Data and Process Modelling

5. A Brief Discussion on the Ontological Foundations of Structural Conceptual Modelling[1]

Marco Montali

KRDB Research Centre for Knowledge and Data
Faculty of Computer Science
Free University of Bozen-Bolzano

Formal Ontology

A discipline that deals with formal ontological structures (e.g., the theory of parts, the theory of wholes, types and instantiation, identity, independence, unity) which apply to all material domains in reality. (Husserl)

Goal

To uncover and analyze the general categories and principles that describe reality.

This is of utmost importance: our conceptual schemas must be not only logically coherent, but also properly reflect the intended semantics!

Red Apples

Logical level

$\exists x.Apple(x) \wedge Red(x)$ Just unary predicates...

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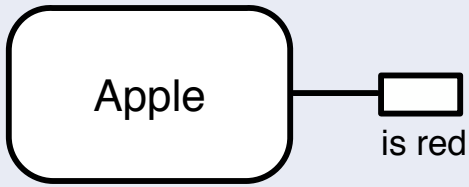
Adding structure...



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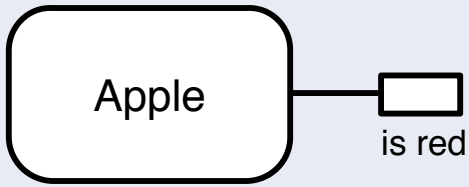


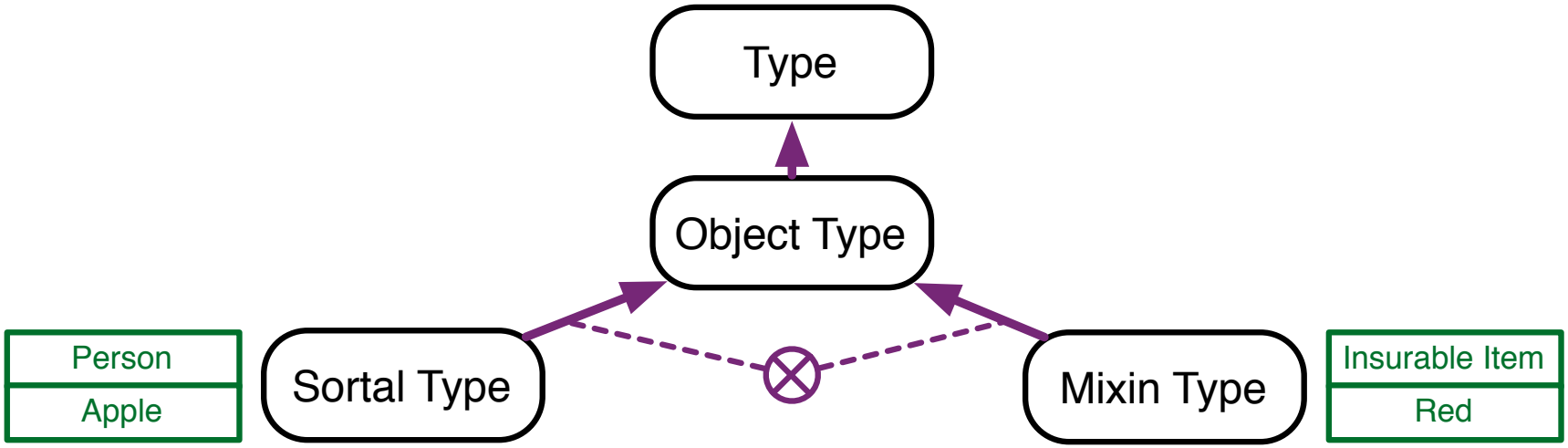
Ontological level

Adding understanding:

- "Apple" is a *sortal* type.
  - It supplies a principle of application for the individuals it collects.
  - It provides a *principle of identity*.
- "Red" is a *characterizing* type (*mixin*).
  - It only supplies a principle of application, but not a principle of identity.

"No entity without identity" (Quine, 1969).

