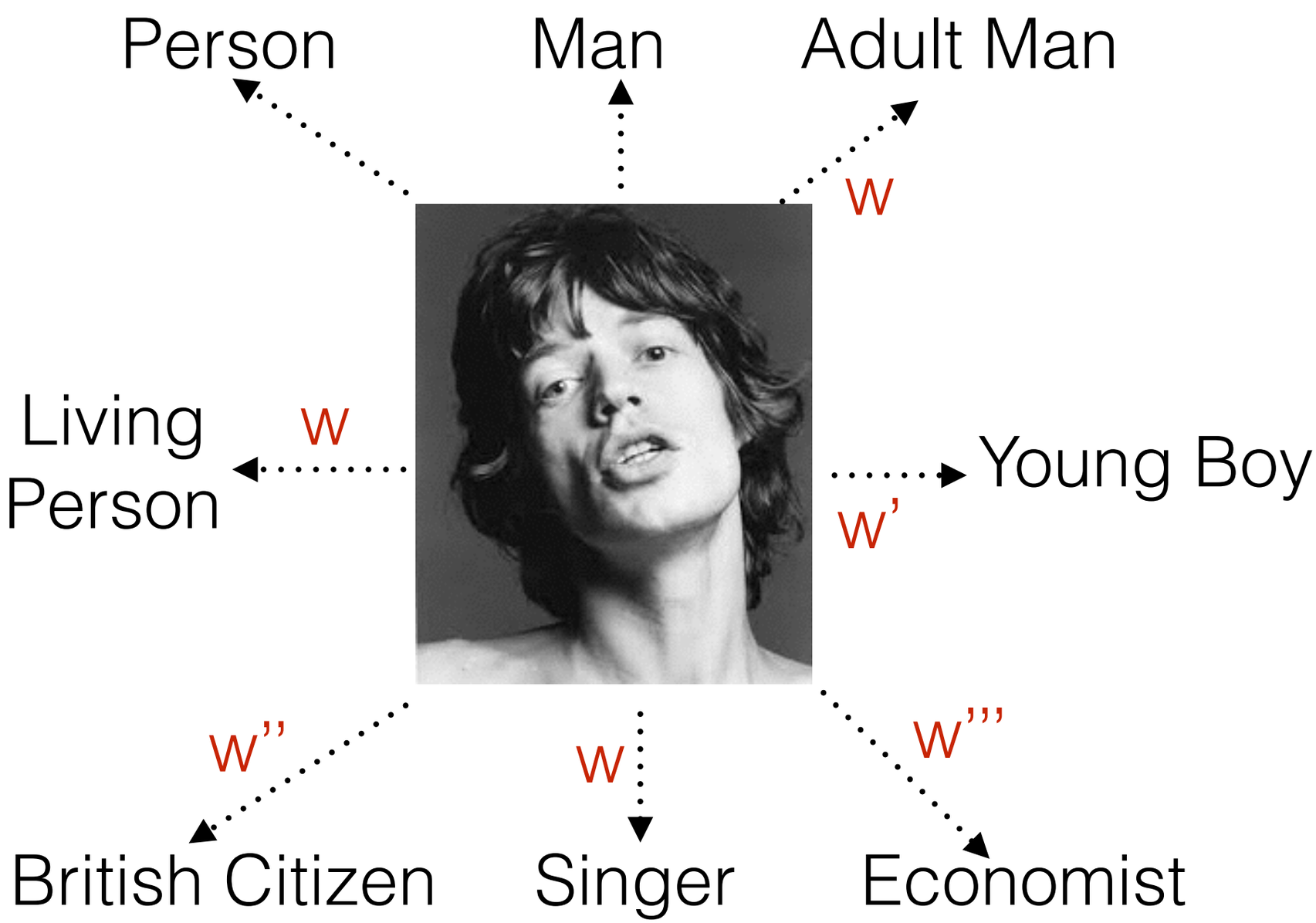


Young Boy

British Citizen

Singer

Economist


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

Solution

1. Characterizing the difference between:

   - NATURAL TYPE/KIND (e.g., Person, Apple, Car) = **RIGID SORTAL**

   - ROLE (e.g., Student, President, Employee) = **ANTI-RIGID + RELATIONALLY DEPENDENT SORTAL**

   - PHASE (e.g., Living Person, President,Employee) = **ANTI-RIGID + RELATIONALLY INDEPENDENT SORTAL**

   - MIXIN (e.g., Crime Weapon, Insurable Item, Sharp Object, Rational Agent, Cultural Heritage Item)? = **MIXIN**

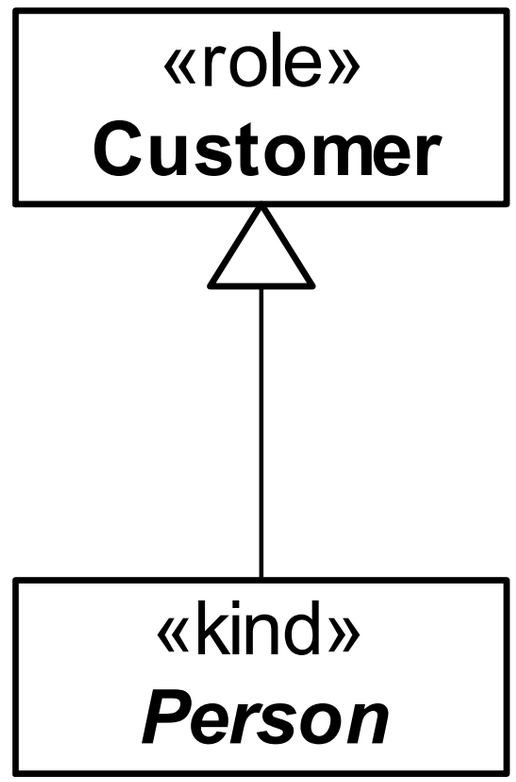
Why is this important?

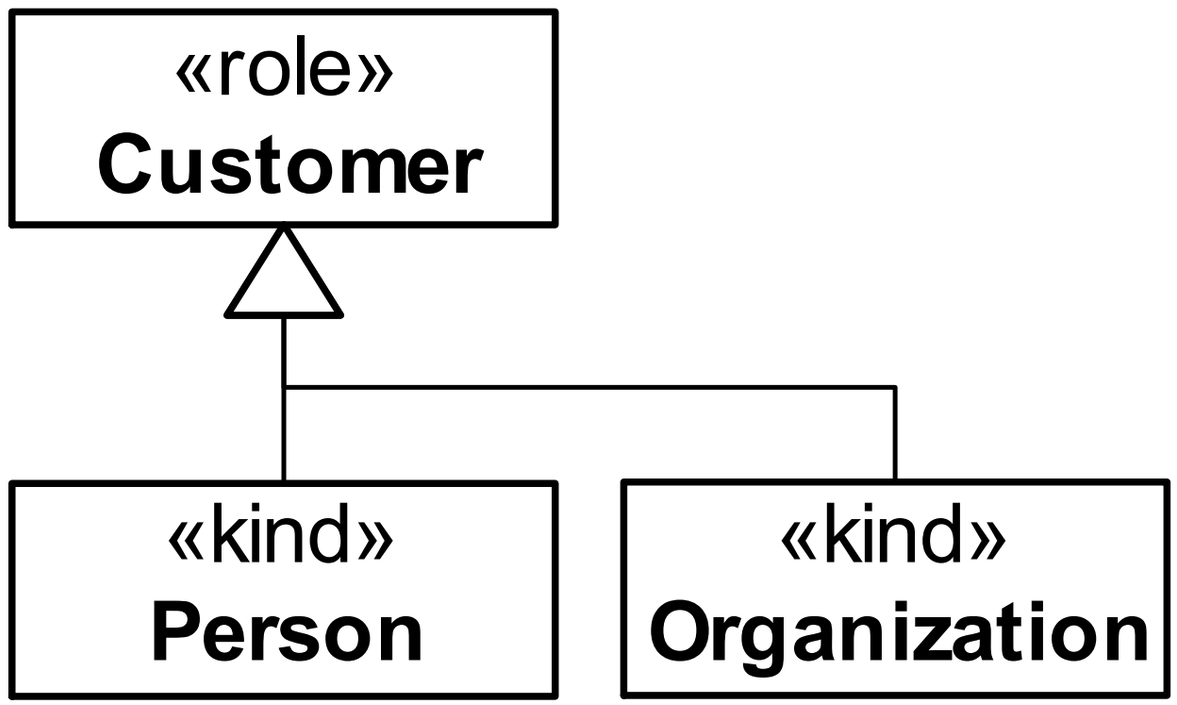
3

Incorporation of ontological constraints in the language metamodel to guarantee *ontological consistency by design*

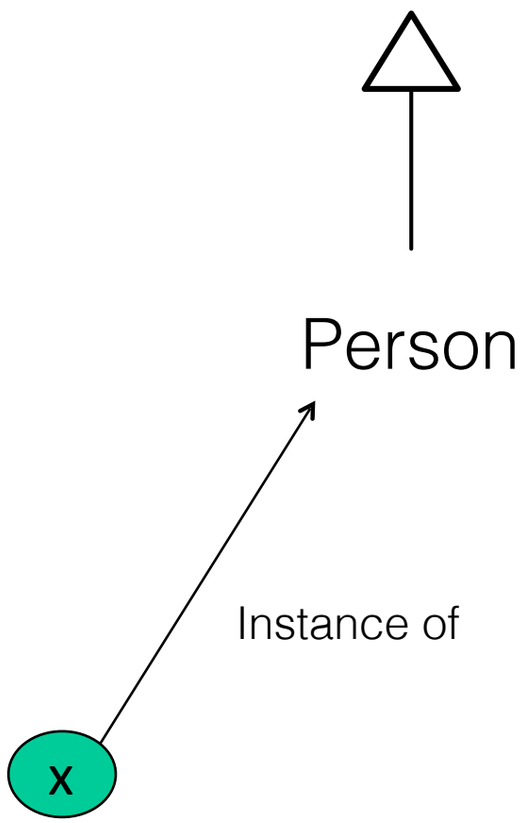
Role

- 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



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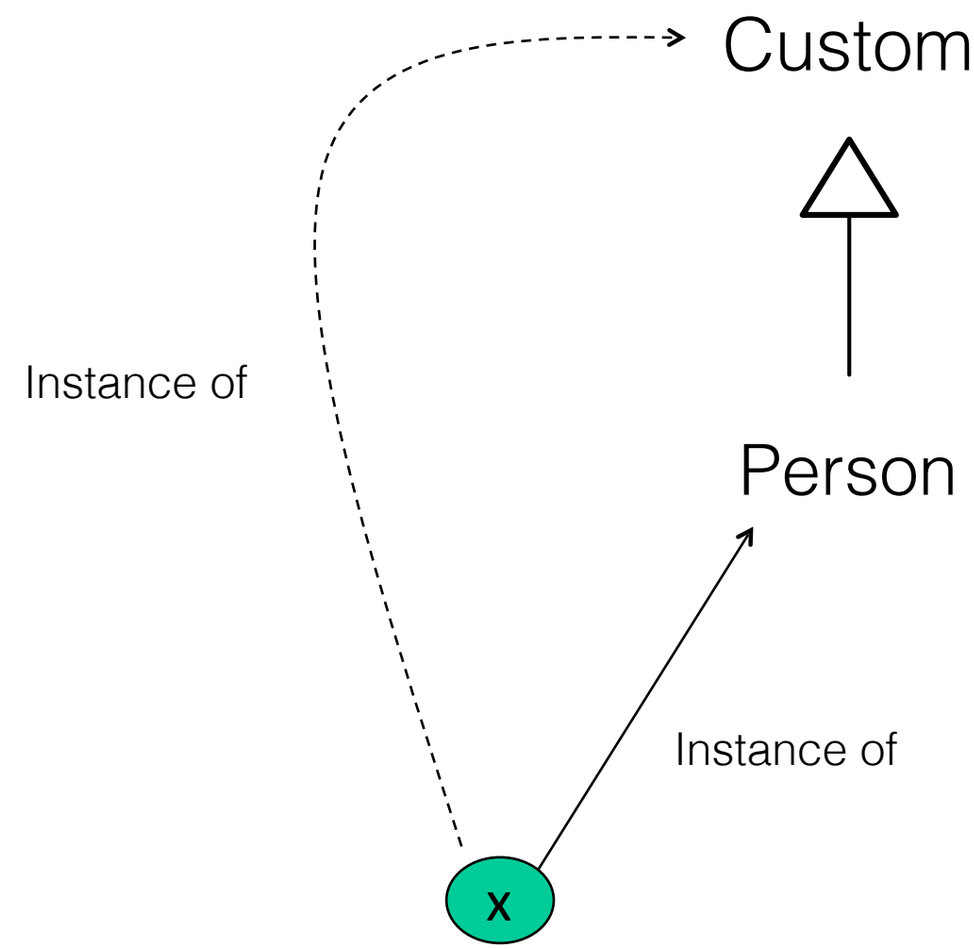

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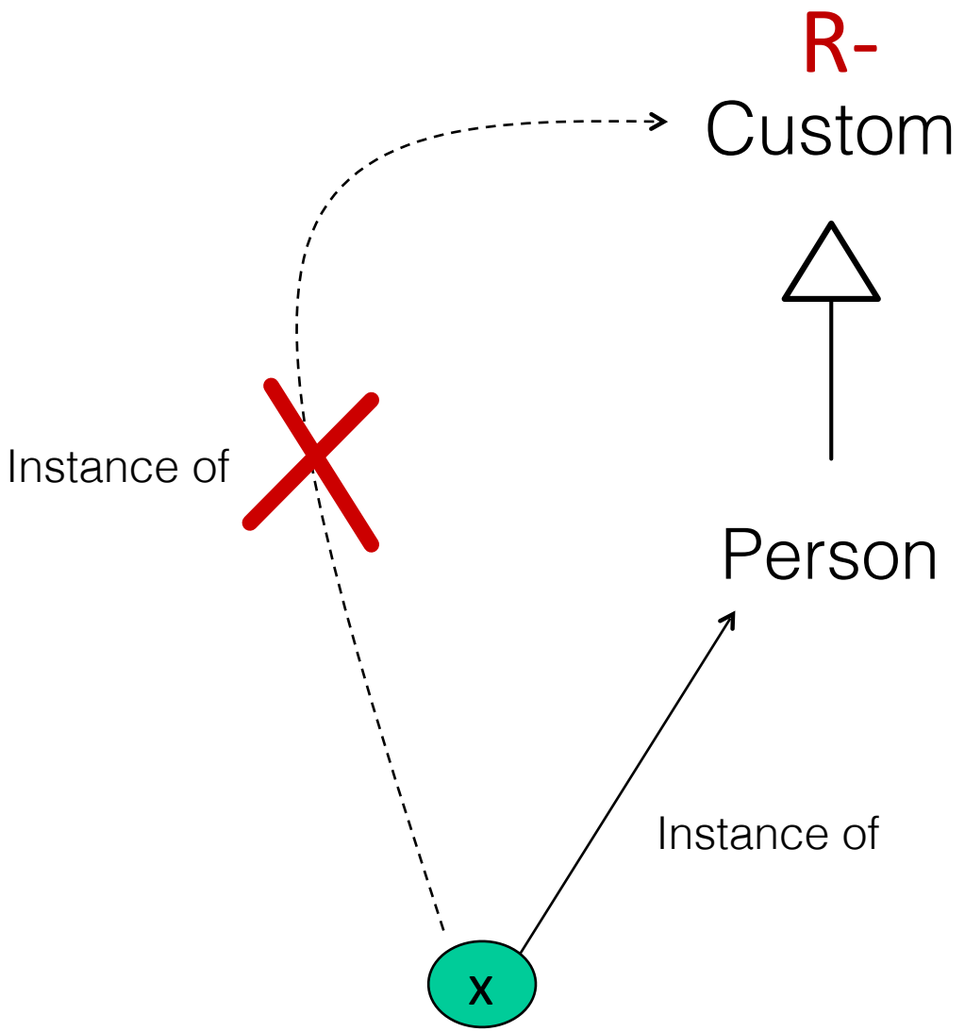

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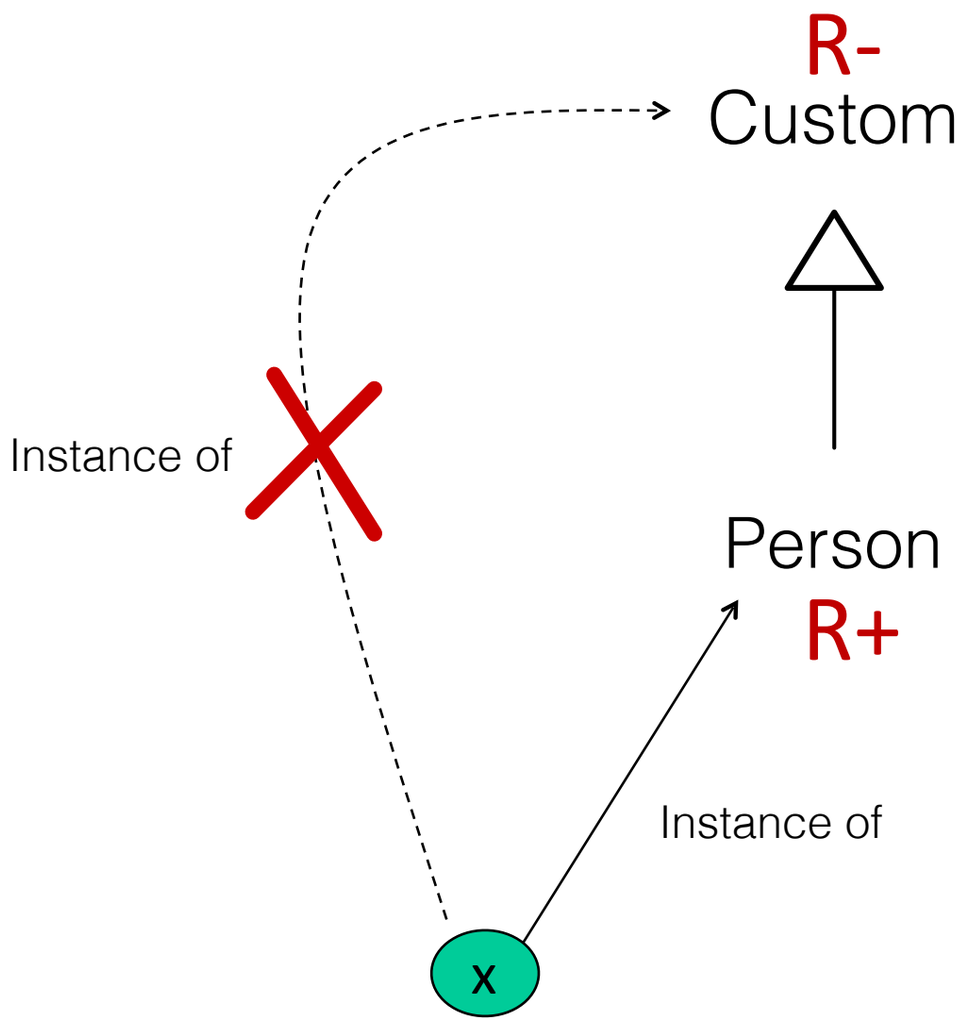

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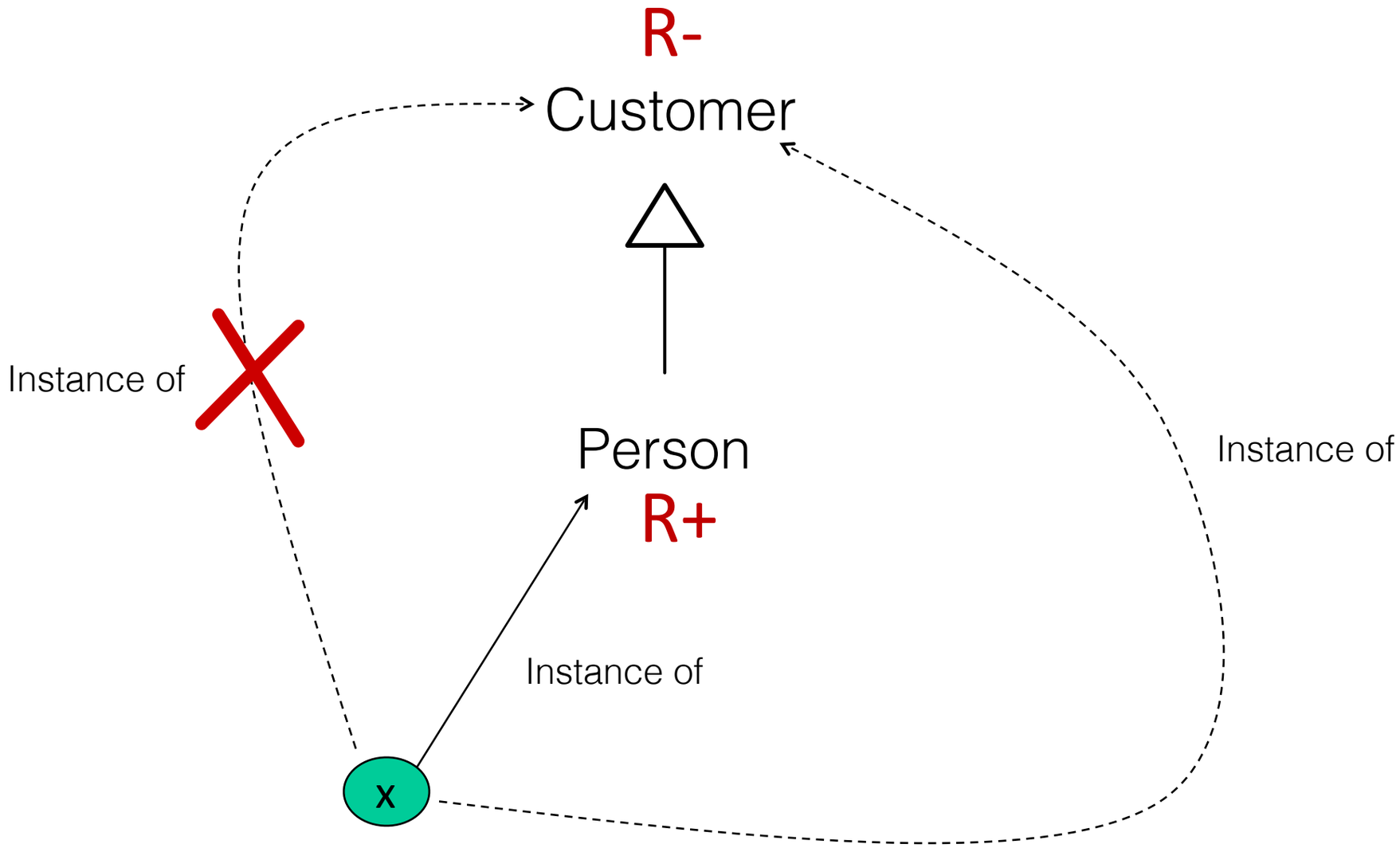