Distinguishing Object Types



Rigidity (Guarino and Welty, 2002)

Rigid type

A type T is rigid, written $R^+(T)$, if, for every instance x of T, x is *necessarily* an instance of T.

Using modal logics: $R^+(T) \triangleq \Box(\forall x.T(x) \rightarrow \Box T(x))$.

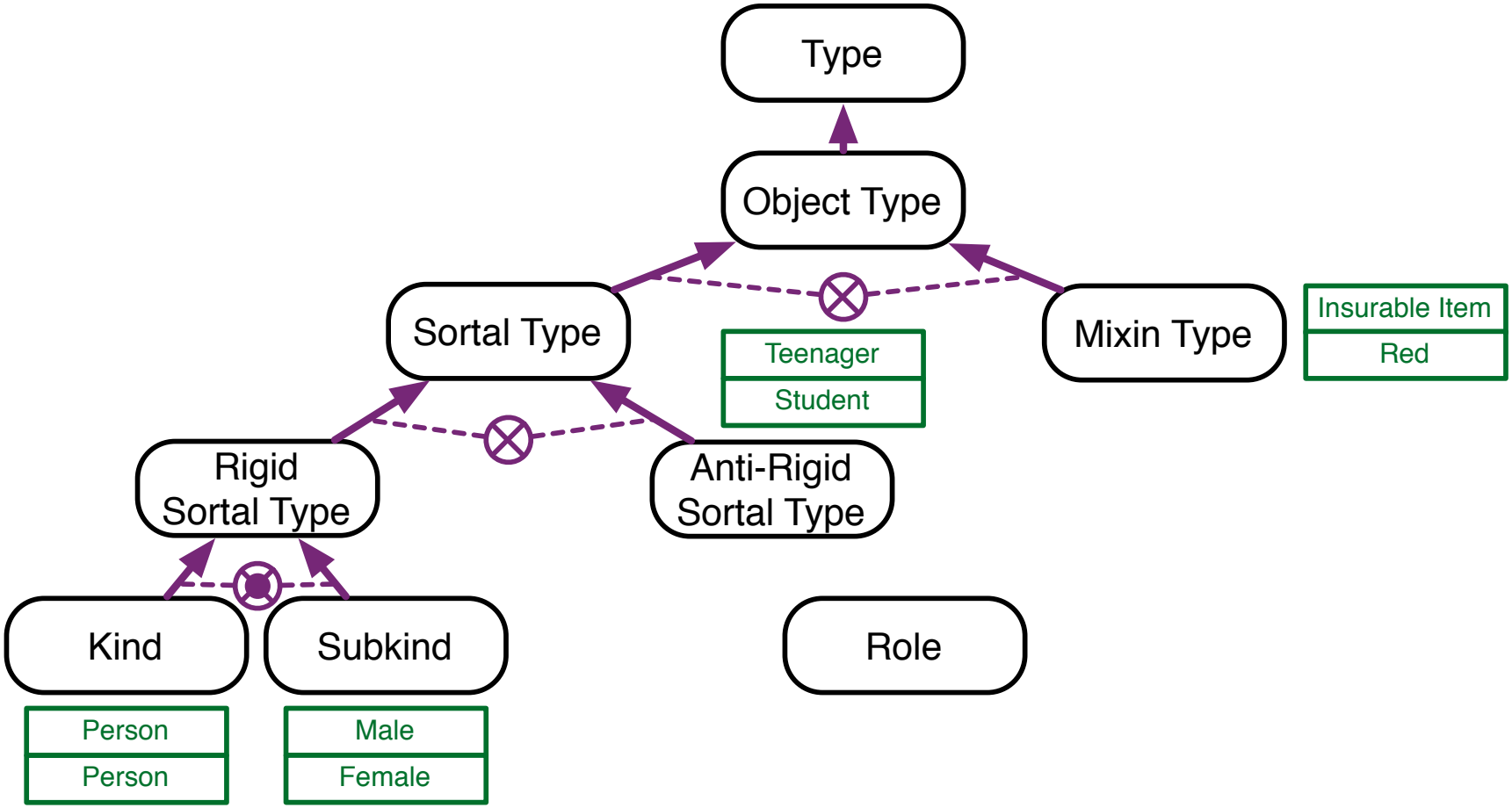
Anti-rigid type

A type T is anti-rigid, written $R^-(T)$, if, for every instance x of T, x is *possibly* not an instance of T.