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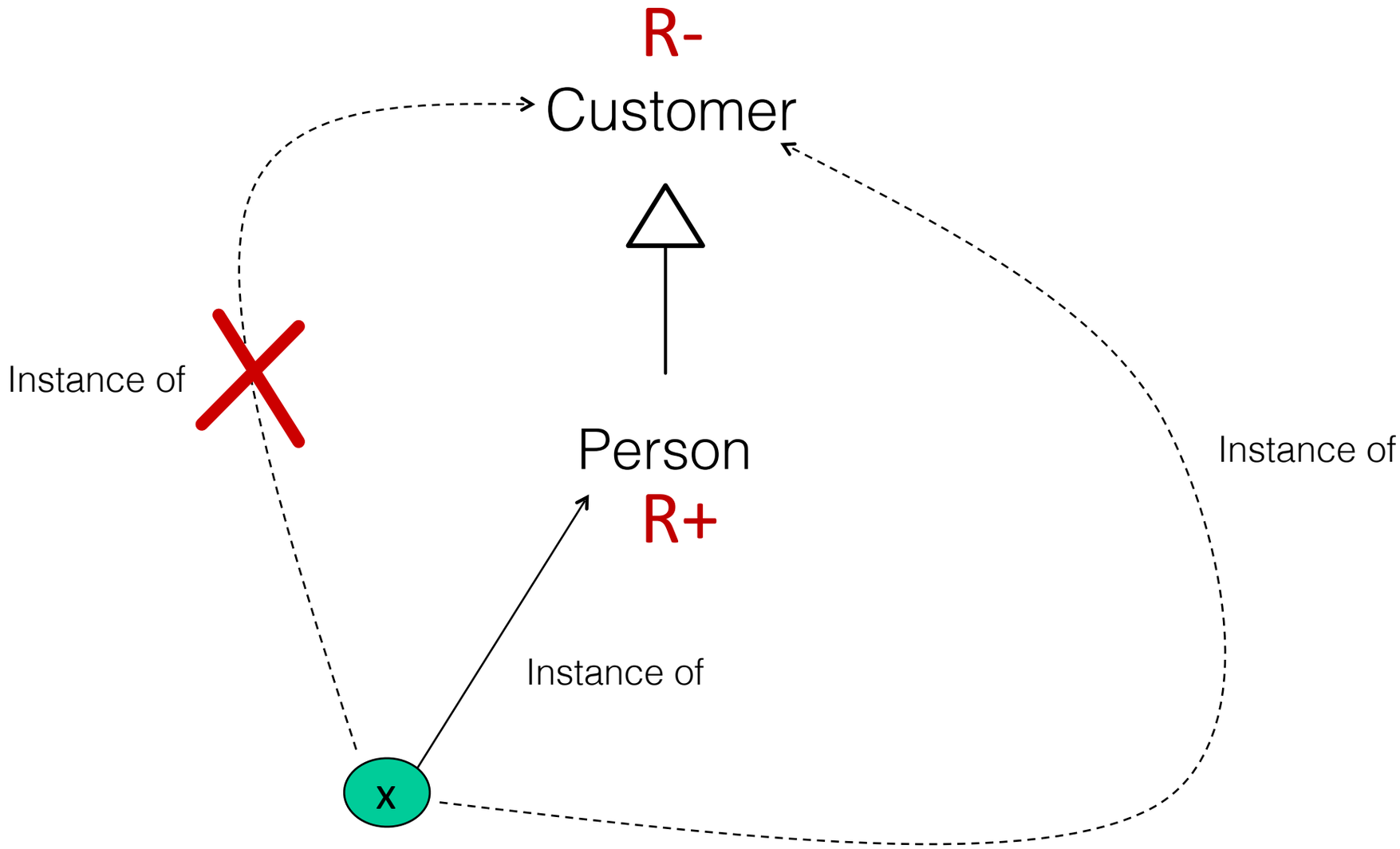


We run into a logical contradiction!

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

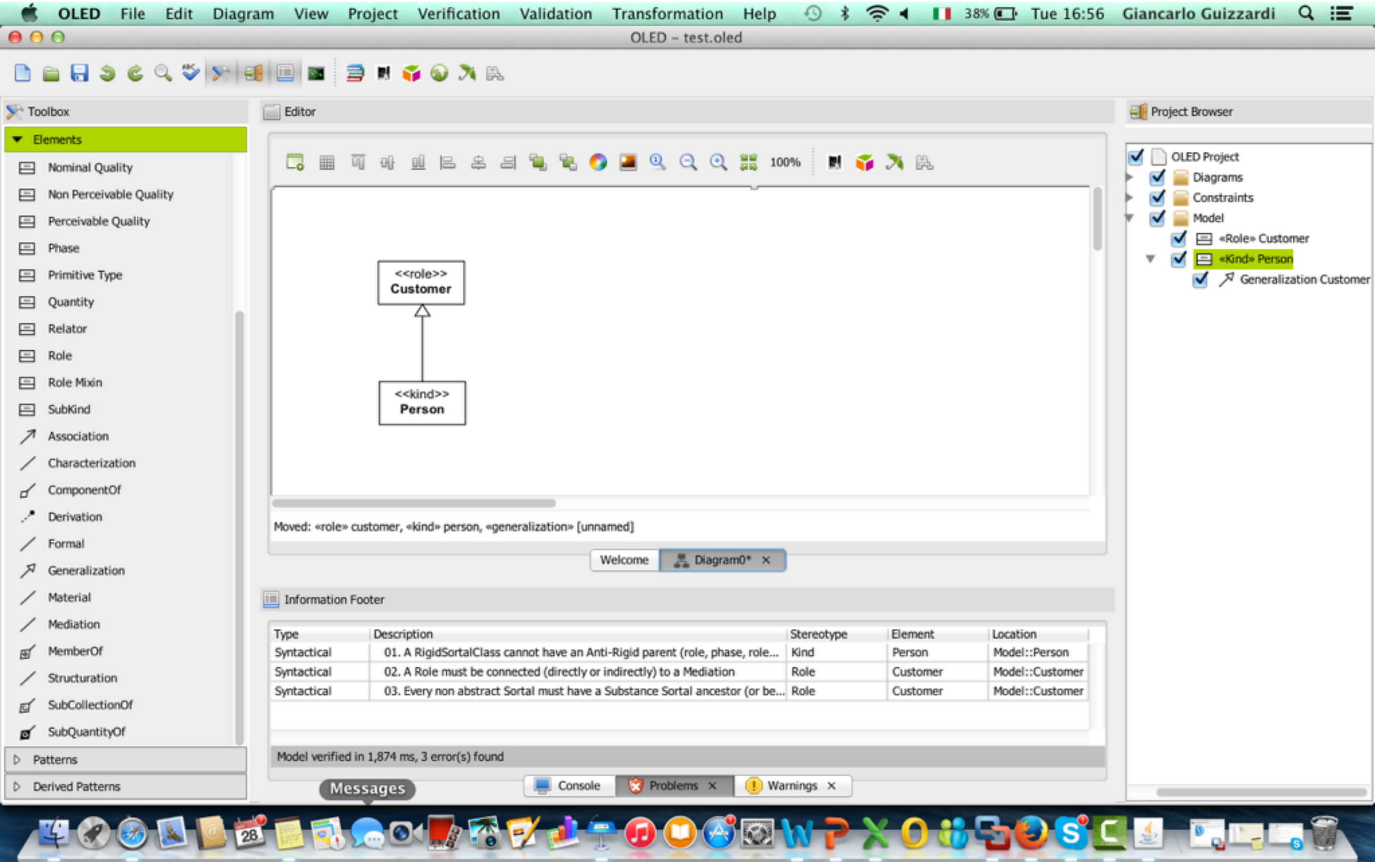
NO!

«role»
Student

enrolled at

«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
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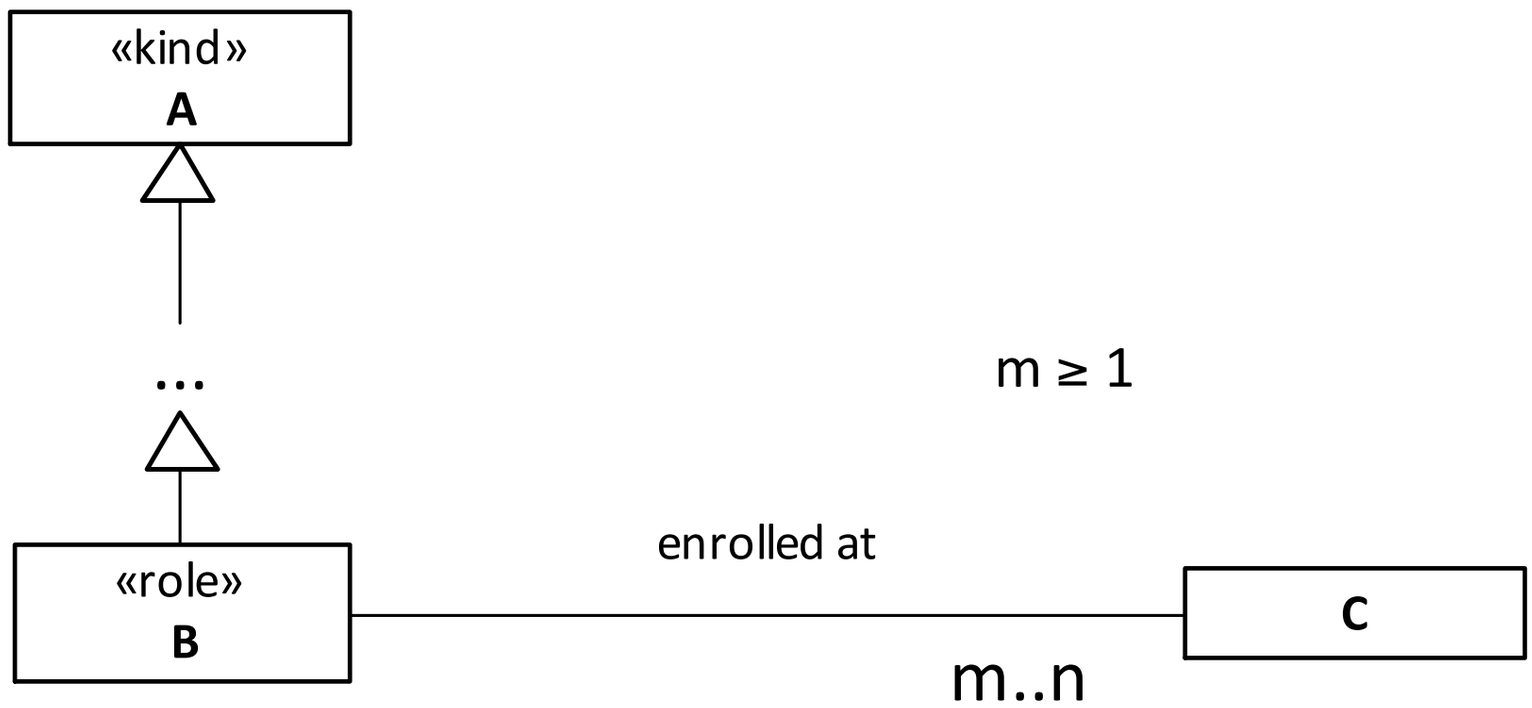
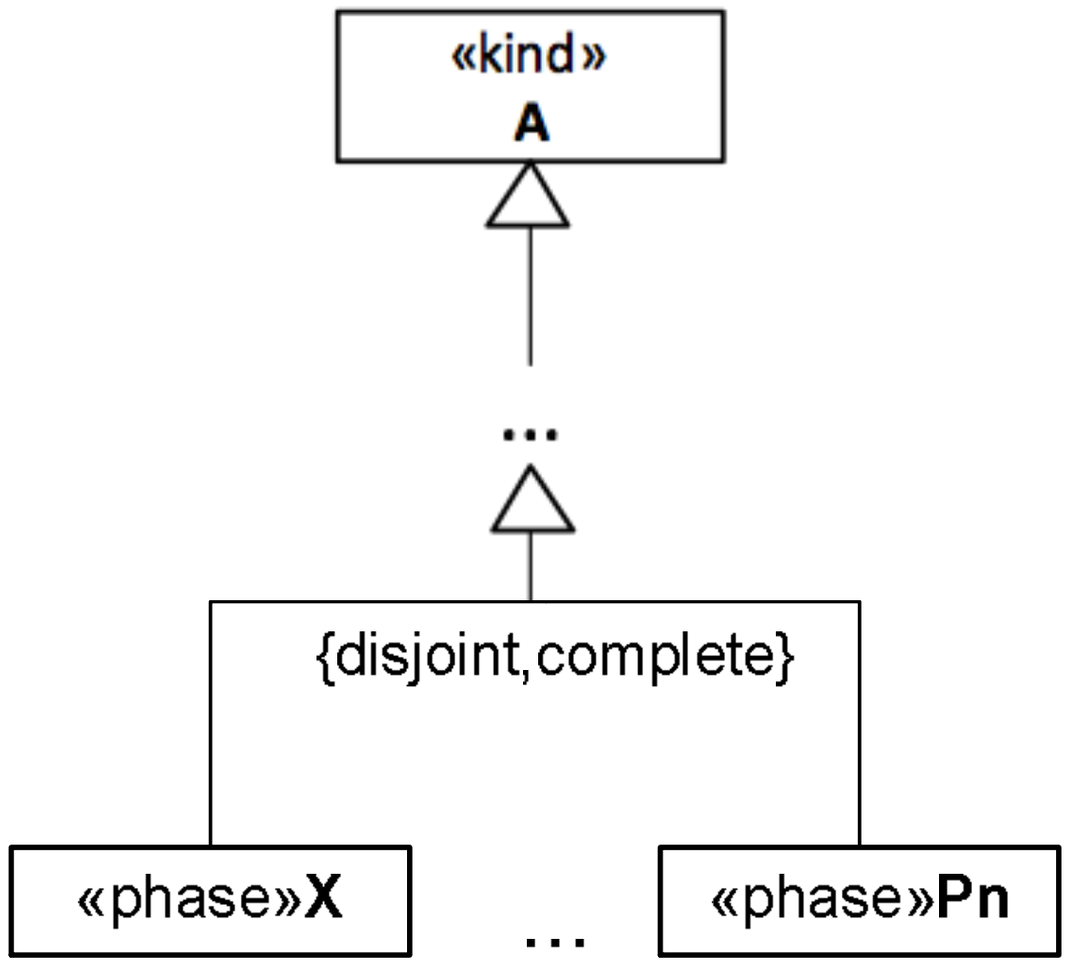
Nominal Quality
Non Perceivable Quality
Perceivable Quality
Phase
Primitive Type
Quantity
Relator
Role
Role Mixin
SubKind
Association
Characterization
ComponentOf
Derivation
Formal
Generalization
Material
Mediation
MemberOf
Structuration
SubCollectionOf
SubQuantityOf
Patterns
Derived Patterns
Editor
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
Console
Problems
Warnings
Messages
Project Browser
OLED Project
Diagrams
Constraints
Model
«Role» Customer
«Kind» Person
Generalization Customer

The Emerging **Role** Pattern



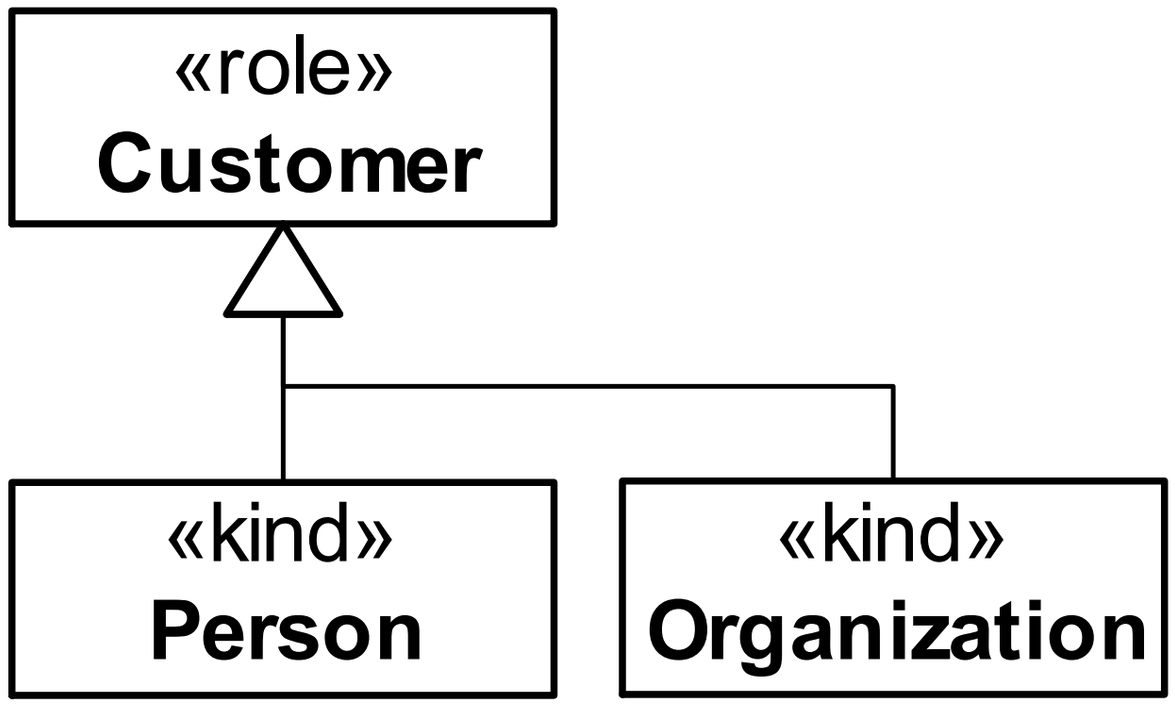
The Emerging **Phase** Pattern

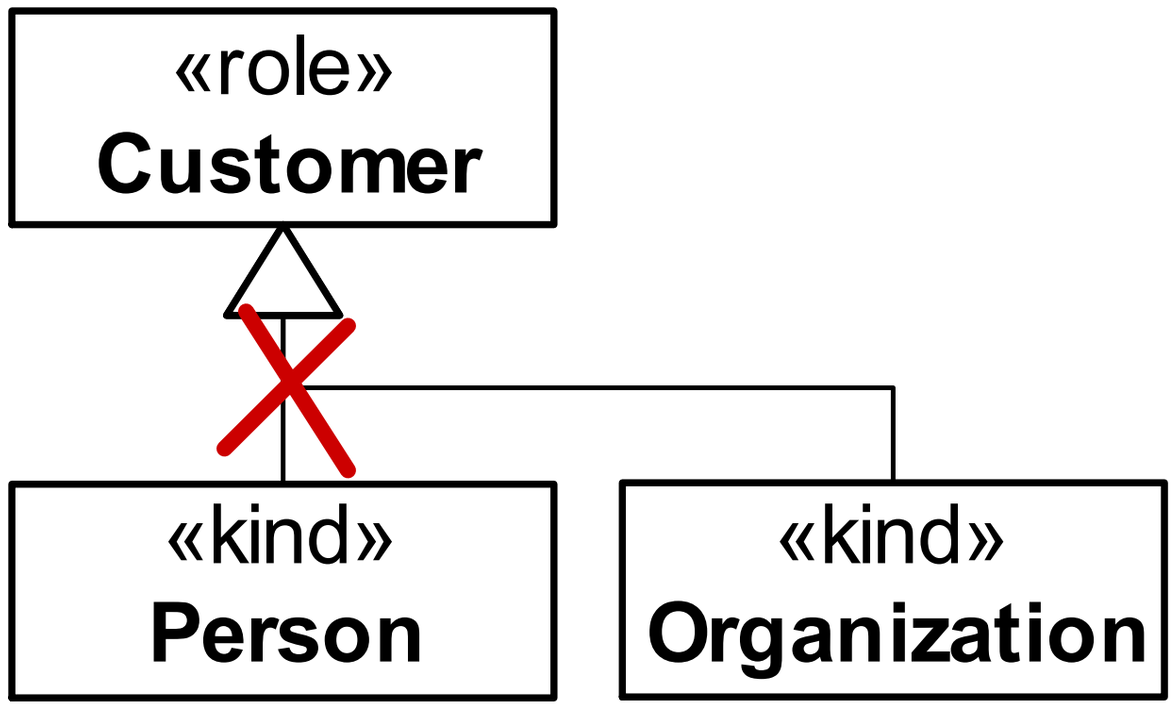


Problem (2)

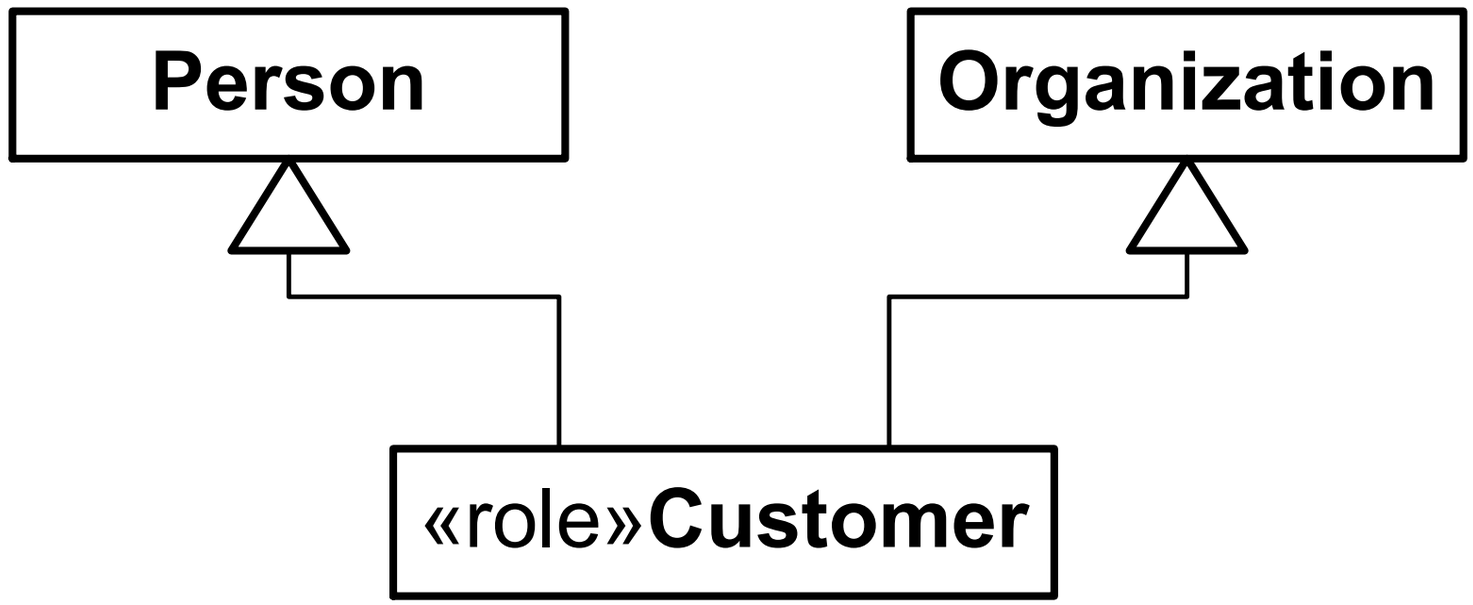
1. Suppose that I want to represent that the ROLE Customer can be played by entities of different KINDS, namely, People and Organizations. How to relate the ROLE and its *allowed types* using subtyping relations?

A Classic Problem

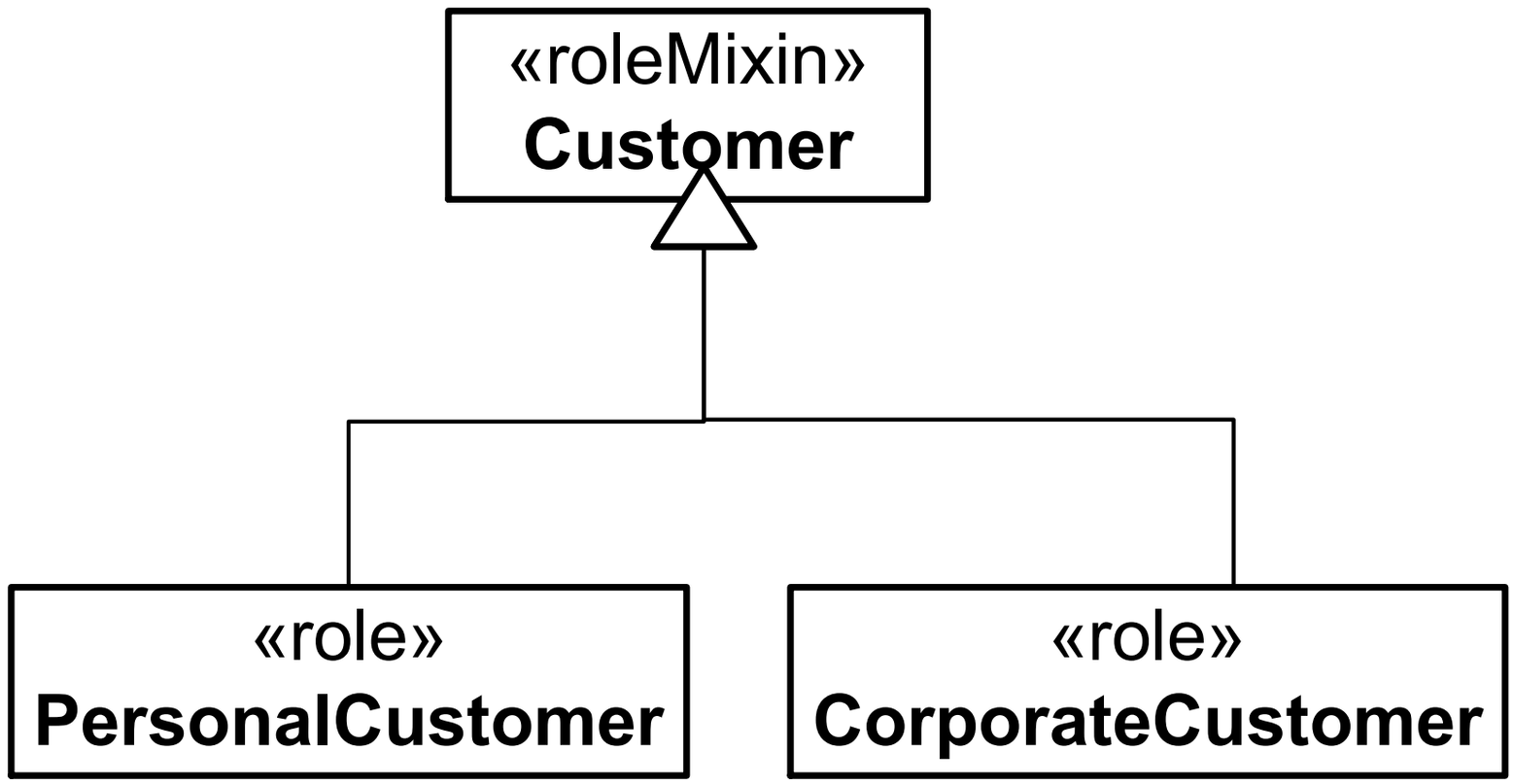


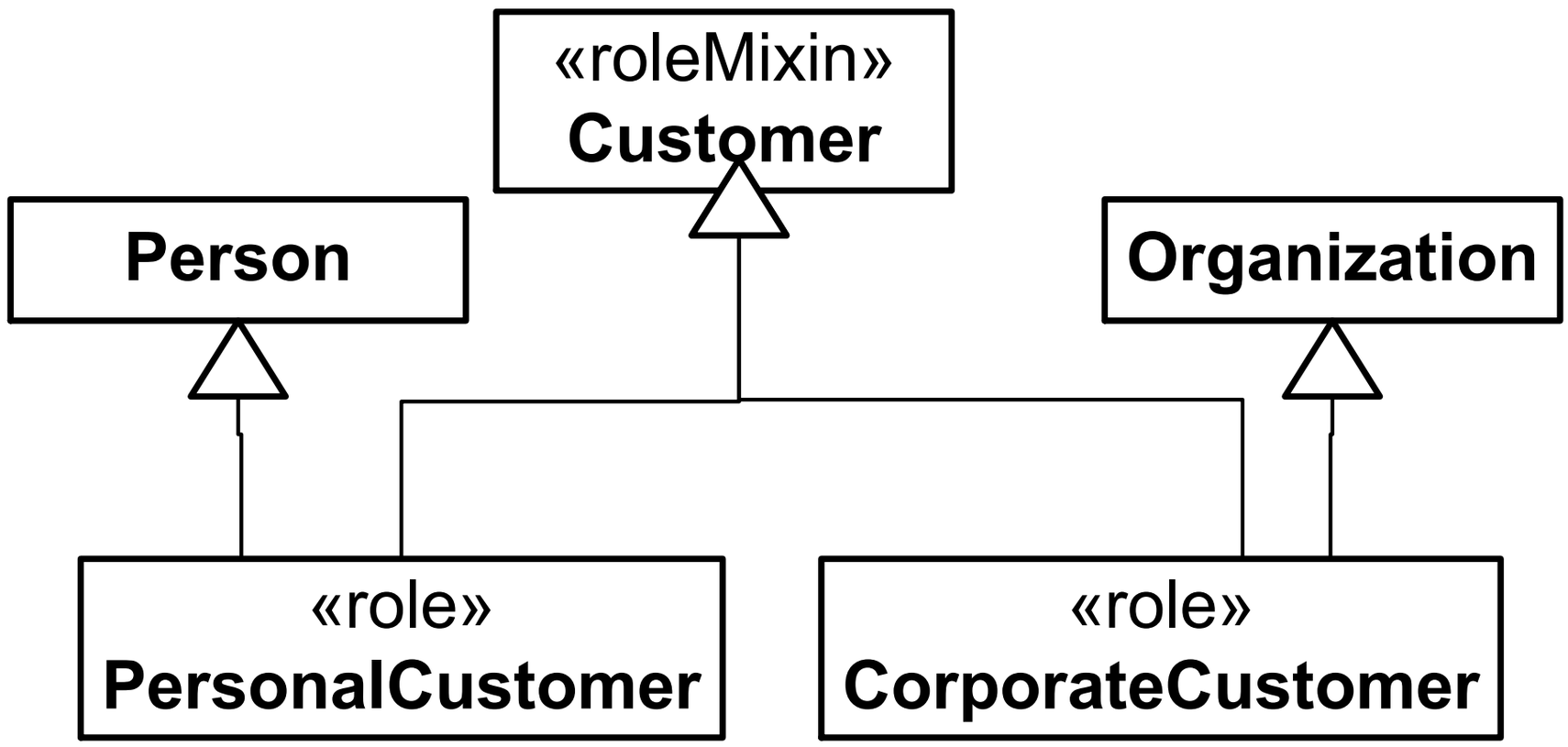

«role»
Customer
«kind»
Person
«kind»
Organization

A Possible Alternative?

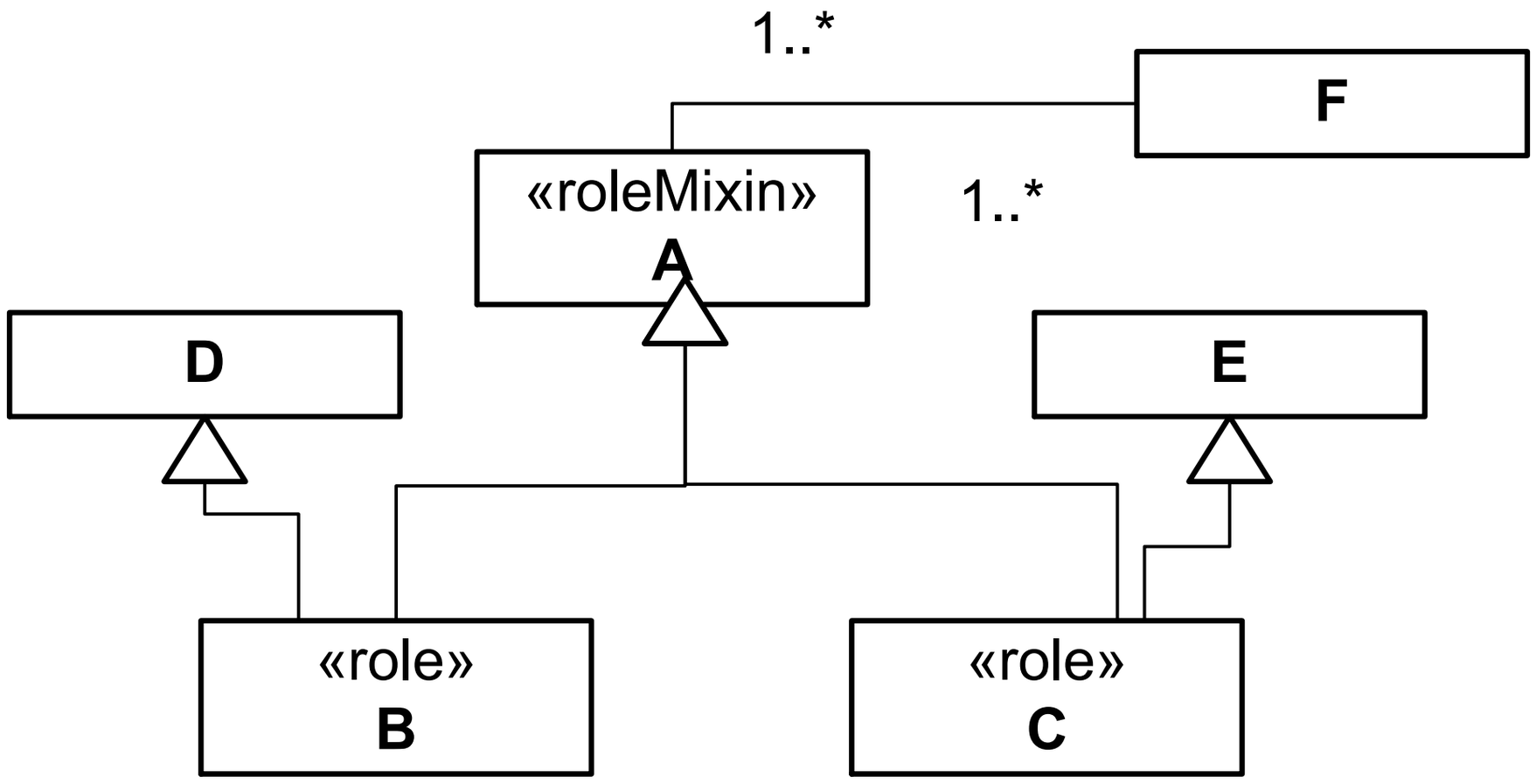


«roleMixin»
Customer


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


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

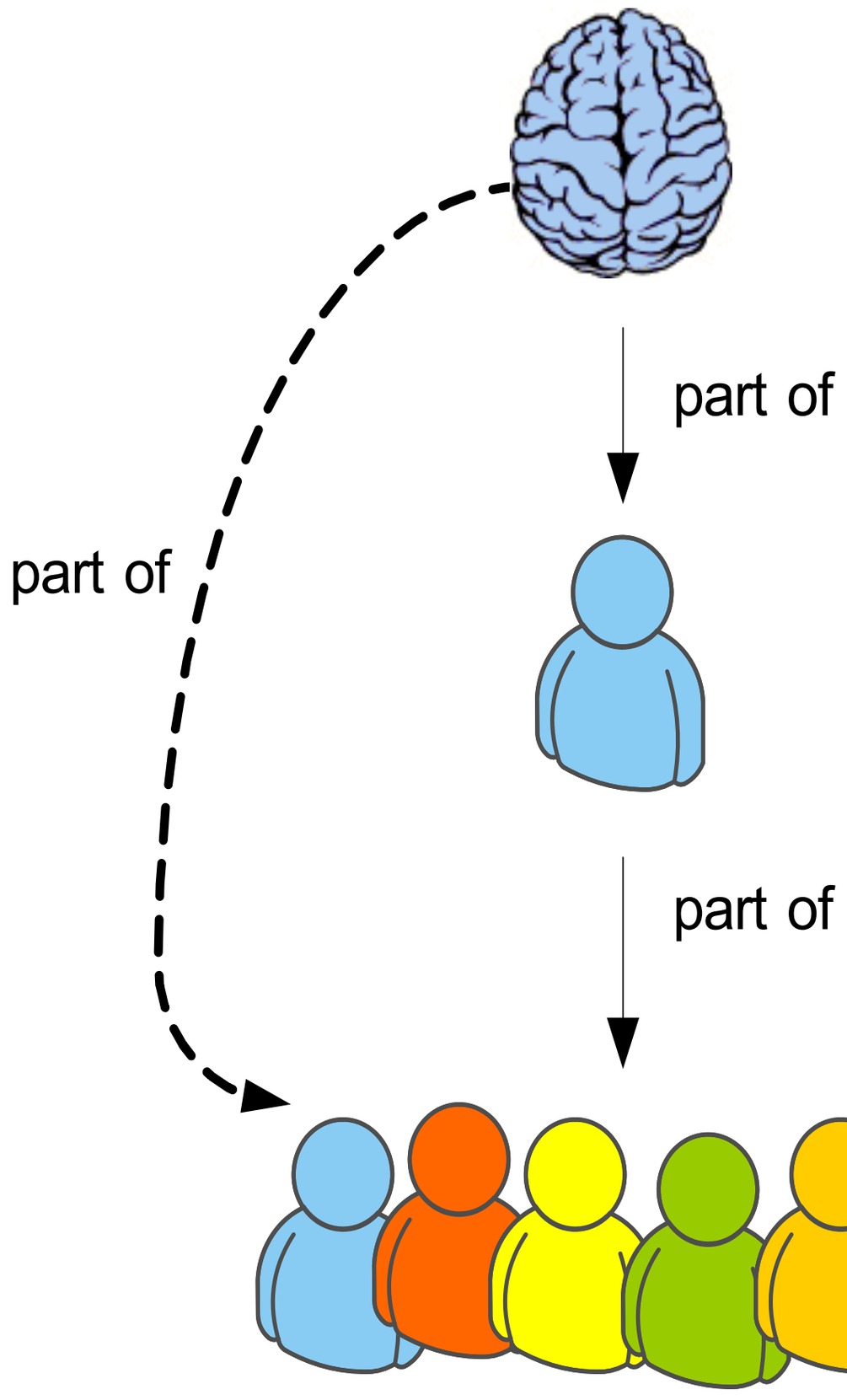
The emerging **RoleMixin** Pattern



Why is this important?

1. Ontologically well-defined, cognitively sound systems of types
2. Precise methodological guidelines for choosing how to model different elements in the universe of discourse

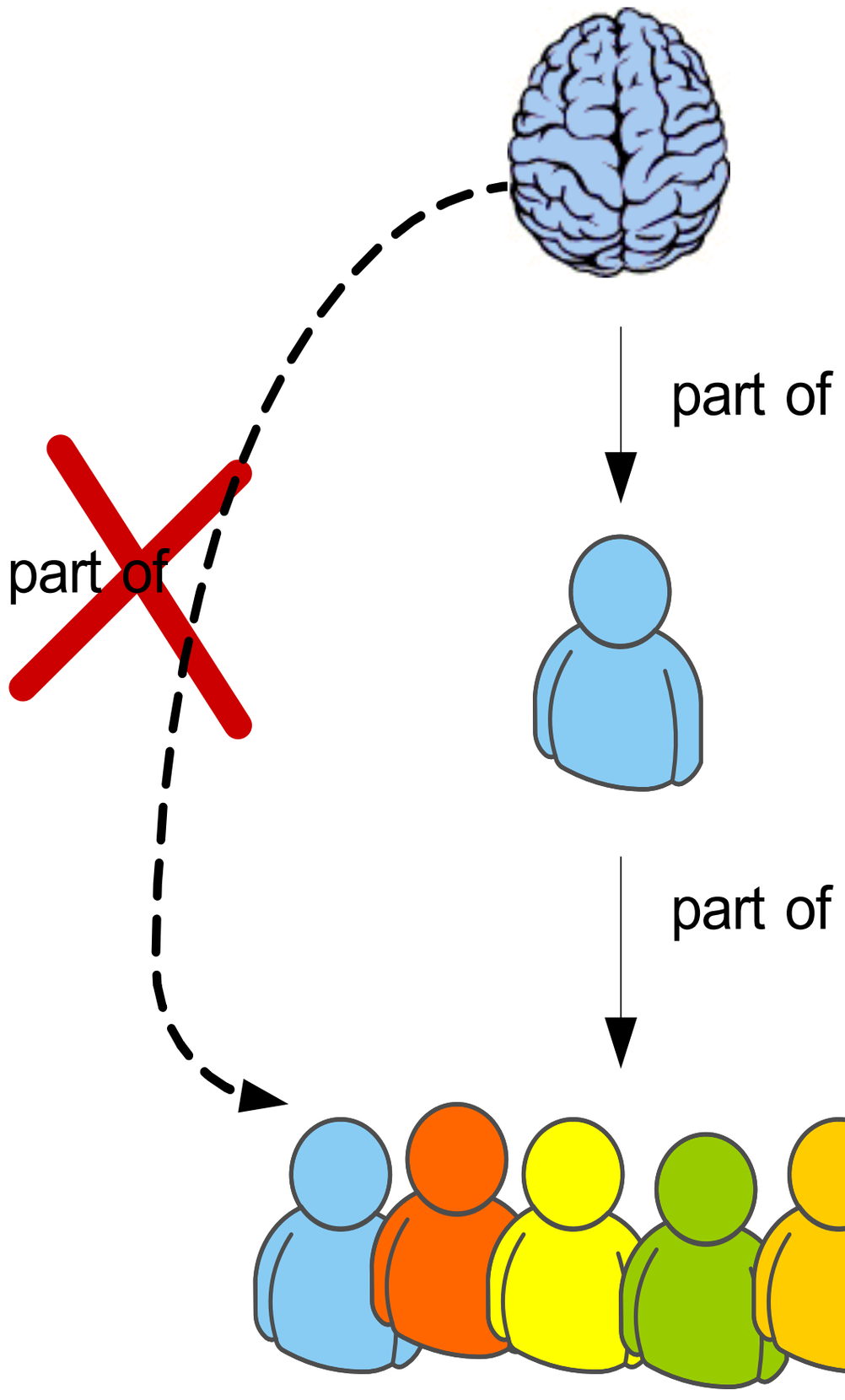
3. **Incorporation of ontological constraints in the language metamodel to guarantee ontological consistency by design**



John´s Brain

John

UNITN

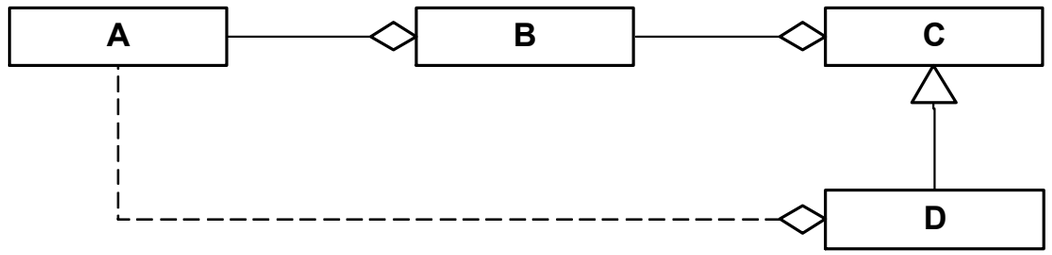


John´s Brain

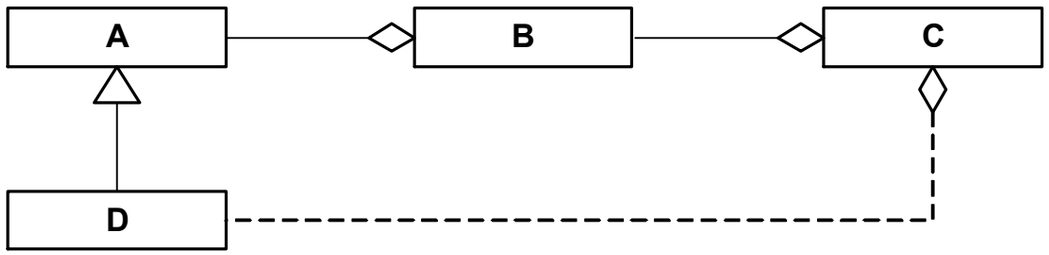
John

UNITN

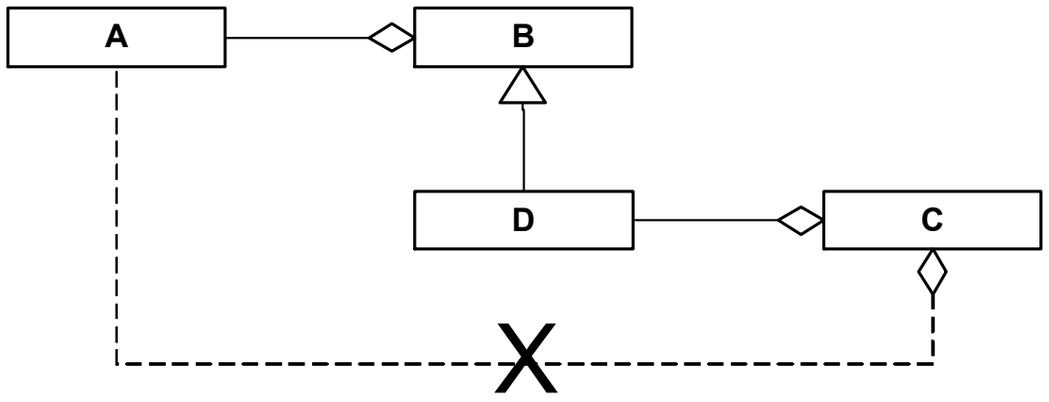
(a)



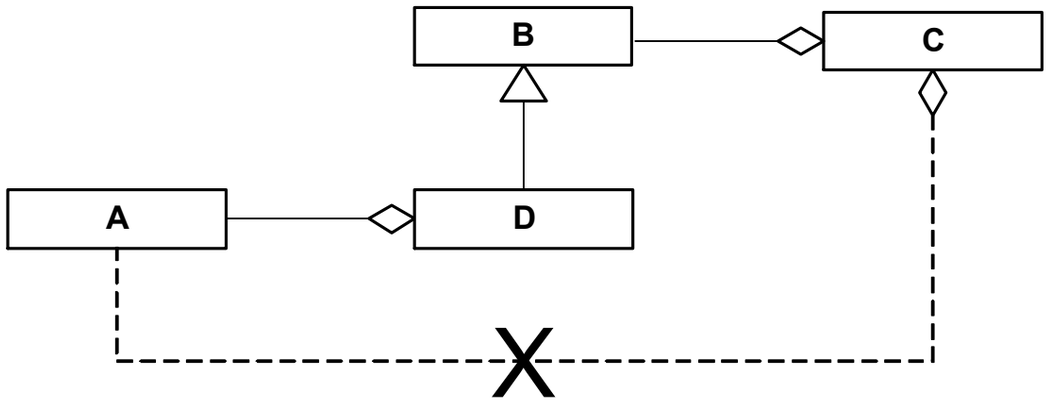
(b)



(c)



(d)



«category»
Blood Pump

Coronary Circulatory System

Circulatory System

Biological Heart

1 1 1 1

d_2 d_1 d_2 d_1

0..1 1 d_1 1 d_1

i_2 i_2

0..1

D

B (?)