Using modal logics: $R^-(T) \triangleq \Box(\forall x.T(x) \rightarrow \Diamond\neg T(x))$.

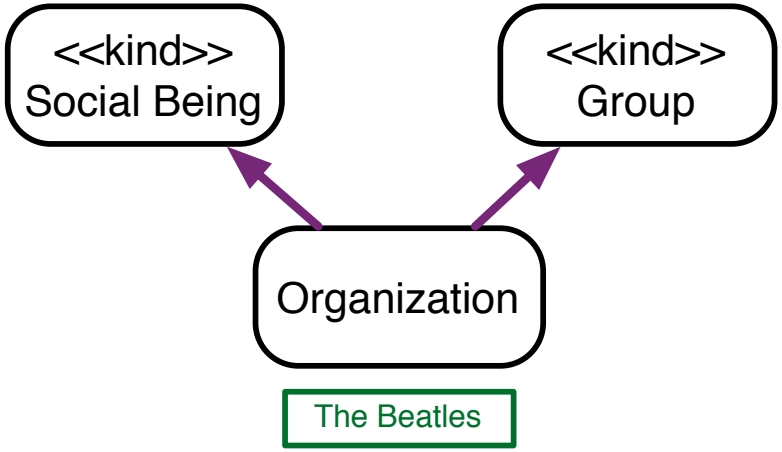
Person? Student? Teenager?

Distinguishing Object Types



- Kind: a top-level entity type ("substance sortal") that supplies a *principle of identity* for its instances
- Subkind: specialization of a kind into more specific rigid subtypes.
  - Inherit the principle of identity supplied by the kind they specialize.

The Danger of Specialization 1



Questions:

- How do the actual members fit into this picture?
- Are the principles of identity provided by the two kinds compatible?
- Did Beatles "change" when Ringo Starr replaced Pete Best?

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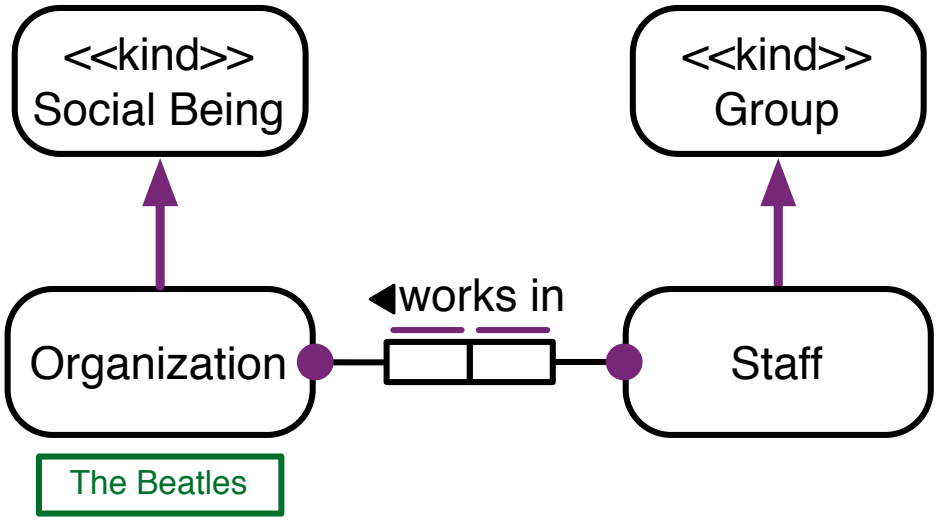

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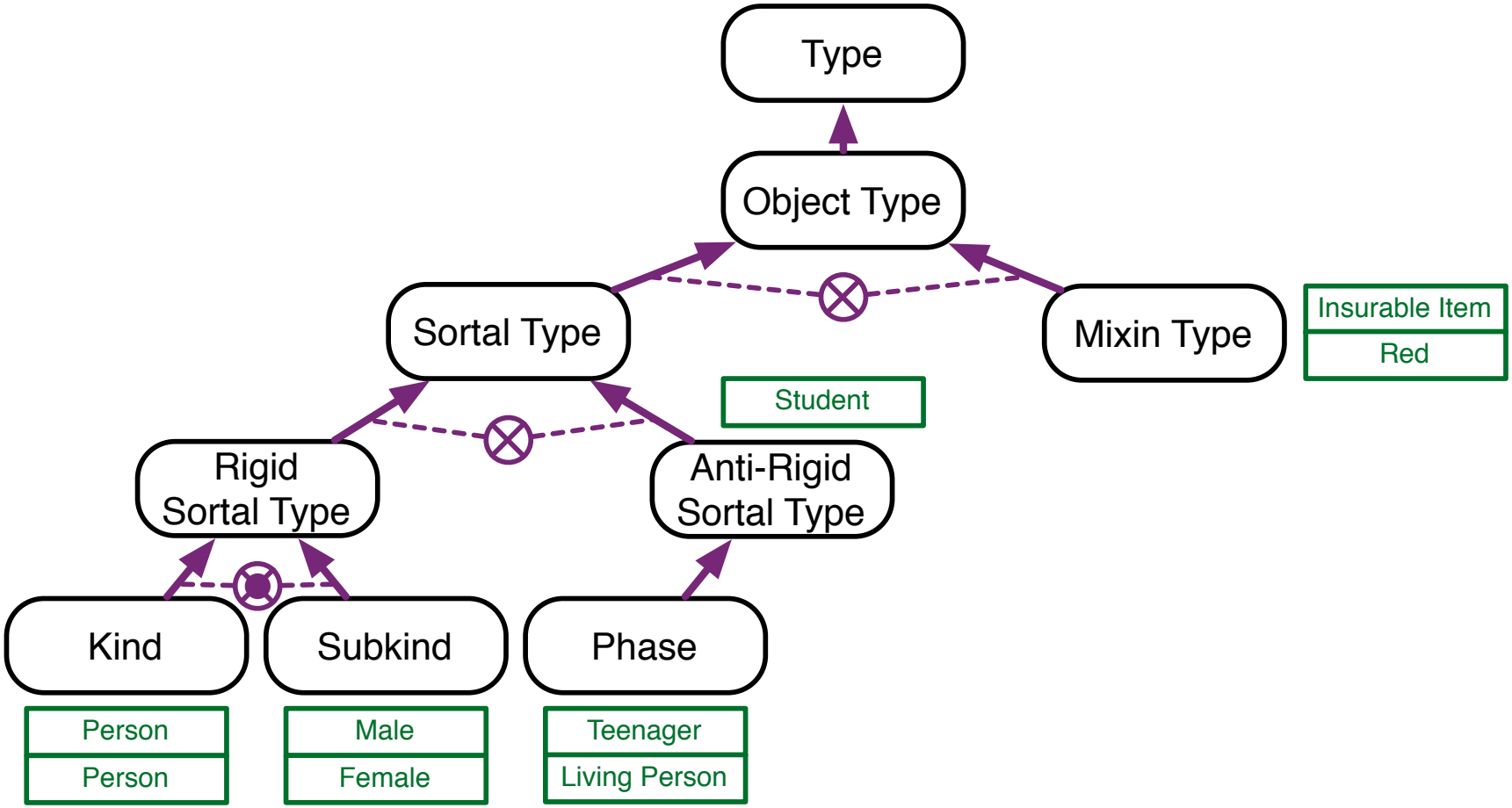
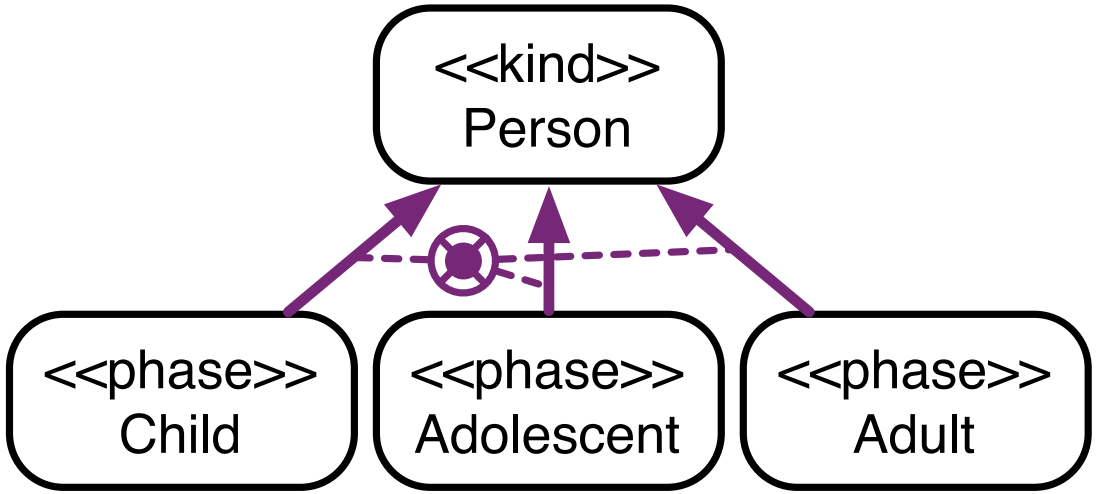