Mitral Valve

Human Heart

«kind»
Person

1 1 1 1

d_2 d_1 d_2 d_2 d_1

1

0..1 1 1

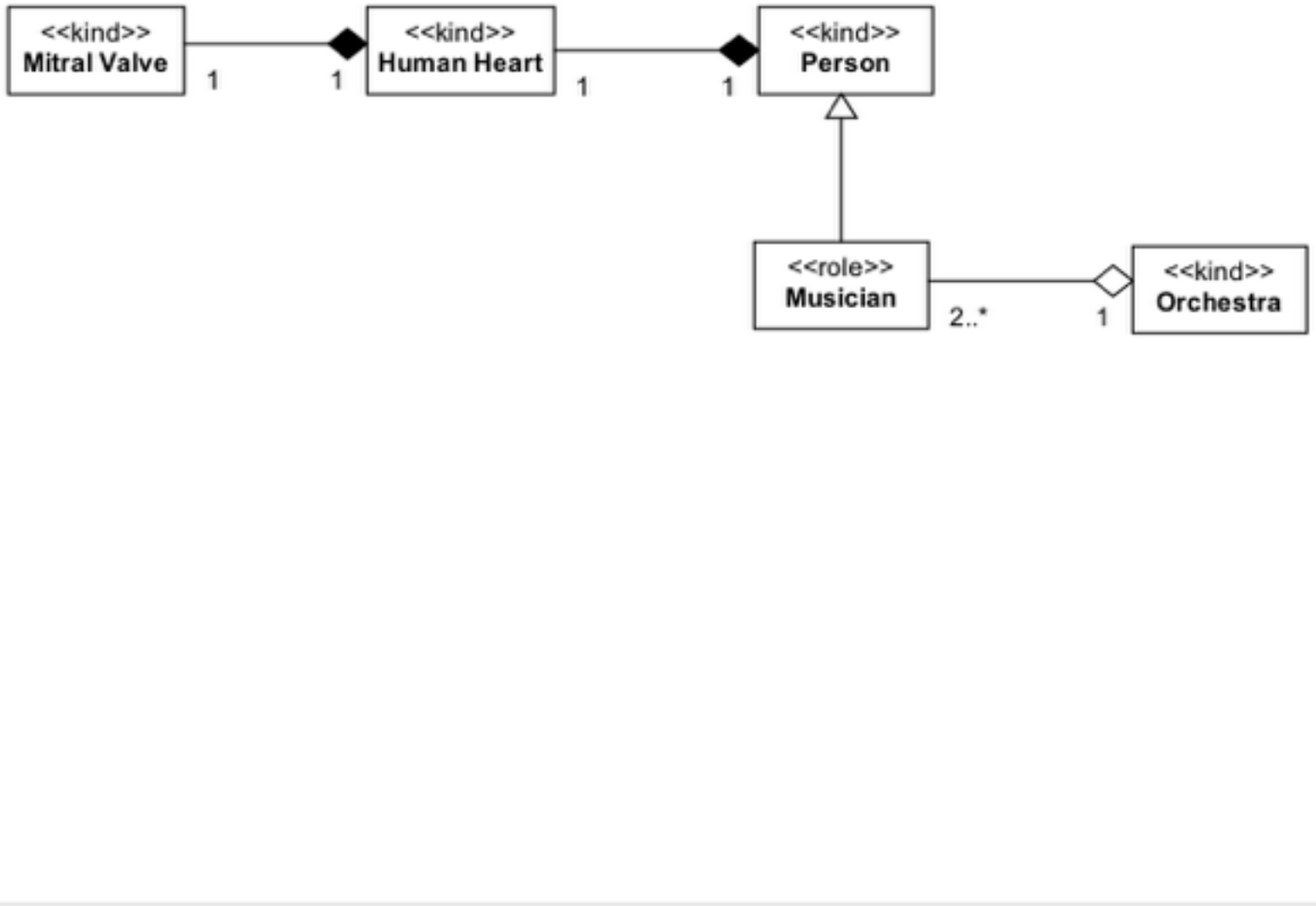
«role»
Musician

Orchestra

i_1 d_2 d_1

A (?)

Editor



Added: «componentof» componentof5

Welcome Diagram0*

Project Browser

OLED Project
Diagrams
Constraints
Model
«Kind» Hu
«Kind» Per
«Kind» Mit
«Compone
«Compone
«Role» Mu
Genera
«Kind» Orc
«Compone

System Preferences

OLED – ER2014+1.oled

Transitivity in Part-Whole Relations

Pre-Condition | Forbidden | Derived

Please select the derivations you would like to validate on your model:

- [x] Derive Functional Parthood
- [ ] Derive Membership and SubCollections
- [ ] Derive SubQuantities

The following part-whole relations can be inferred from your model:

Persist All | Fix

Whole	Part	Stereotype	Pattern	Path	Exists?	Has Fix?
«Kind» Person	«Kind» Mitral Valve	COMPONENTOF	Direct Functional ...	Person -> Human Heart -> Mitral Valve		
«Role» Musician	«Kind» Mitral Valve	COMPONENTOF	Indirect Functiona...	Musician -> Human Heart -> Mitral Valve		
«Role» Musician	«Kind» Human Heart	COMPONENTOF	Indirect Functiona...	Musician -> Human Heart		

100%

Check | Stop

Output Console:

```
Functional Parts Derivation: deriving direct functional parts
Functional Parts Derivation: 1 direct functional parts derived
Functional Parts Derivation: deriving indirect functional parts (type 2)
Functional Parts Derivation: 0 indirect functional parts (type 2) derived
Functional Parts Derivation: deriving indirect functional parts (type 3)
Functional Parts Derivation: 2 indirect functional parts (type 3) derived
Functional Parts Derivation: derivation completed!
Functional Parts Derivation: a total of 3 relations were derived!
```

Apply | Save | Close

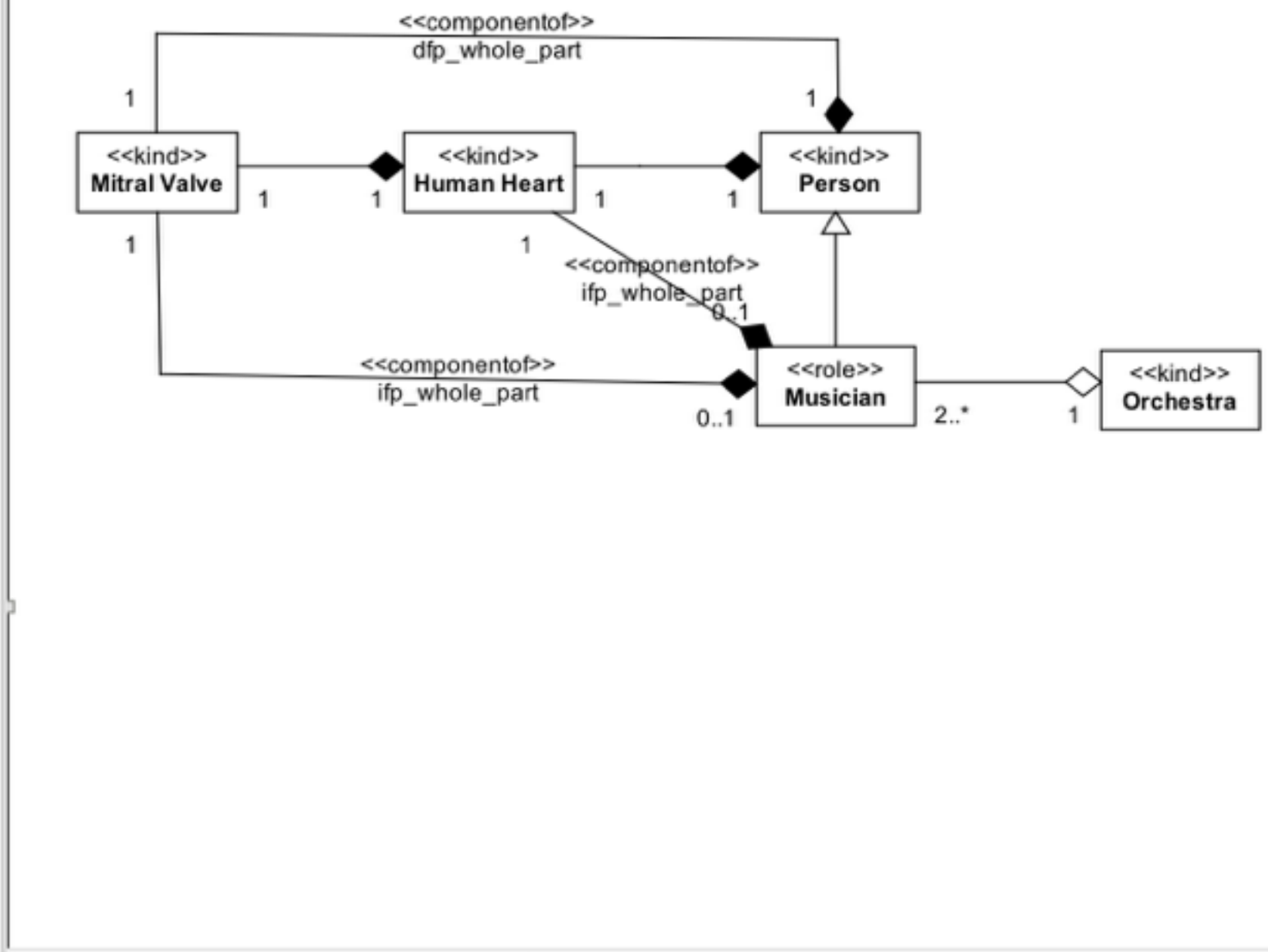
Project Browser

OLED Project
- Diagrams
- Constraints
- Model
  - «Kind» Hu
  - «Kind» Per
  - «Kind» Mit
  - «Compone
  - «Compone
  - «Role» Mu
  - Genera
  - «Kind» Orc
  - «Compone

Added: «componentof» componentof5

Welcome | Diagram0* ×

Editor



Connection point edited: «componentof» ifp_whole_part

Welcome | Diagram0* ×

Project Browser

OLED Project
Diagrams
Constraints
Model
«Kind» Hun
«Kind» Pers
«Kind» Mitr
«Componen
«Componen
«Role» Mus
Genera
«Kind» Orc
«Componen
«Componen
«Componen
«Componen
«Componen

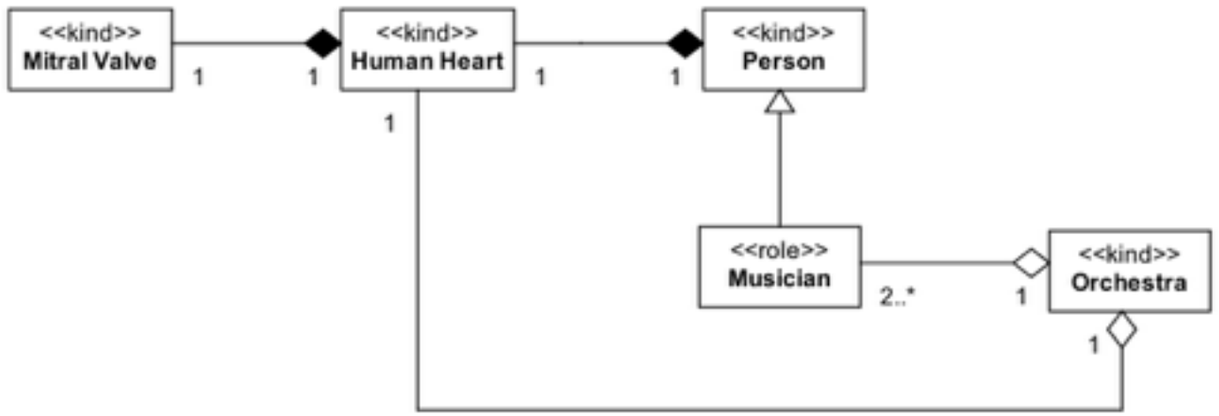
OLED File Edit Diagram View Project Verification Validation Transformation Help 8% Sat 06:56 Giancarlo Guizzardi

OLED – ER2014+1.oled

Toolbox

- Elements
  - Pointer
  - Category
  - Collective
  - Data Type
  - Enumeration
  - Kind
  - Mixin
  - Mode
  - Nominal Quality
  - Non Perceivable Quality
  - Perceivable Quality
  - Phase
  - Primitive Type
  - Quantity
  - Relator
  - Role
  - Role Mixin
  - SubKind
  - Association
  - Characterization
  - ComponentOf
  - Derivation
- Patterns
- Derived Patterns

Editor



100%

Connection point edited: «null» [unnamed]

Welcome Diagram0*

Project Browser

- OLED Project
  - Diagrams
  - Constraints
  - Model
    - «Kind» Human Heart
    - «Kind» Person
    - «Kind» Mitral Valve
    - «ComponentOf» componentOf2
    - «ComponentOf» componentOf4
    - «Role» Musician
      - Generalization Person
    - «Kind» Orchestra
    - «ComponentOf» componentOf5
    - «ComponentOf» componentOf6

Transitivity in Part-Whole Relations

Pre-Condition | Forbidden | Derived

To validate the transitivity of part-whole relations, the model must pass the following tests:

- [x] Forbidden MemberOf
- [x] Forbidden ComponentOf

Fix

The following part-whole relations characterize errors:

Whole	Part	Name	Stereotype	Description	...
Orchestra	Human Heart	componentOf6	ComponentOf	Pattern 4«Kind» 'Orchestra' -> «Kind» 'Person' -> «Kin...	...

100%

Check | Stop

Output Console:

```
(Edge) Human Heart -> Mitral Valve
Intransitve ComponentOf: Analyzing graph...
Intransitive ComponentOf: Identifying indirect functional parthood paths...
Intransitive ComponentOf: Identifying alternative paths between functinal parthoods...
Intransitve MemberOf: Analysis successfuly concluded!
Intransitve MemberOf: 0 forbidden relations found!
Intransitve ComponentOf: Analysis successfully concluded!
Intransitve ComponentOf: 1 forbidden relations found!
```

Apply | Save | Close

Project Browser

- OLED Project
- Diagrams
- Constraints
- Model
- «Kind» Hu
- «Kind» Per
- «Kind» Mit
- «Compone
- «Compone
- «Role» Mu
- Genera
- «Kind» Orc
- «Compone
- «Compone

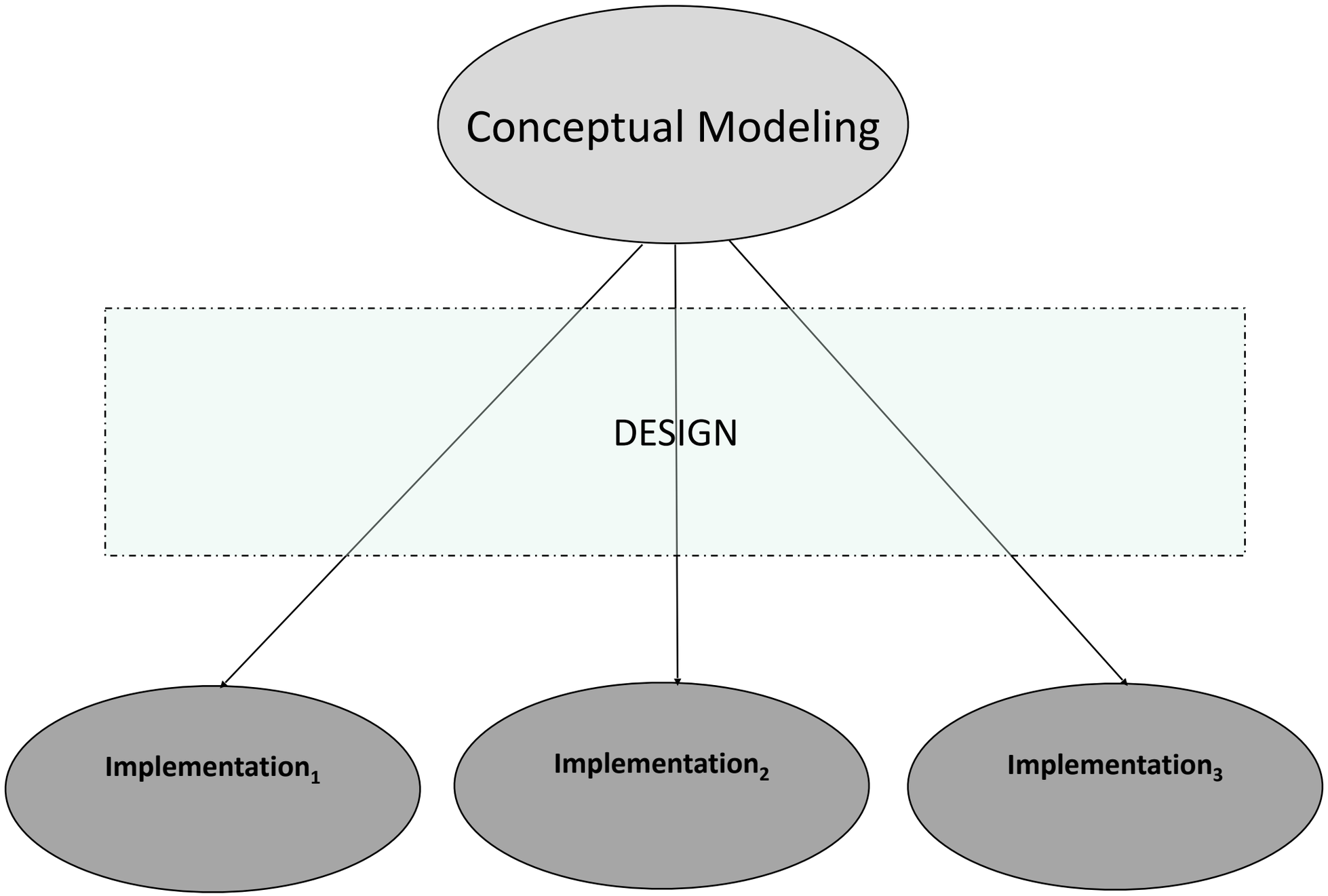
Connection point edited: «null» [unnamed]

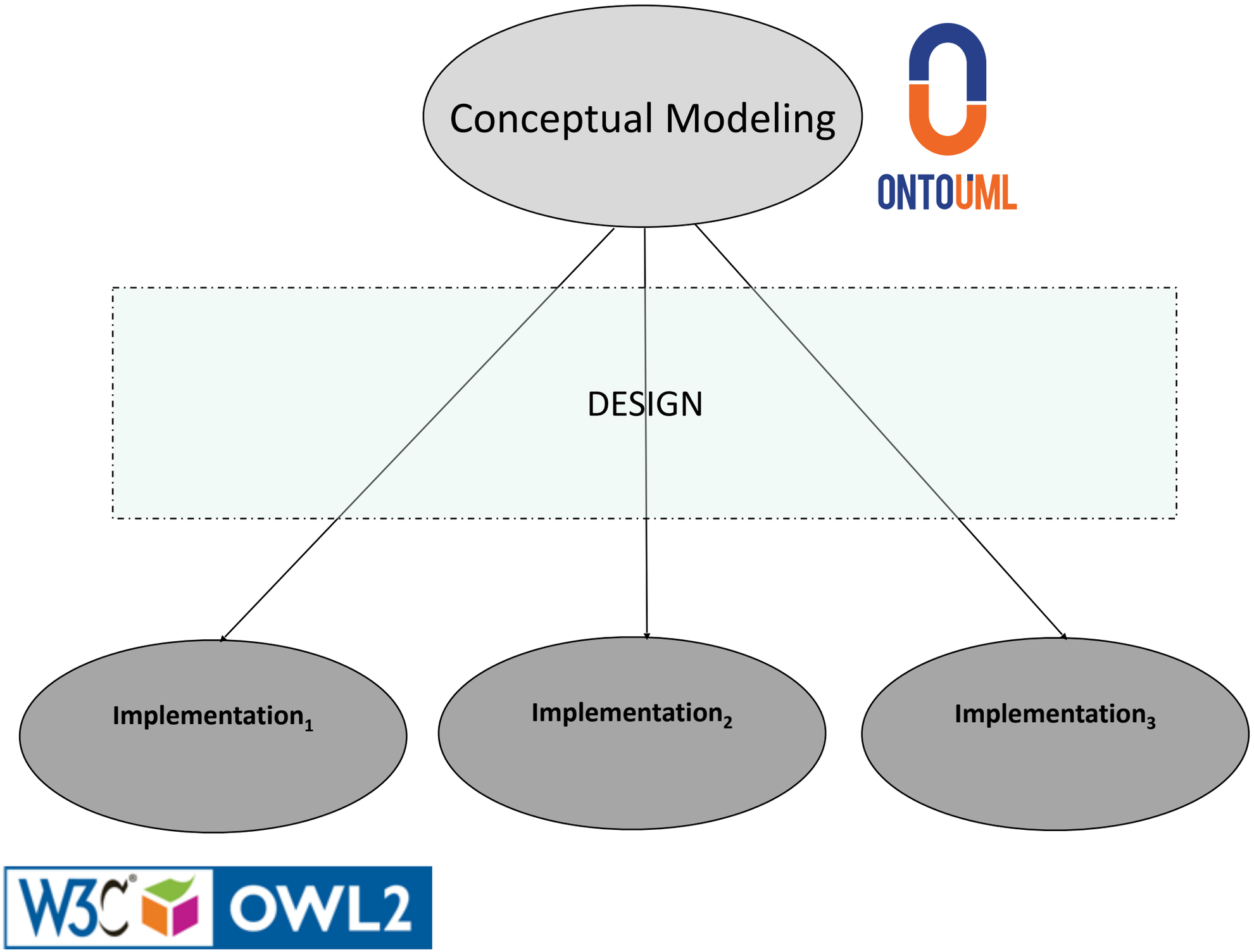
Welcome | Diagram0*

Why is this important?