Phase: sortal that applies to an individual only during a certain stage of its existence (defined through a *specialization condition* that is intrinsic to the sortal).

Phases

Different phases specializing a kind form a *partition* for that kind.



Relational Dependence

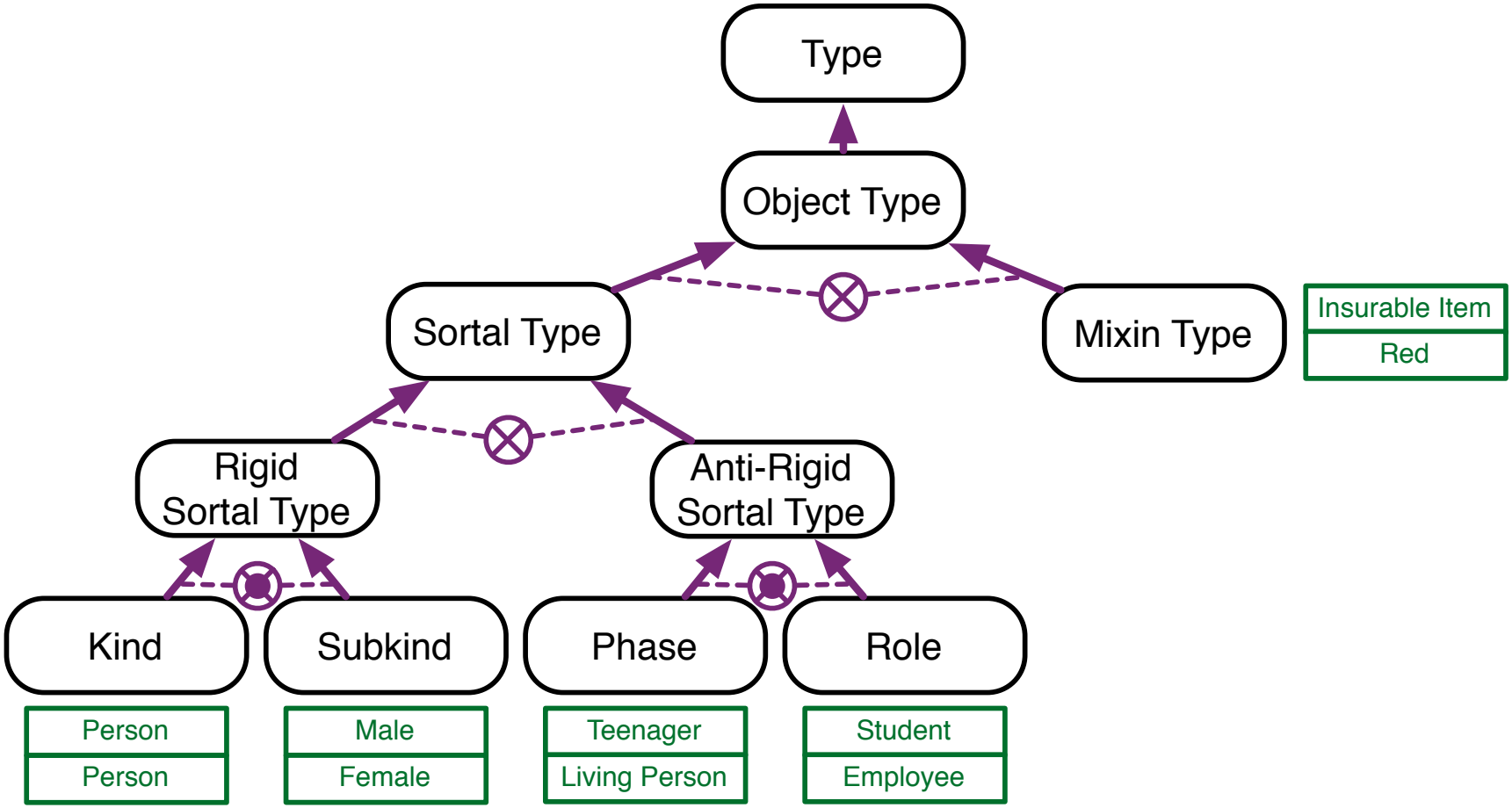
Relational dependent types

A type T is relationally dependent on another type P via relation R, written $D^+(T, P, R)$, if, for every instance x of T there is an instance y of P such that x and y are related via R.