4

Precise methodological guidelines for mapping into different implementation environments


Conceptual Modeling
DESIGN
Implementation1
Implementation2
Implementation3


Conceptual Modeling
ONTOUML
DESIGN
Implementation1
Implementation2
Implementation3
W3C OWL2

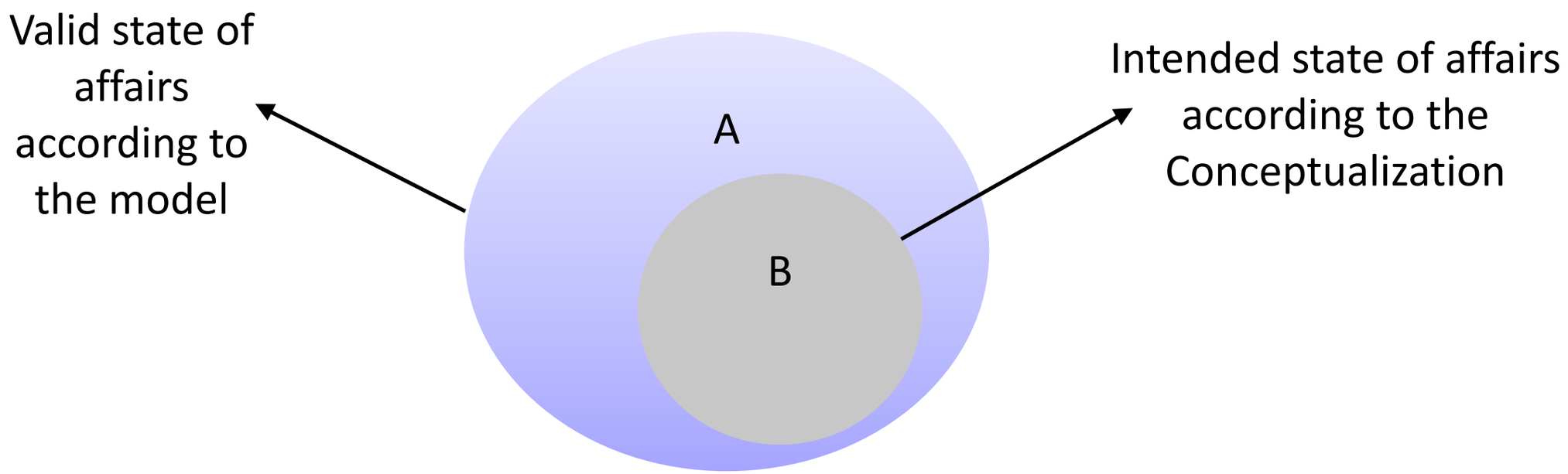
Why is this important?

5

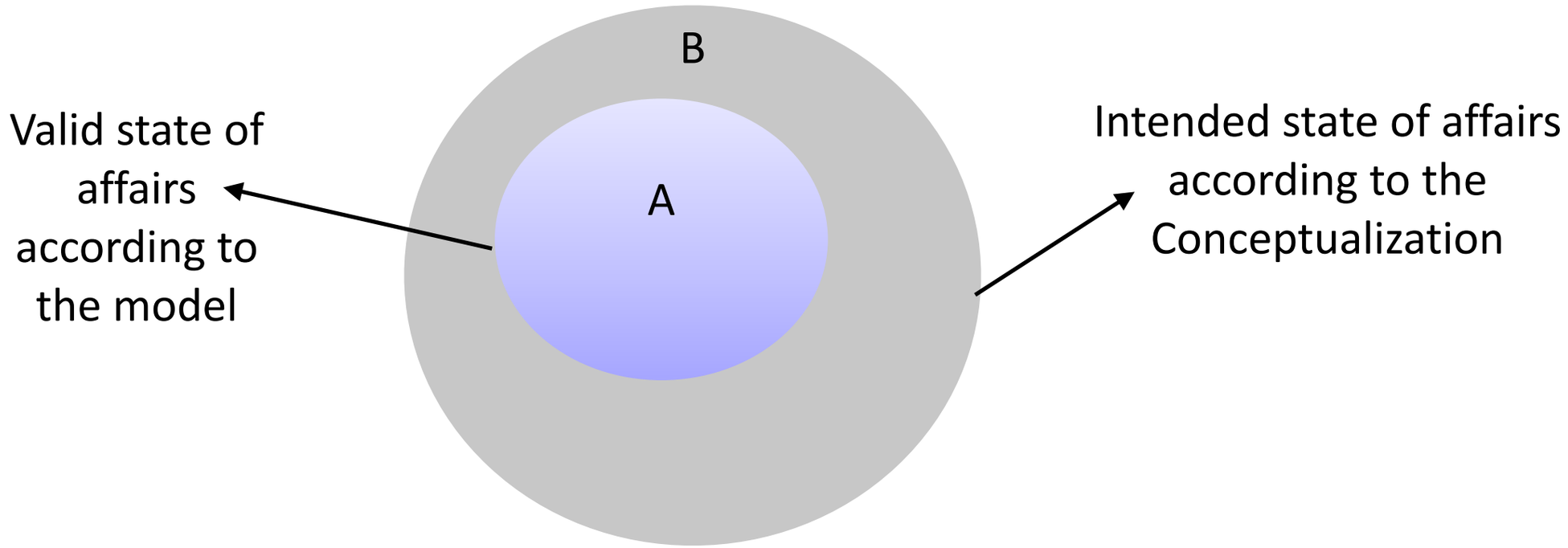
Precise modal semantics with implications for validation

Valid state of affairs
according to the representation

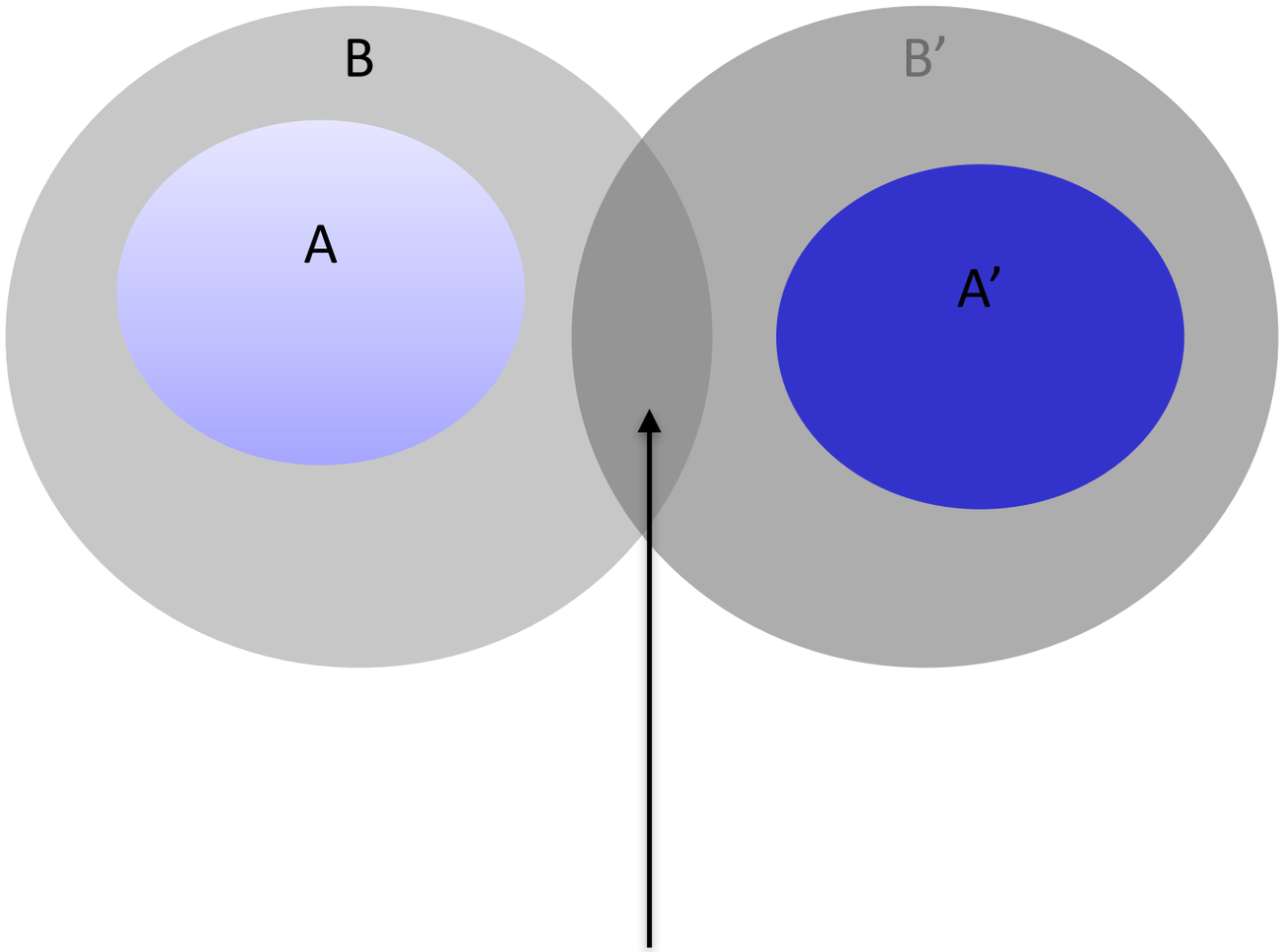
Intended state of affairs
according to the Conceptualization

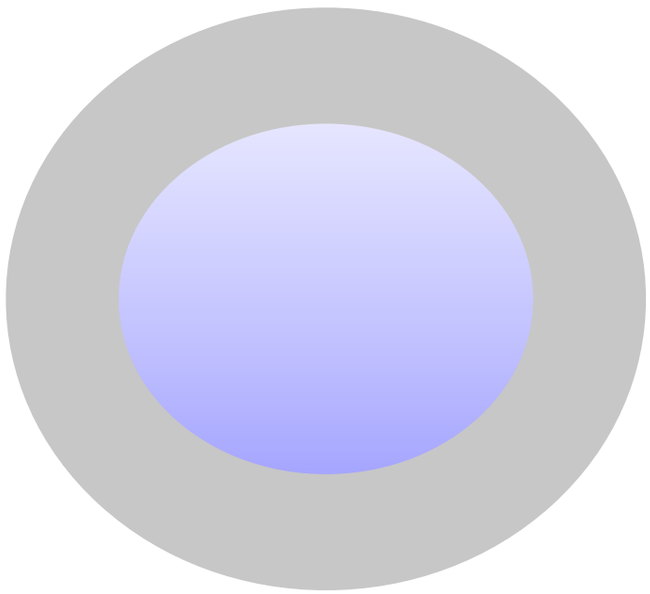


Under-constraining

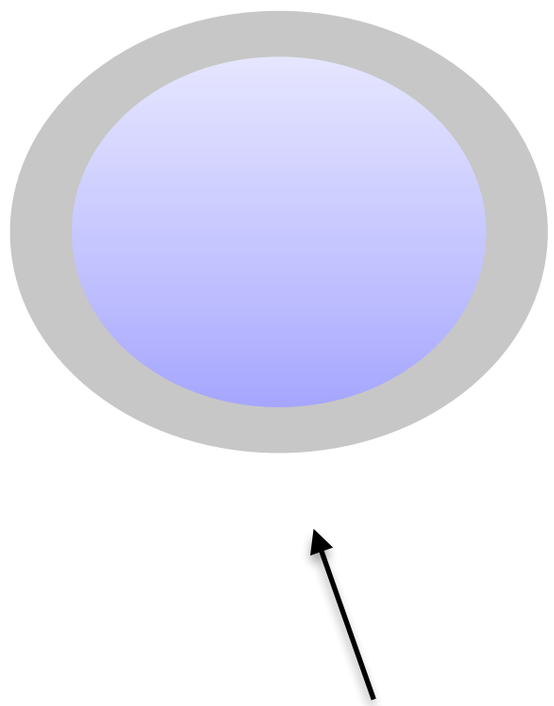


Over-constraining

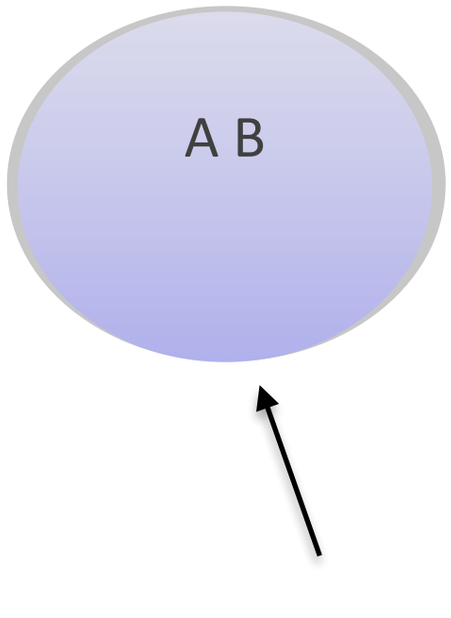

B
B’
A
A’
False Agreement



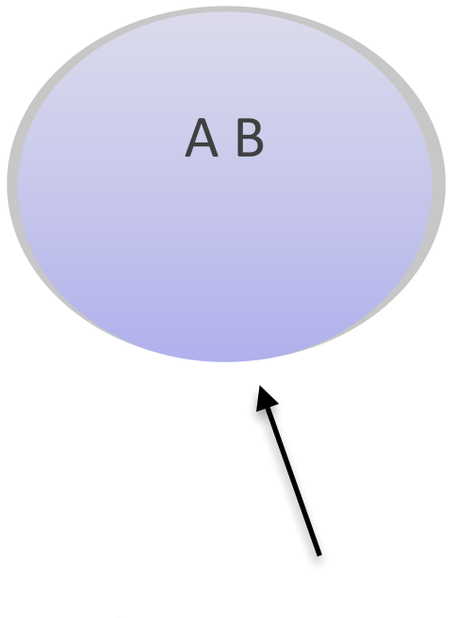
Constraints



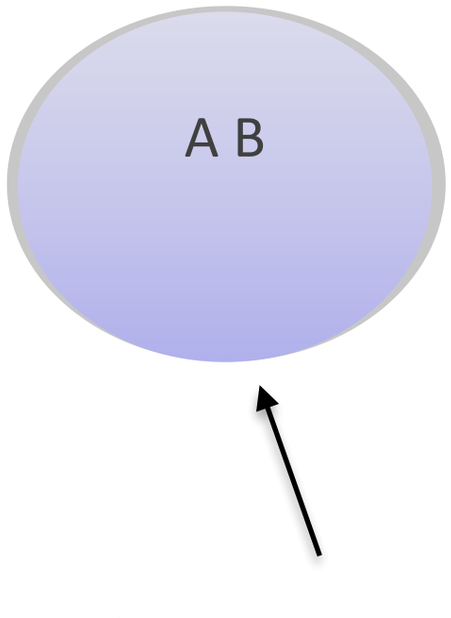
Constraints



Constraints

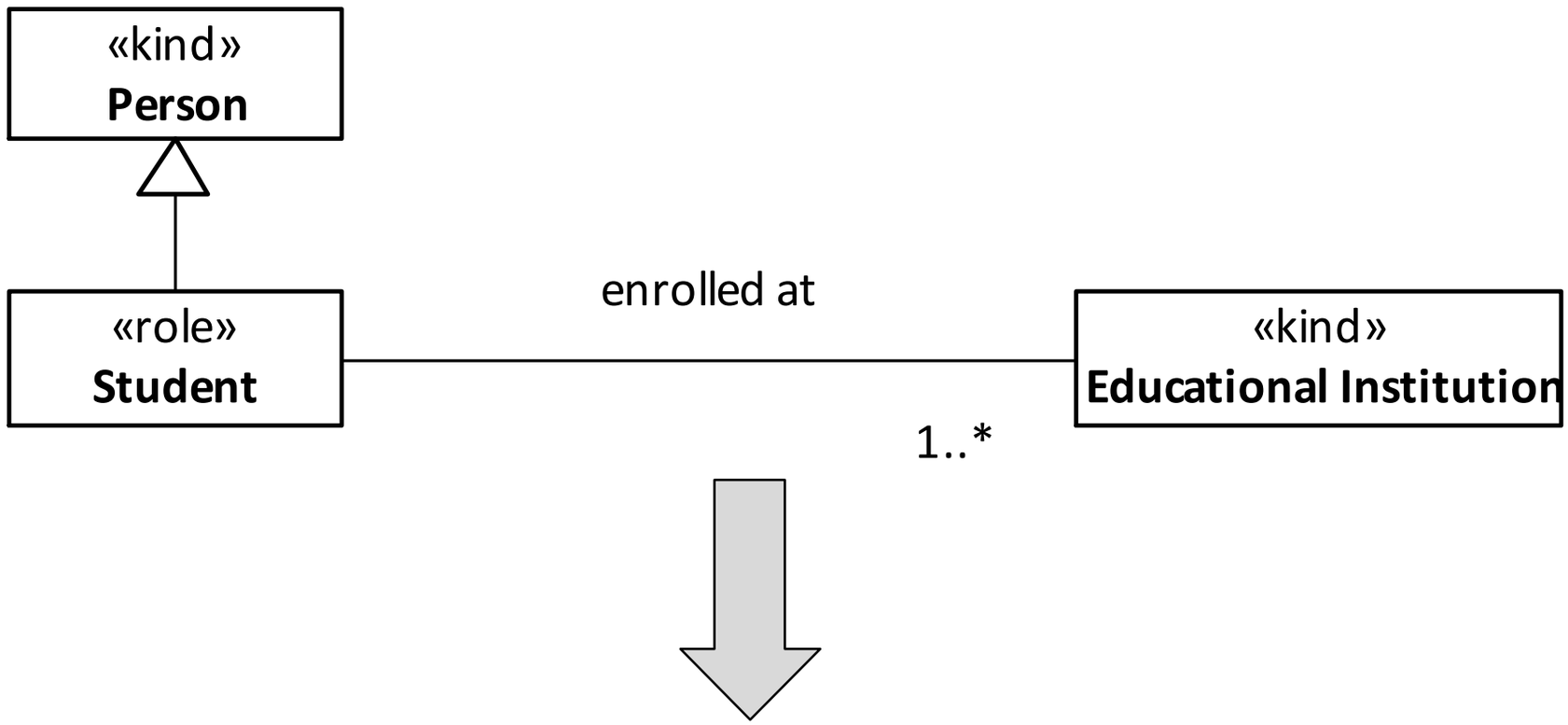


Conceptual Model = Structure + Axiomatization



Conceptual Model = Structure + Axiomatization

(**Ontological Commitment**)



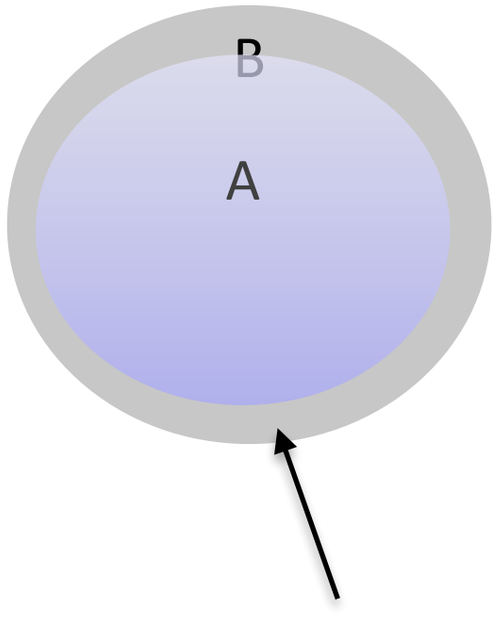
□(∀x **Person(x)** → □(**Person(x)**))

□(∀x **Student(x)** → ◊(¬**Student(x)**))

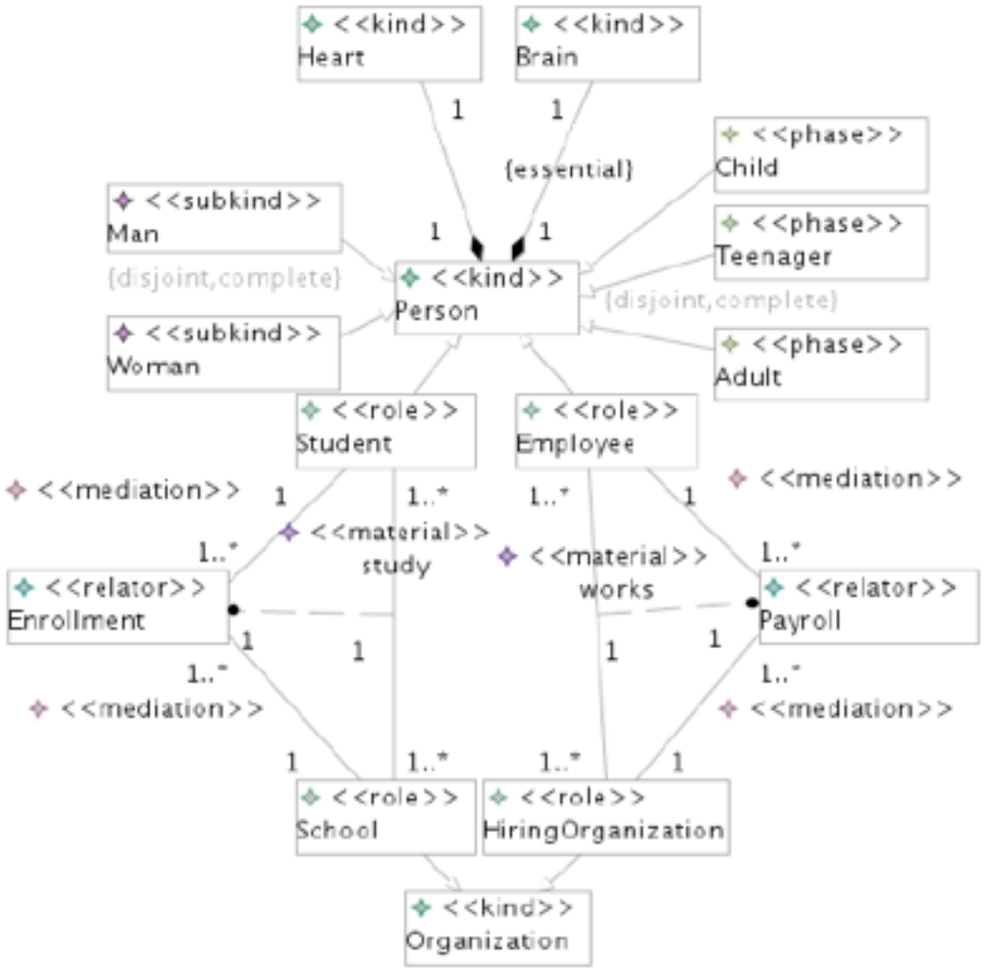
□(∀x **Student(x)** → **Person(x)**)