Using modal logics: $D^+(T, P, R) \triangleq \Box(\forall x.T(x) \rightarrow \exists y.P(y) \wedge R(x, y))$.

The notion of relational dependence leads to the anti-rigid sortal of role.

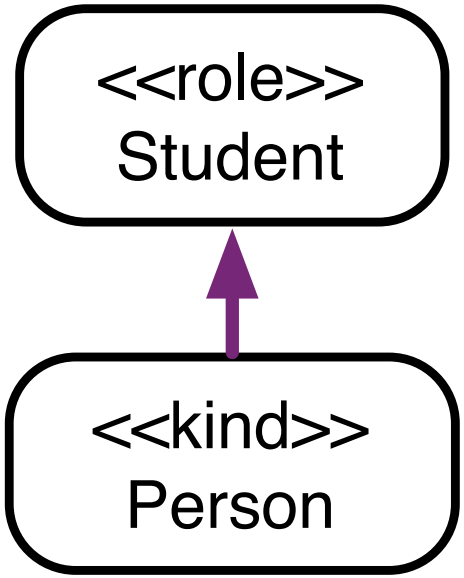
Distinguishing Object Types



Role: sortal that applies to an individual when it meets a *specialization condition*, defined in terms of its extrinsic properties, i.e., how it relates with *other* entities.

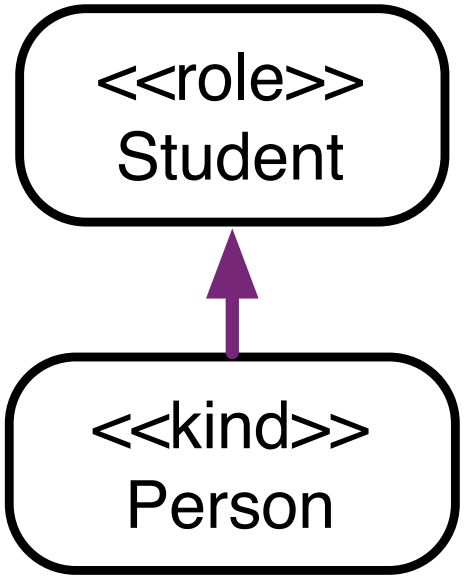
- An individual plays a role in a certain "context".