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

…



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

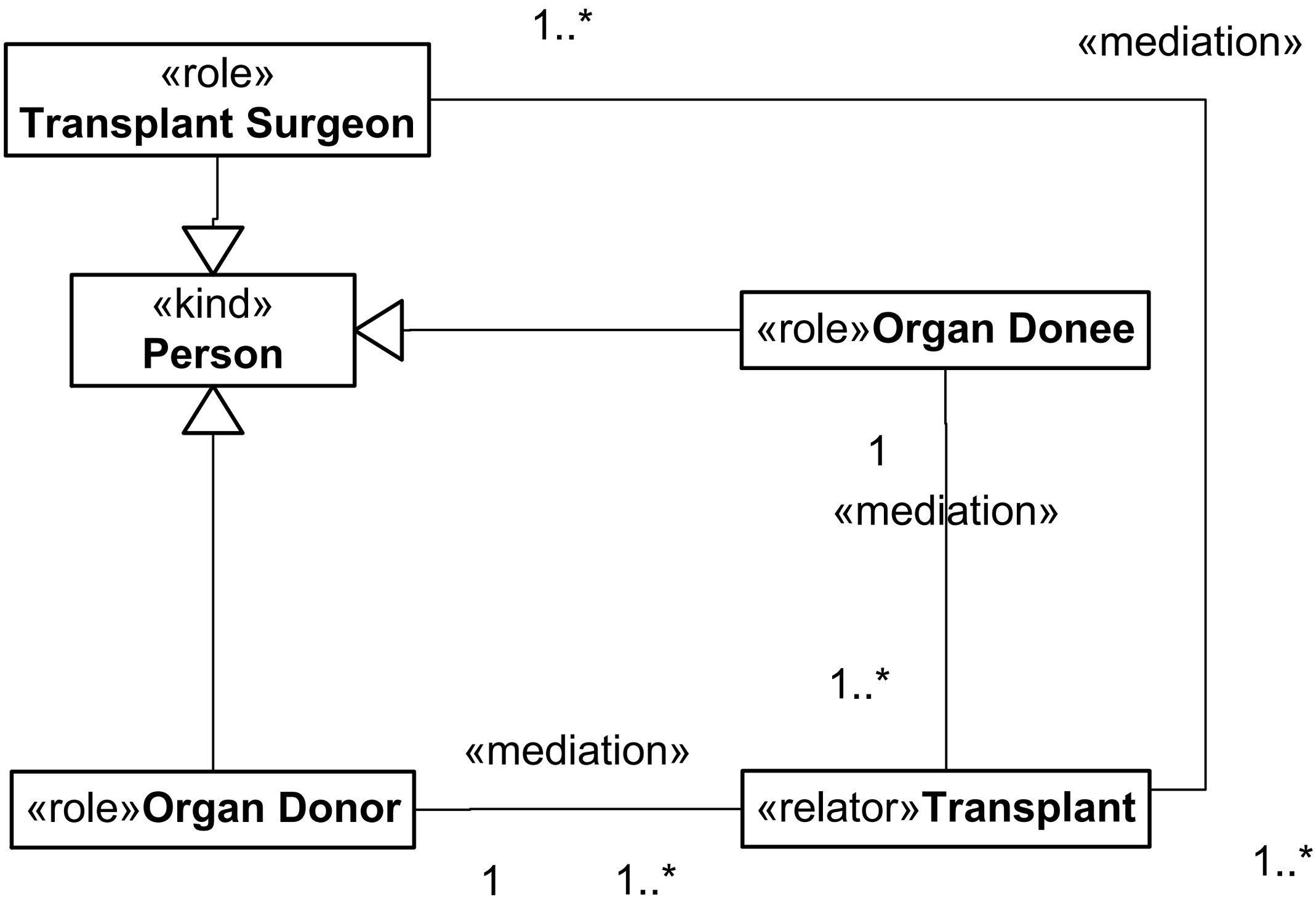


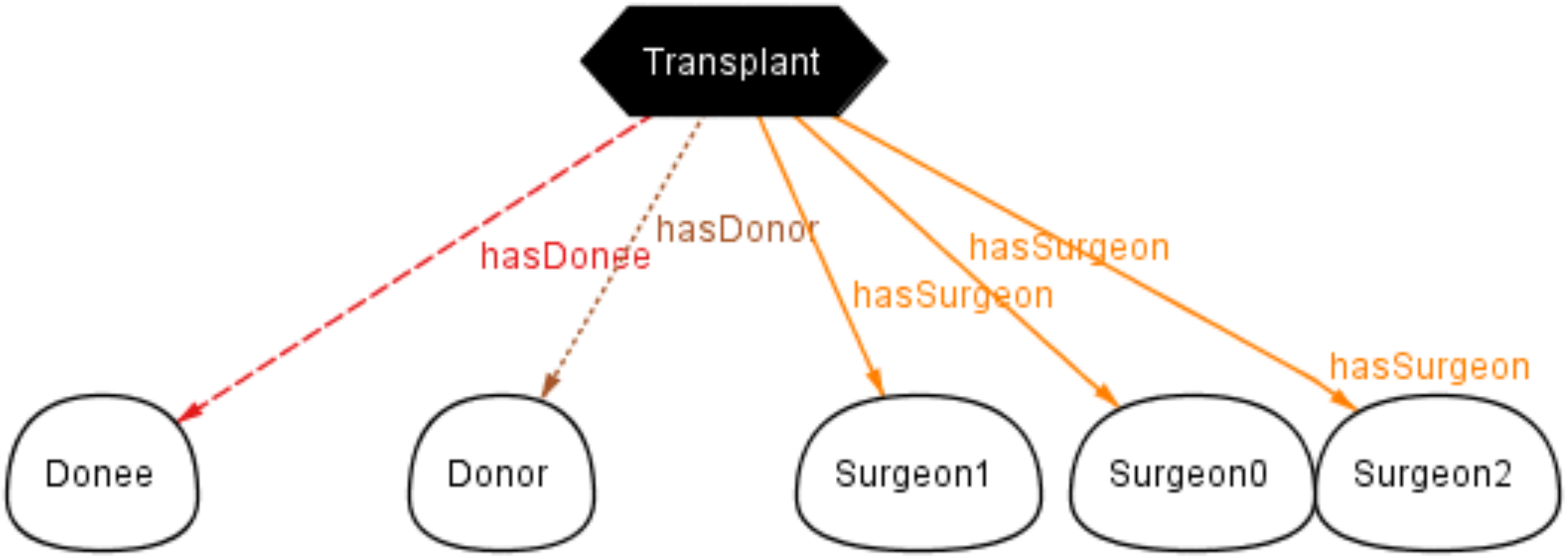
ATL Transformation

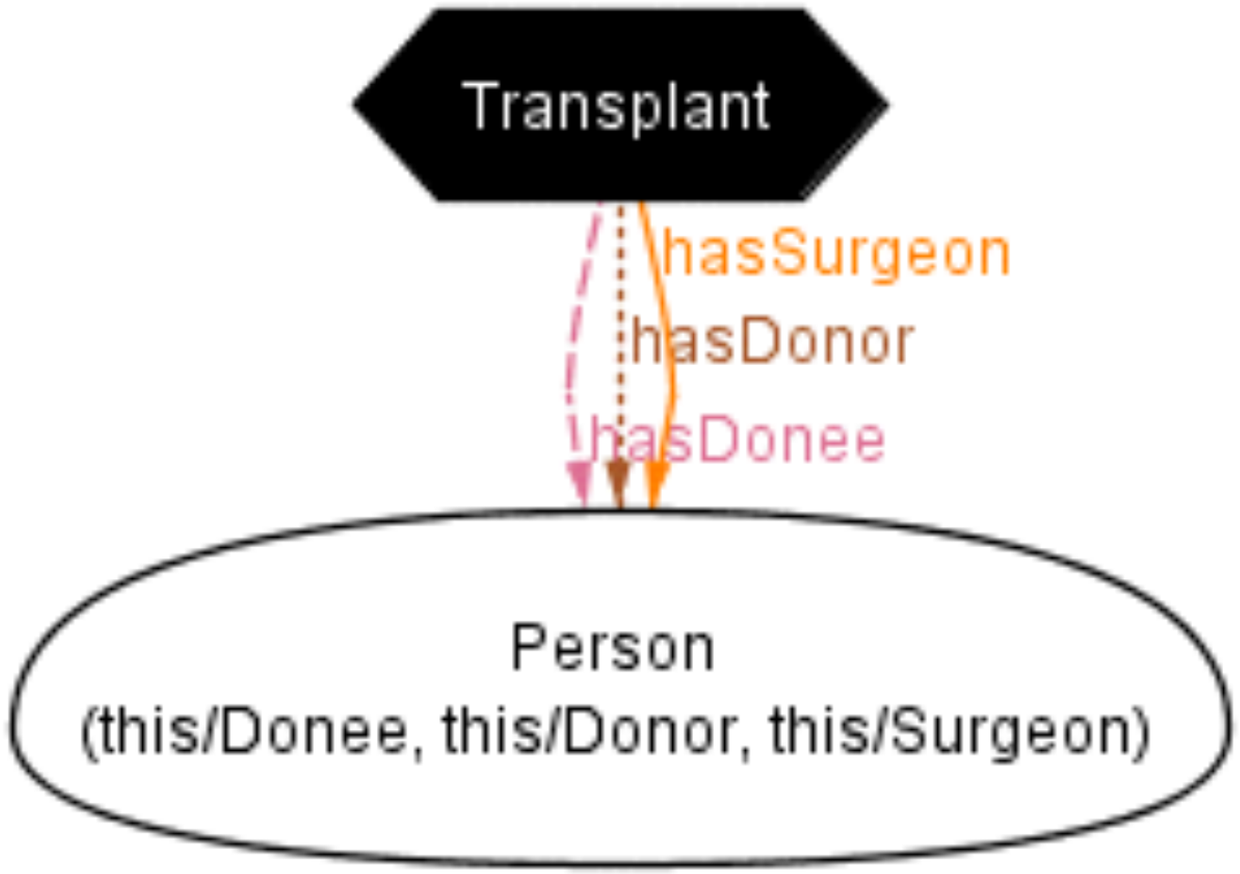
```
1 sig Person_Set in Concept { Person: some World }
2 {
3   Person in existsIn
4   all w1: World | w1 in Person => (all w2:
        w1.access | (w2 in existsIn) => (w2 in
        Person)) -- Rigidity
5   some w: World | w in this.Child -- Phase
6   some w: World | w in this.Teenager -- Phase
7   some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

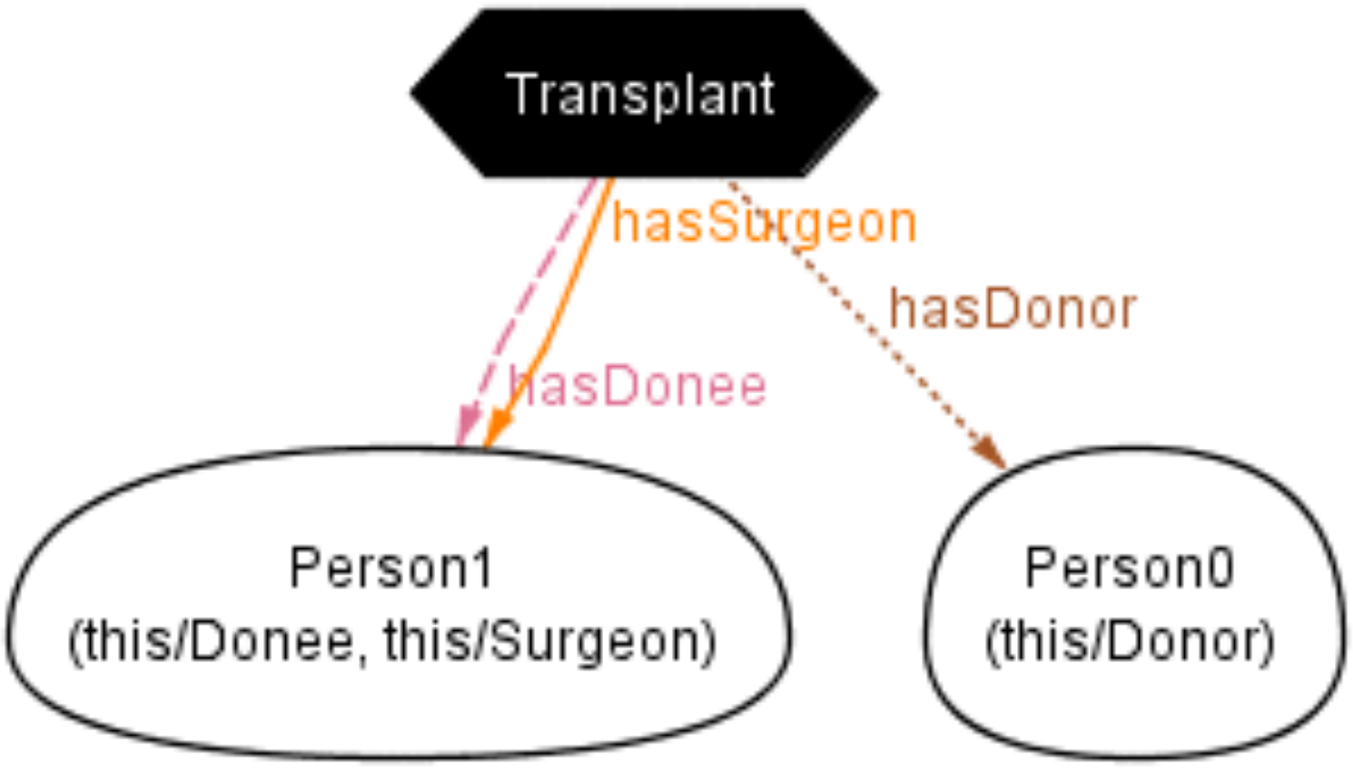
Simulation and Visualization

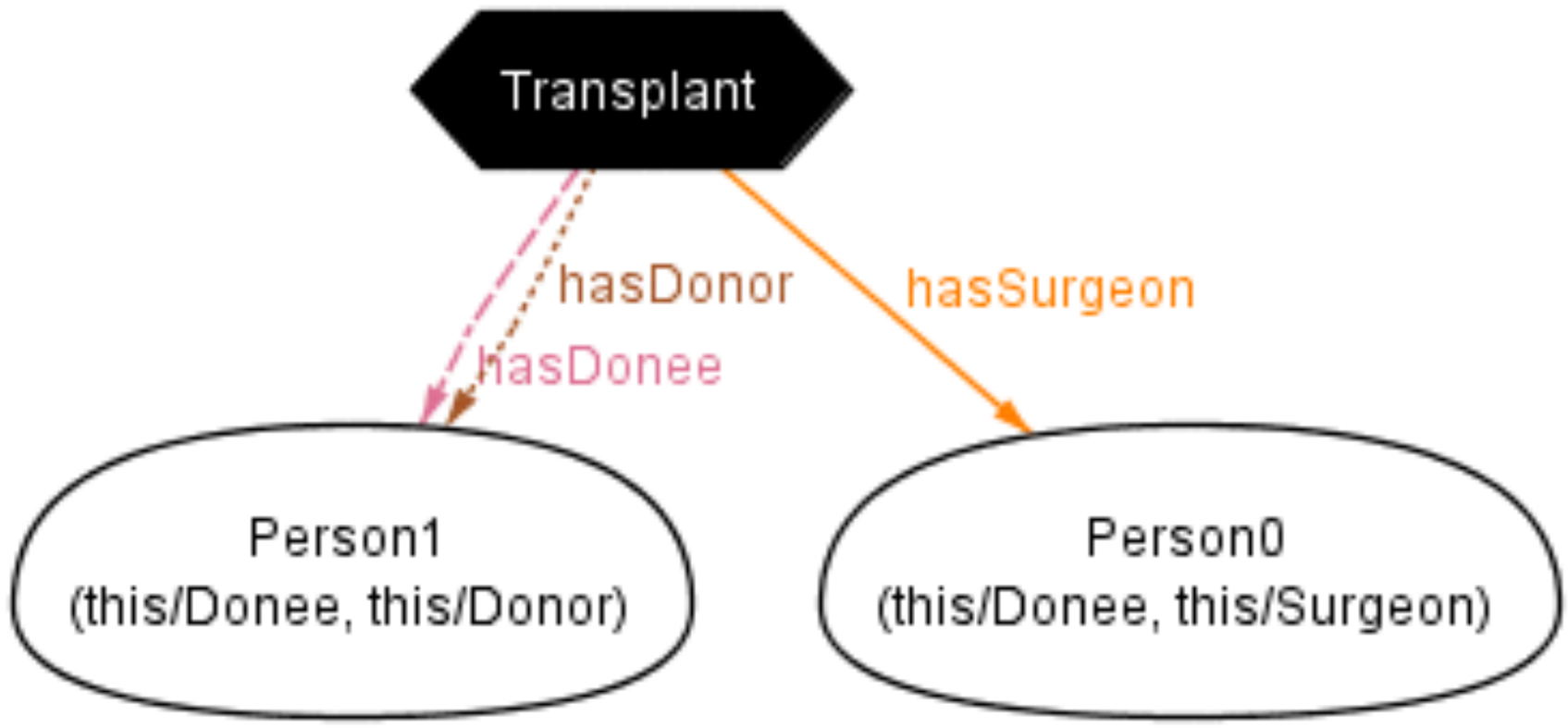
Alloy Analyzer + OntoUML visual Plugin

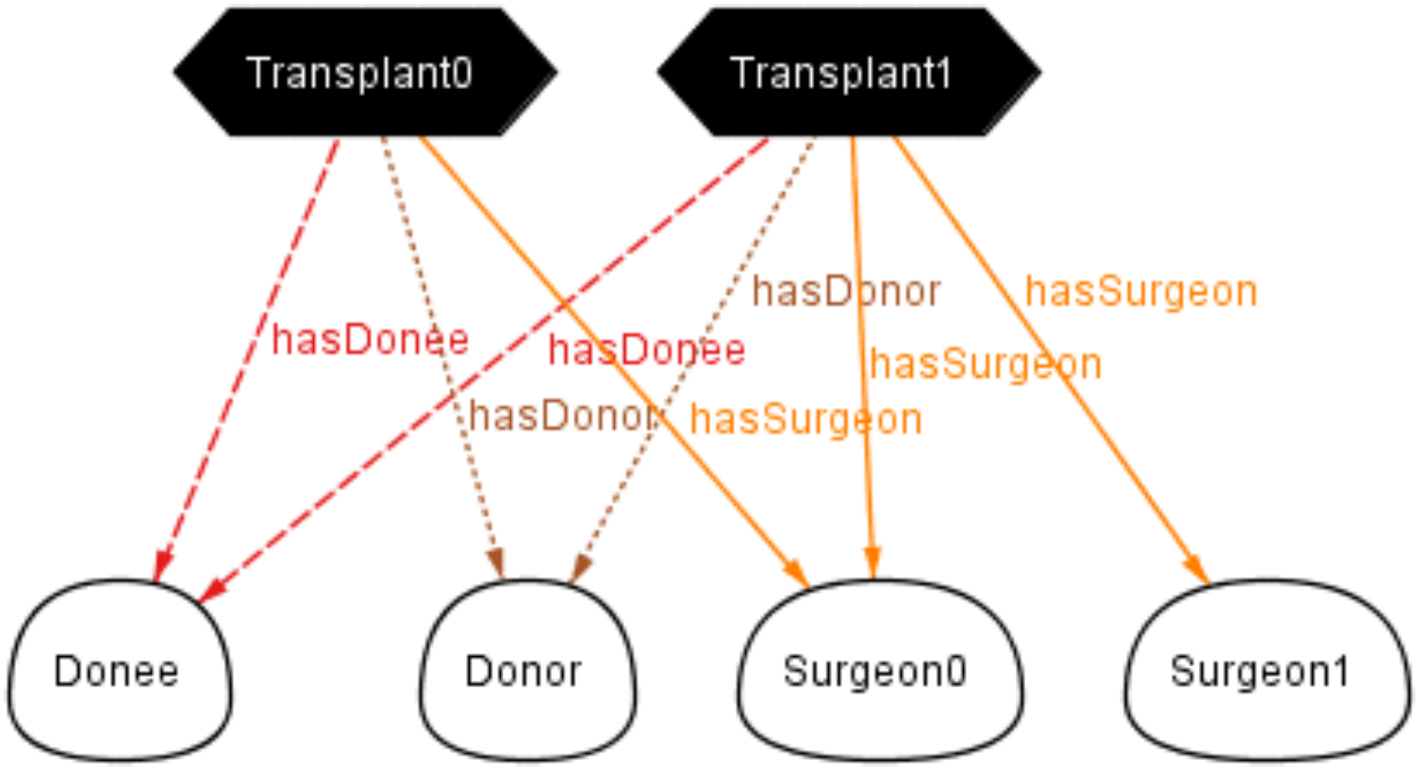

1..*
«mediation»
«role»
Transplant Surgeon
«kind»
Person
«role»Organ Donee
1
«mediation»
1..*
«mediation»
«role»Organ Donor
«relator»Transplant
1
1..*
1..*


Transplant
hasDonee
hasDonor
hasSurgeon
hasSurgeon
hasSurgeon
Donee
Donor
Surgeon1
Surgeon0
Surgeon2

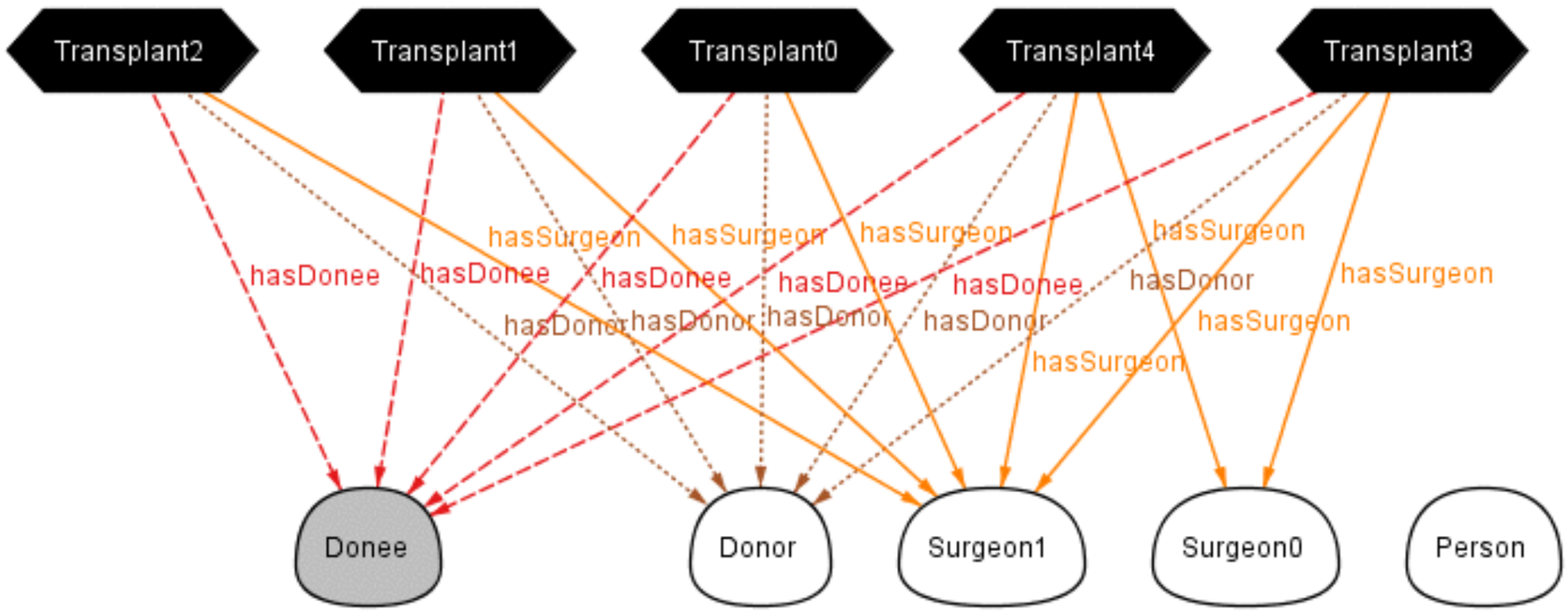

Transplant
hasSurgeon
hasDonor
hasDonee
Person
(this/Donee, this/Donor, this/Surgeon)


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


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



Real-Word Semantics



Data Modeling Guide (DMG)

For An Enterprise

Logical Data Model (ELDM)

Version 2.3

March 15, 2011

Data Modeling Guide (DMG) For An Enterprise Logical Data Model, V2.3; 15 March 2011

Preface

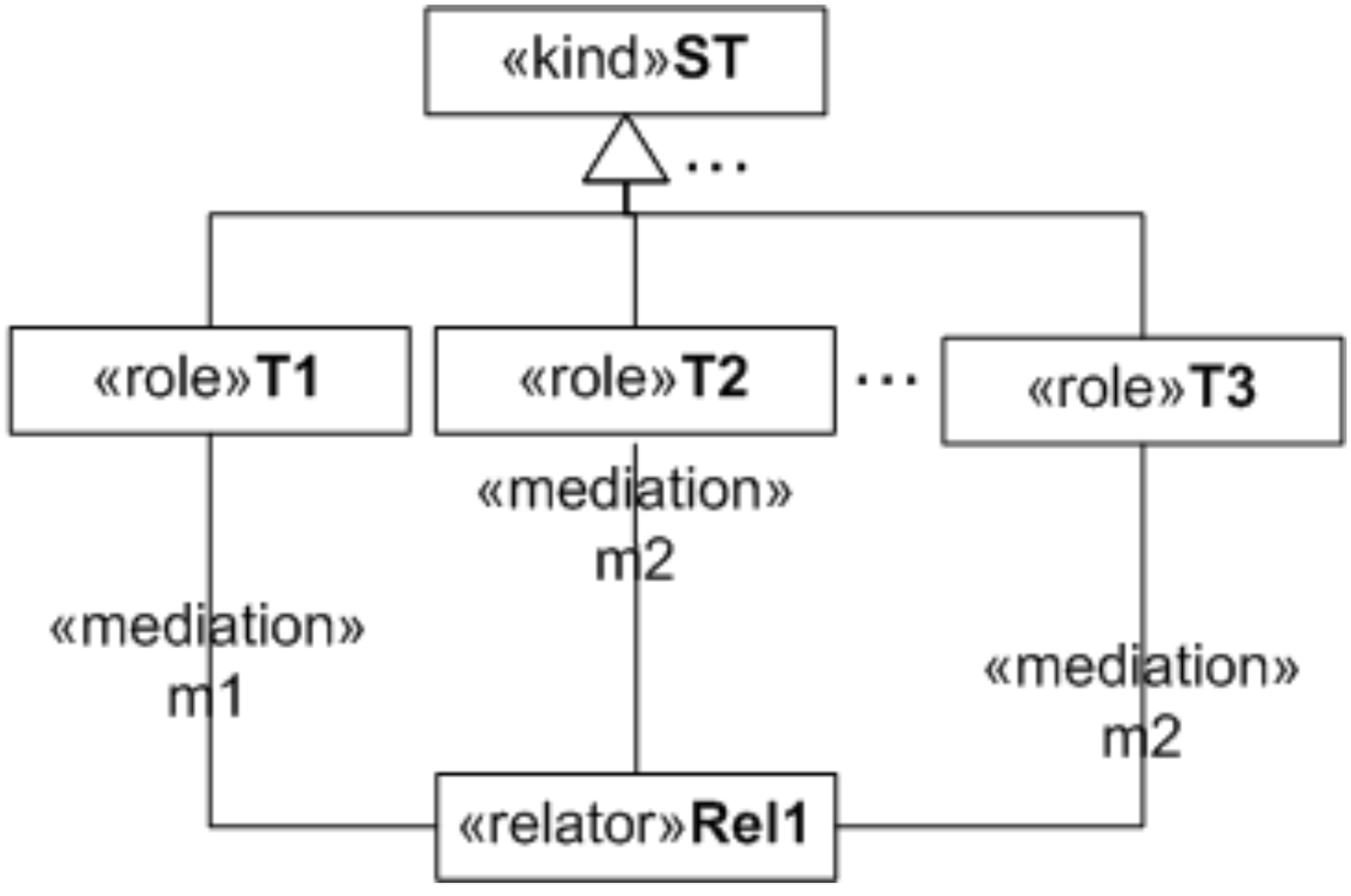
The success of this Data Modeling Guide for an Enterprise Logical Data Model could not have been possible without the inspired and exhaustive research of Giancarlo Guizzardi, notably his "Ontological Foundations for Structural Conceptual Models," published in 2005 in association with the Centre for Telemetrics and Information Technology, which provided the theoretical foundation for the methodologies describe within, and from which real world, practical implementations have already ensued.

At the core of Guizzardi's modeling paradigm are the principles of Rigidity, Uniform Identity and Existential Dependence. From those foundational tenets he extrapolates the concepts of SortalUniversal (Unified Principle of Identity), MixinUniversal (Disparate Set of Concepts), and finally the constructs of SubstanceSortal (Kind, Quantity, and Collective), Subkind, Phase, Role, Category, RoleMixin and Mixin. In short, the total package offered to us by Guizzardi contained a complete and fully integrated set of concepts and constructs that left us wanting for nothing.

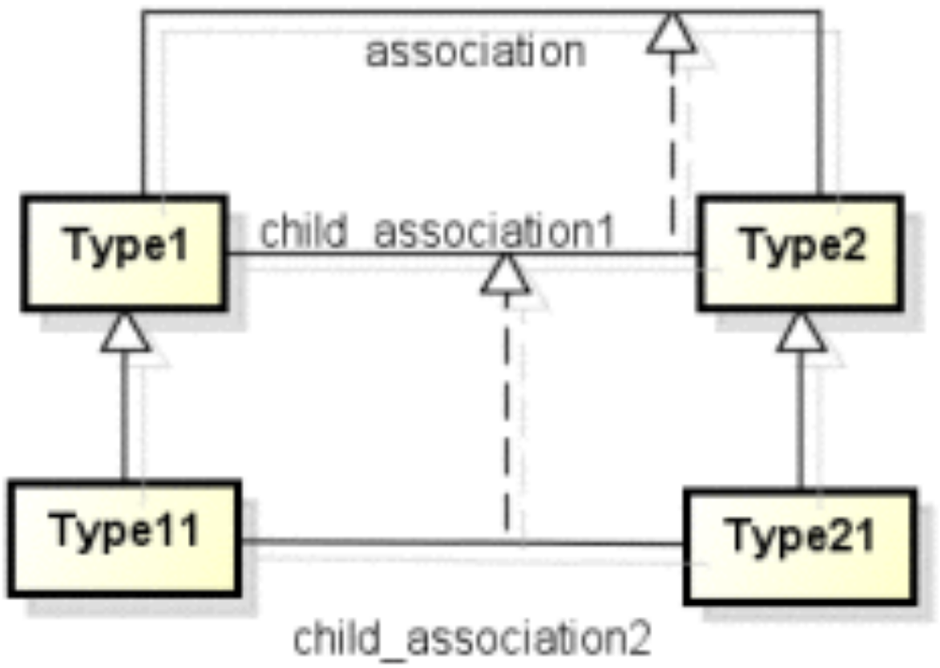
OntoUML Model Benchmark

- 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

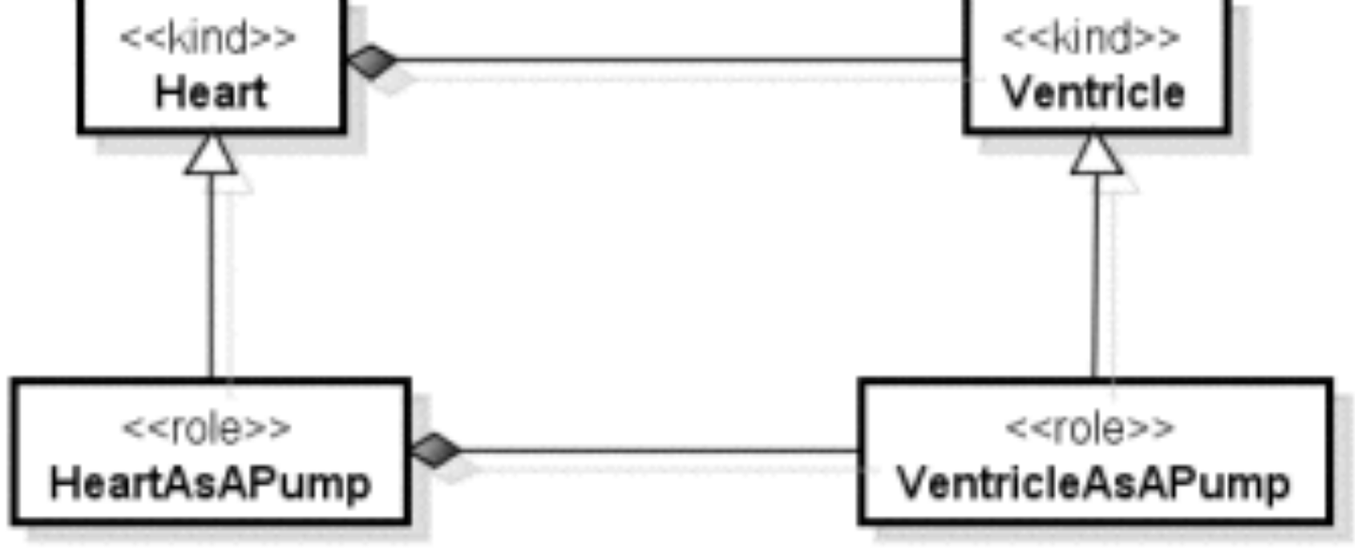
The Emerging Anti-Pattern: Relation Between Overlapping Types (**RelOver**)



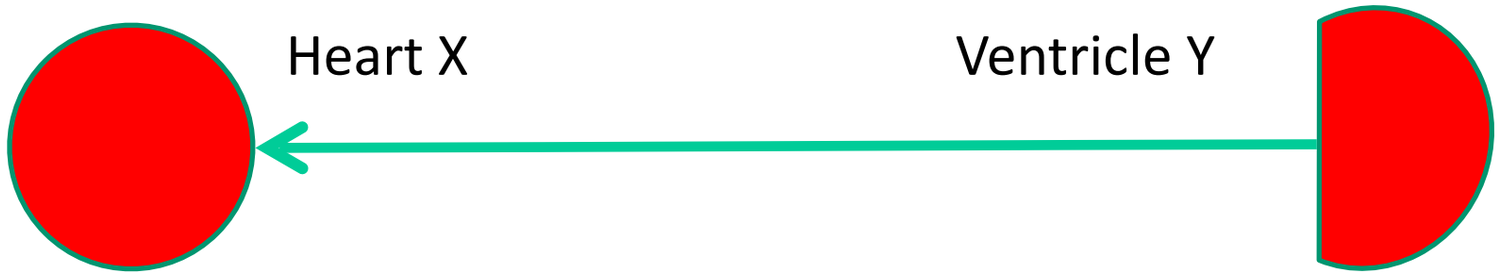
The Emerging Anti-Pattern: Relation Specialization (**RelSpec**)

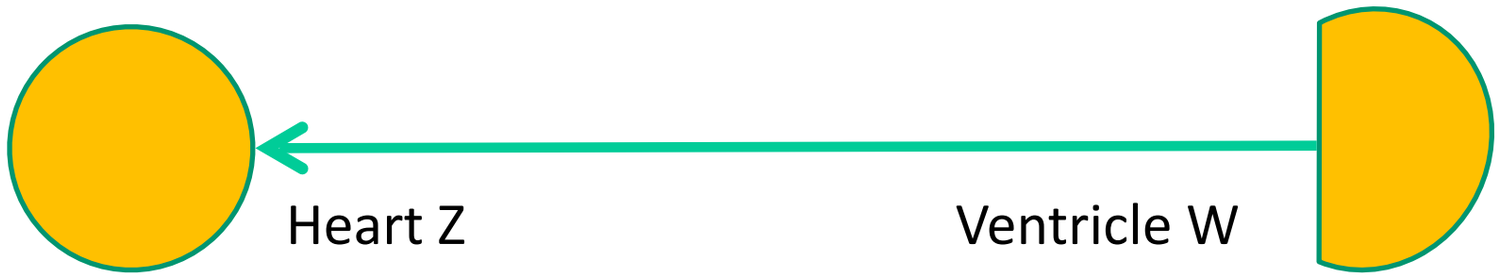


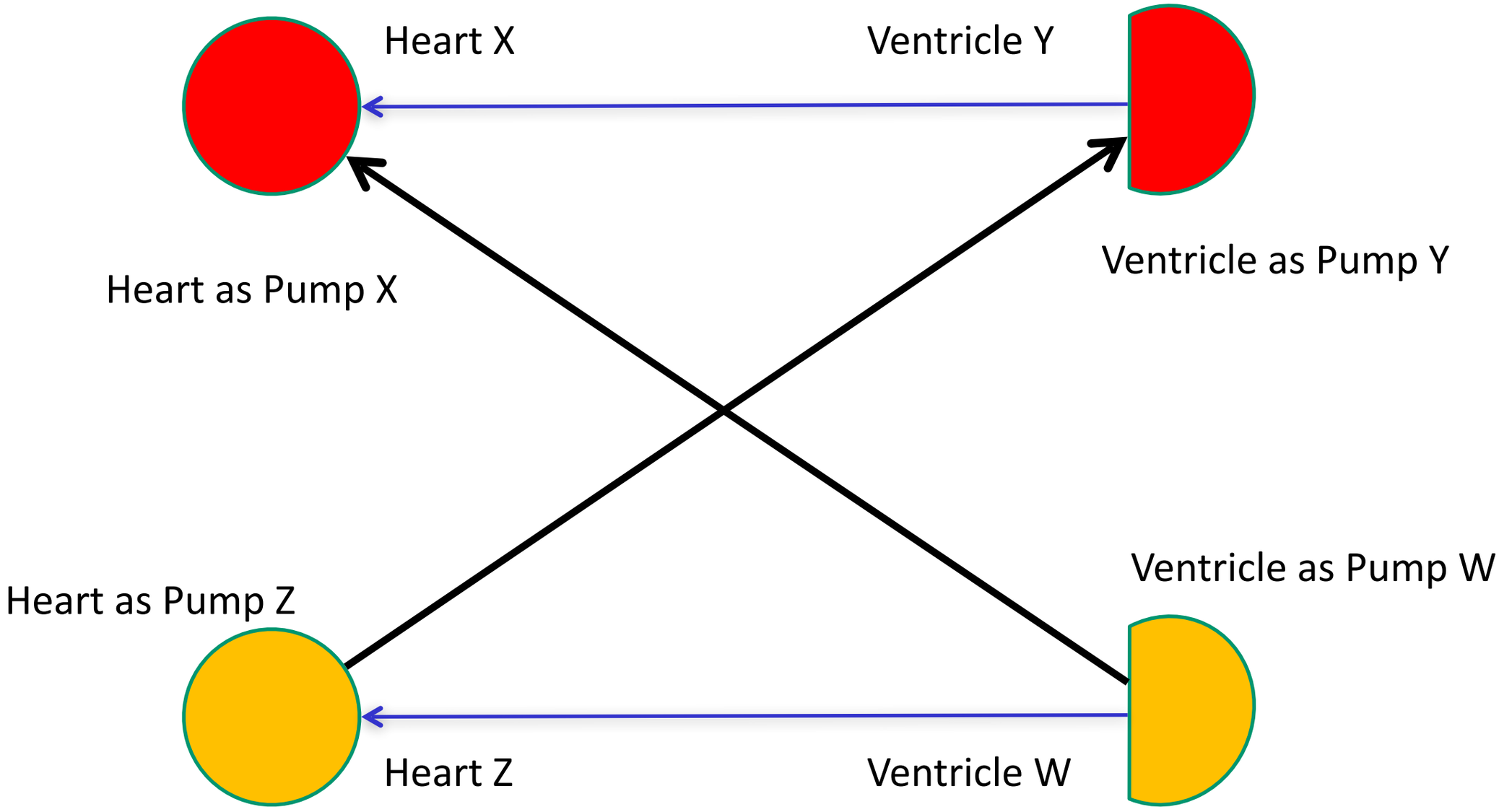
(a)



(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%

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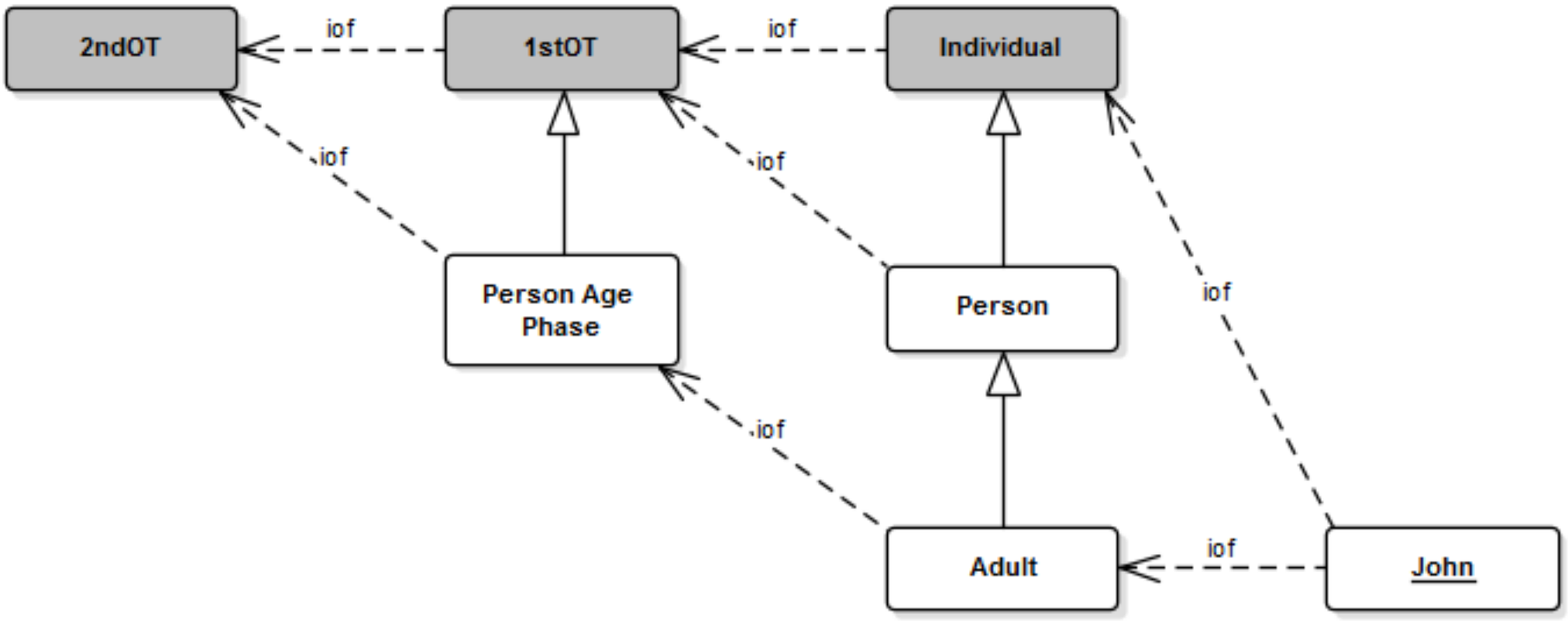
Total	879	462	52.56%	88.53%

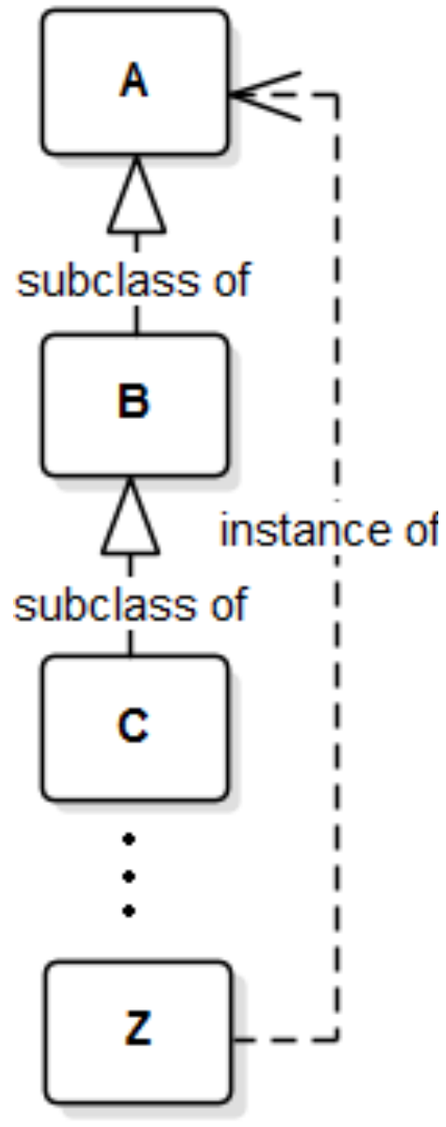
What if we went big…

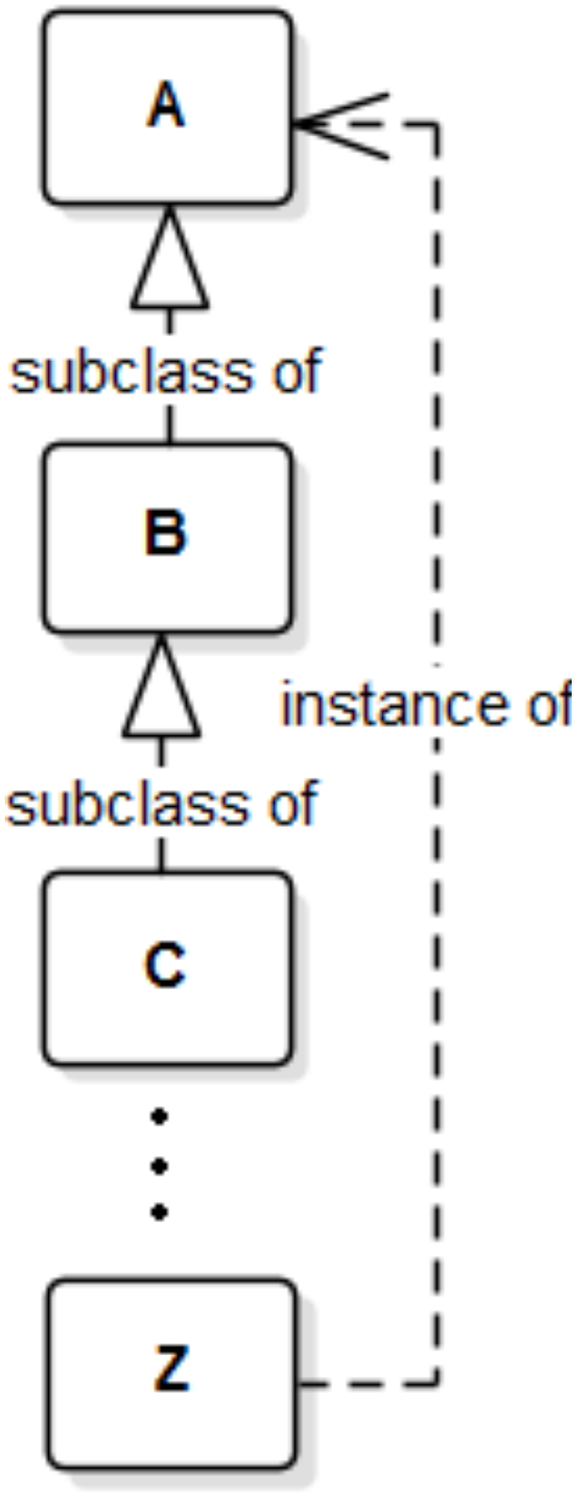
(searching for Anti-Patterns on WikiData)

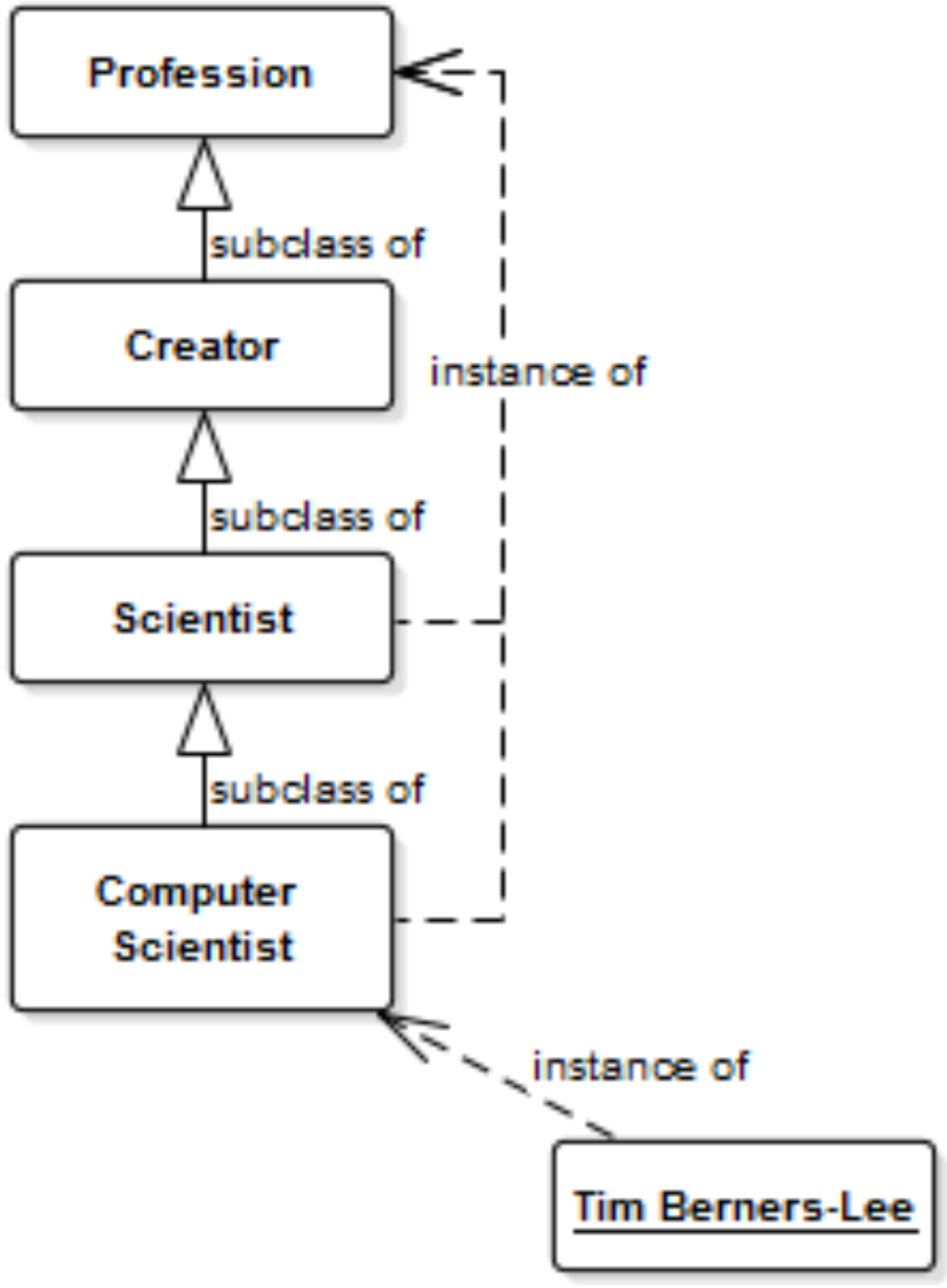
Multi-Level Modeling



WD-AP-1




A
subclass of
B
subclass of
C
Z
instance of


Profession
subclass of
Creator
subclass of
Scientist
subclass of
Computer
Scientist
instance of
instance of
Tim Berners-Lee

What if we went big…

Number of classes in any taxonomic hierarchy	337,102
Number of classes in taxonomic hierarchies spanning more than one level	17,819
Number of classes involved in AP1	15,177

OntoUML Criminal Investigation

«Role» Officer

«Role» Captain

«Role» Parent

«Role» Child

parentOf

+child

«Material»

+parent

1..2

«Kind» Person

«Material» knows

«Role» Detective

«Role» Suspect

+detective

conductedBy

«Mediation»

2..*

investigates

+suspect

1..*

+investigation

1

1..*

+interrogator

«Relator» Criminal Investigation

«Role» Lead Detective

«Role» Witness

+leader

responsibleFor

«ComponentOf»

+investigative context

+witness

relatedTo

+part of investigatic...

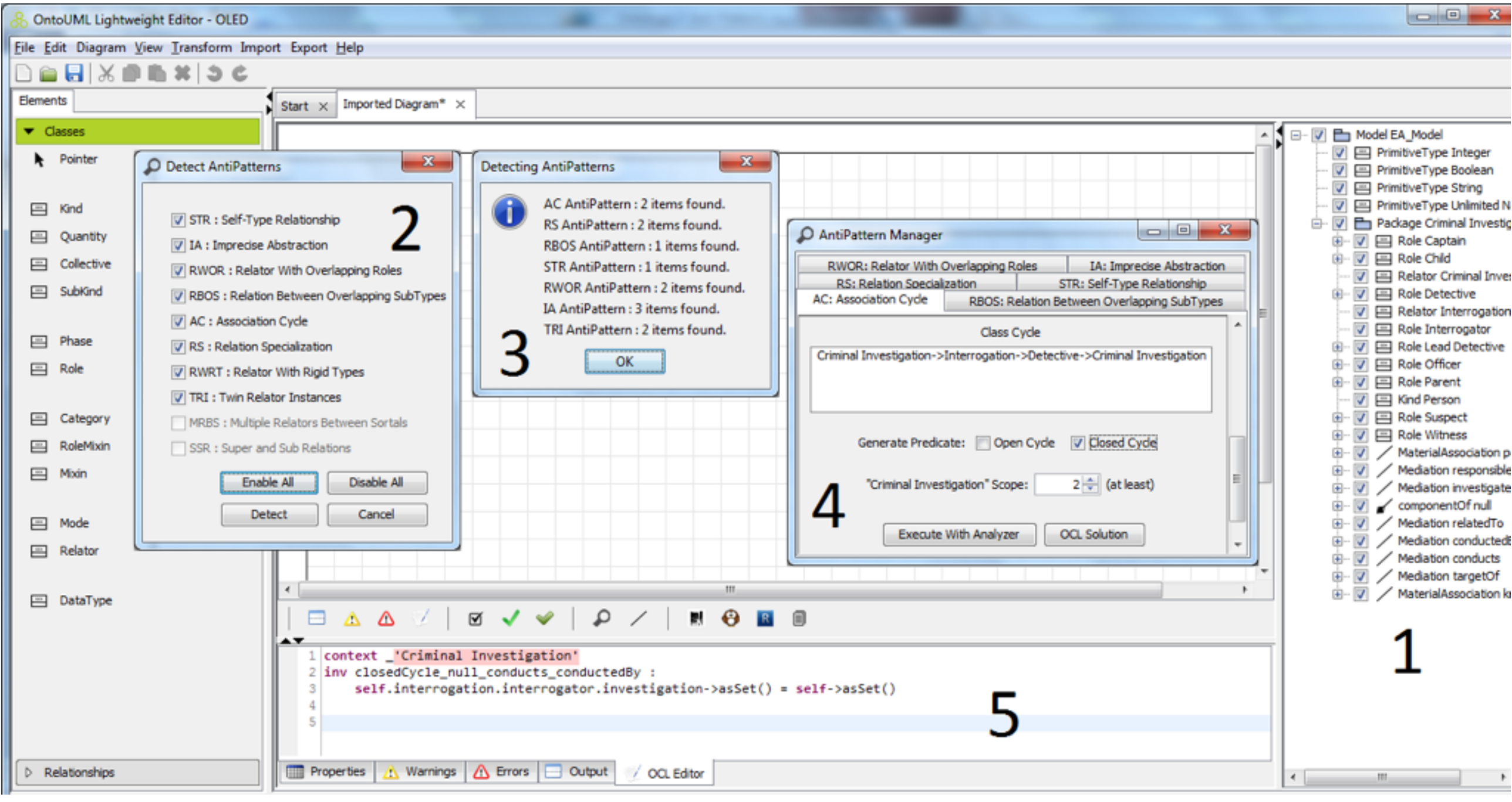
«Relator» Interrogation

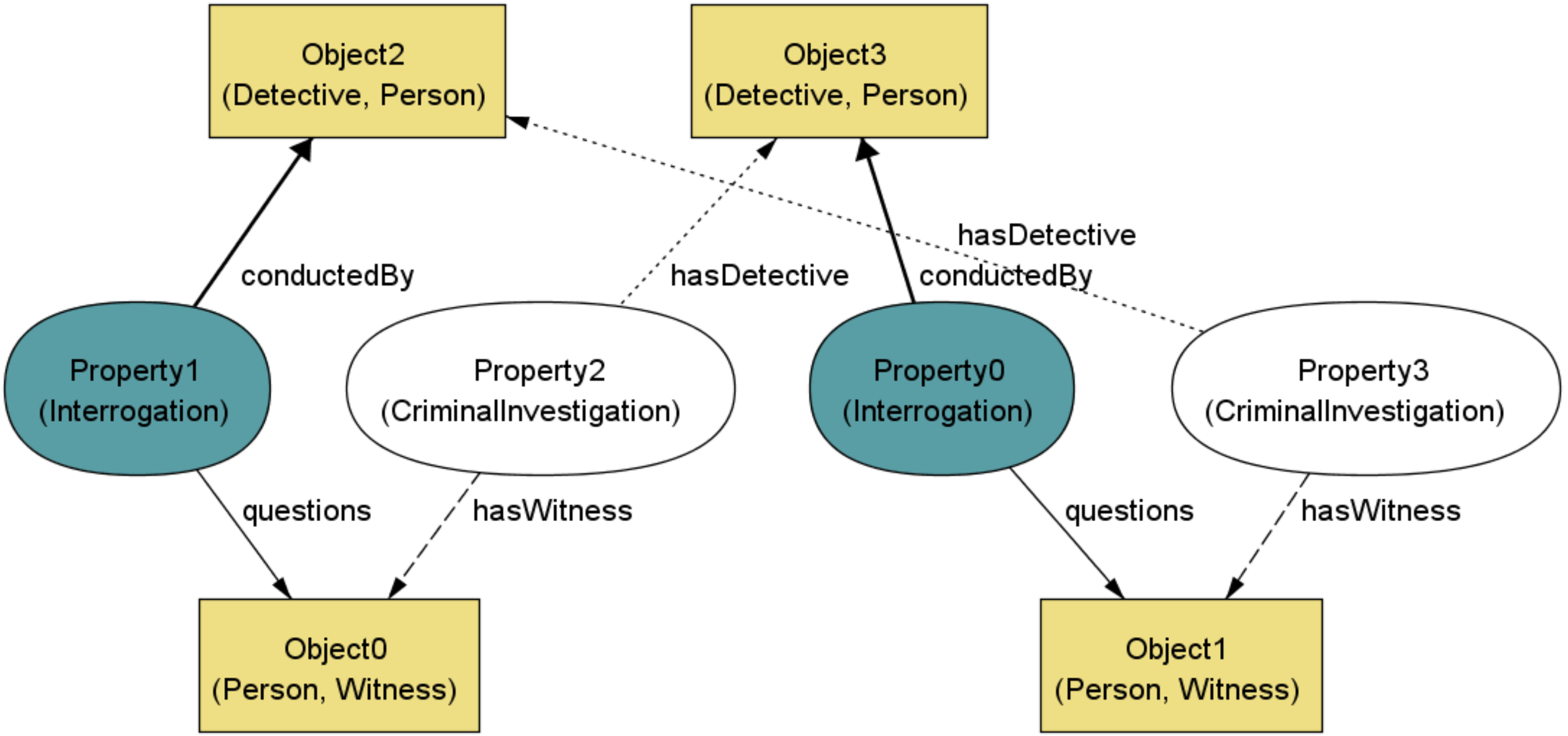
+interrogation

targetOf

«Mediation»

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
2
Enable All
Disable All
Detect
Cancel
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.
3
OK
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)
4
Execute With Analyzer
OCL Solution
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
context _'Criminal Investigation'
inv closedCycle_null_conducts_conductedBy :
self.interrogation.interrogator.investigation->asSet() = self->asSet()
5
Properties
Warnings
Errors
Output
OCL Editor


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)

Relator With Overlapping Roles

Relator: Criminal Investigation

Customizing Disjoints Roles: Add

Lead Detective	Witness	Detective	Suspect
☐	☑	☑	☐
☐	☑	☐	☑
☐	☐	☑	☑

☐ Exclusive ☑ Exclusive from Table ☐ Overlapping

☐ Disjoint ☑ Disjoint from Table

"Criminal Investigation" Scope: 2 (at least)

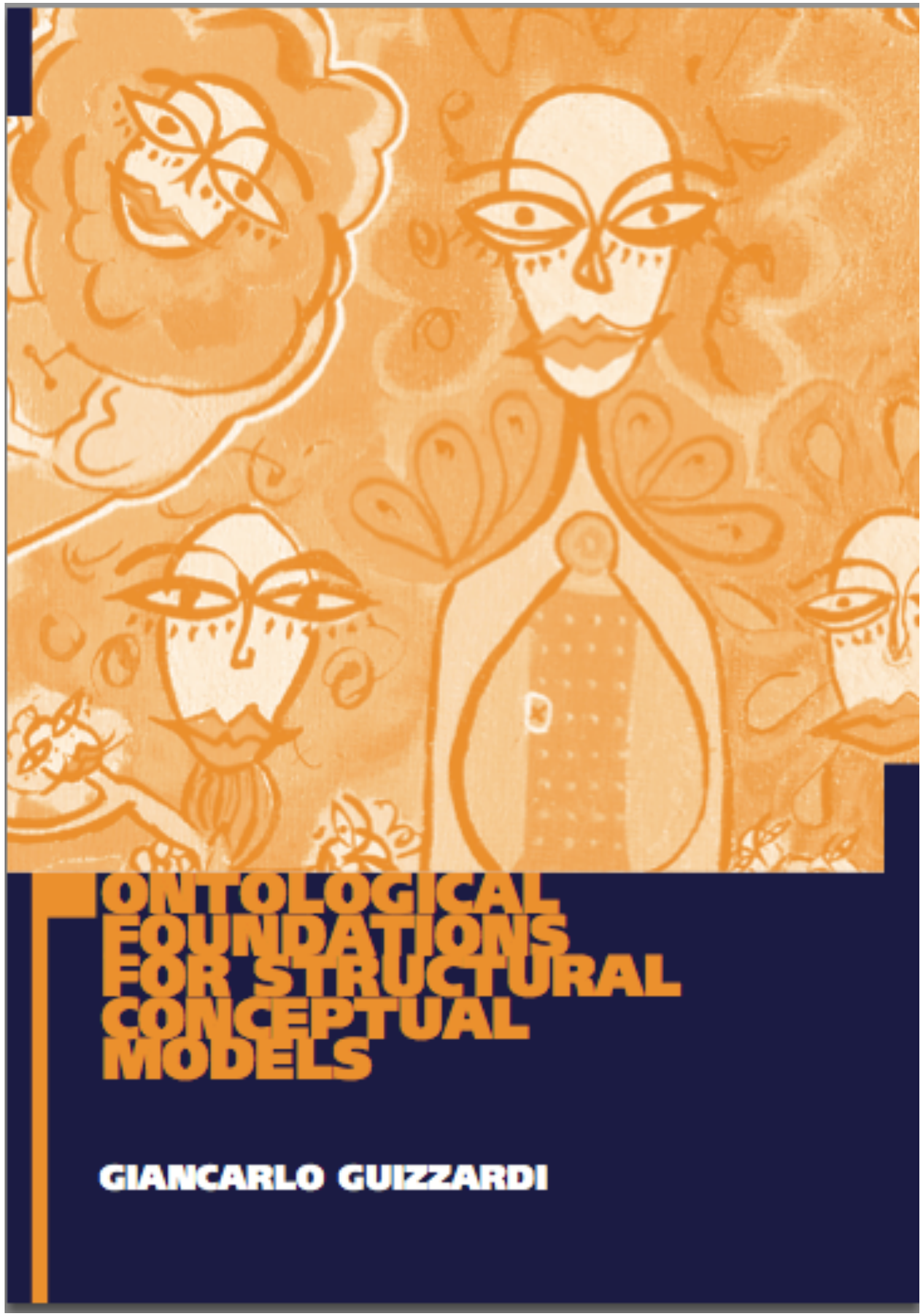
Execute With Analyzer | OCL Solution

```
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

Demos, Tools and Model Repository

http://www.menthor.net/


ONTOLOGICAL
FOUNDATIONS
FOR STRUCTURAL
CONCEPTUAL
MODELS
GIANCARLO GUIZZARDI

http://nemo.inf.ufes.br/
gguizzardi@inf.ufes.br