The Danger of Specialization 2



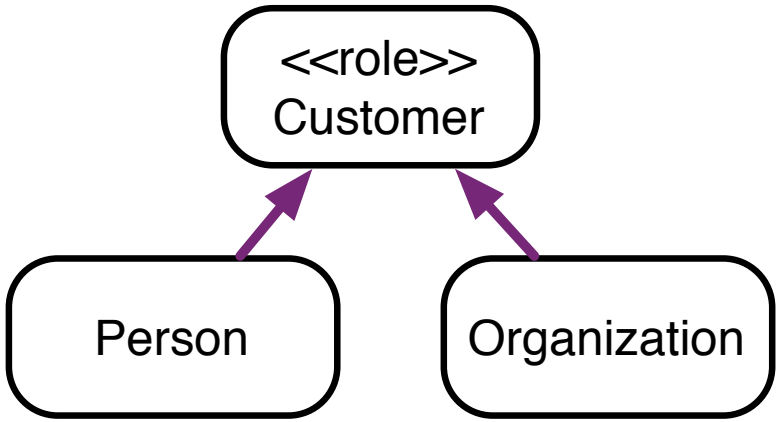
Question: is this conceptual schema ontologically correct?

The Danger of Specialization 2



Question: is this conceptual schema ontologically correct?
Answer: NO! A rigid type cannot specialize an anti-rigid type.

The Danger of Specialization 3



Question: are these solutions ontologically correct?

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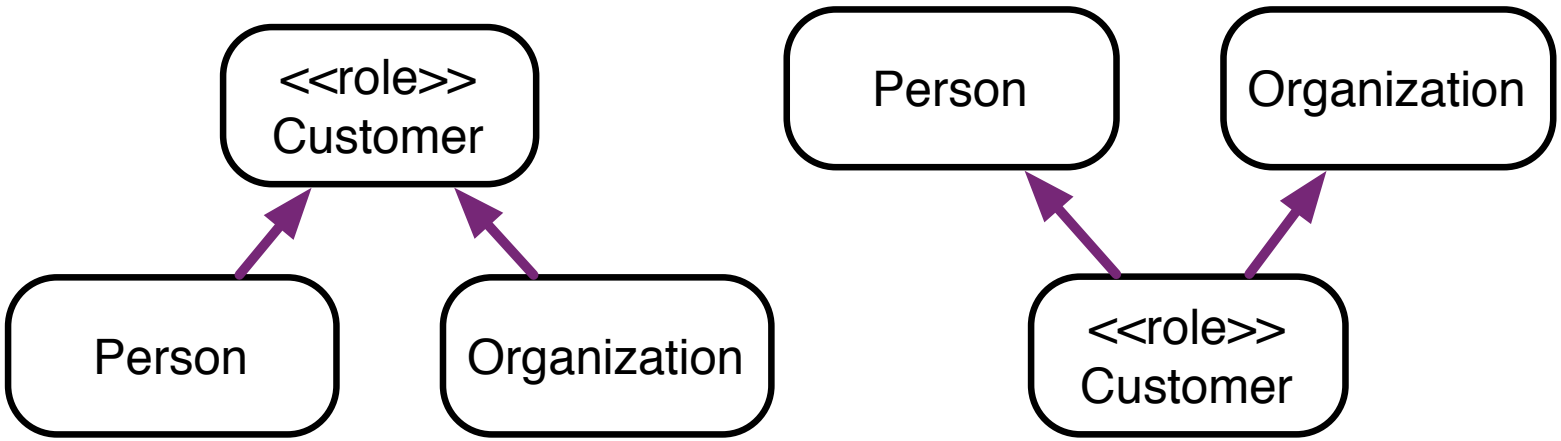

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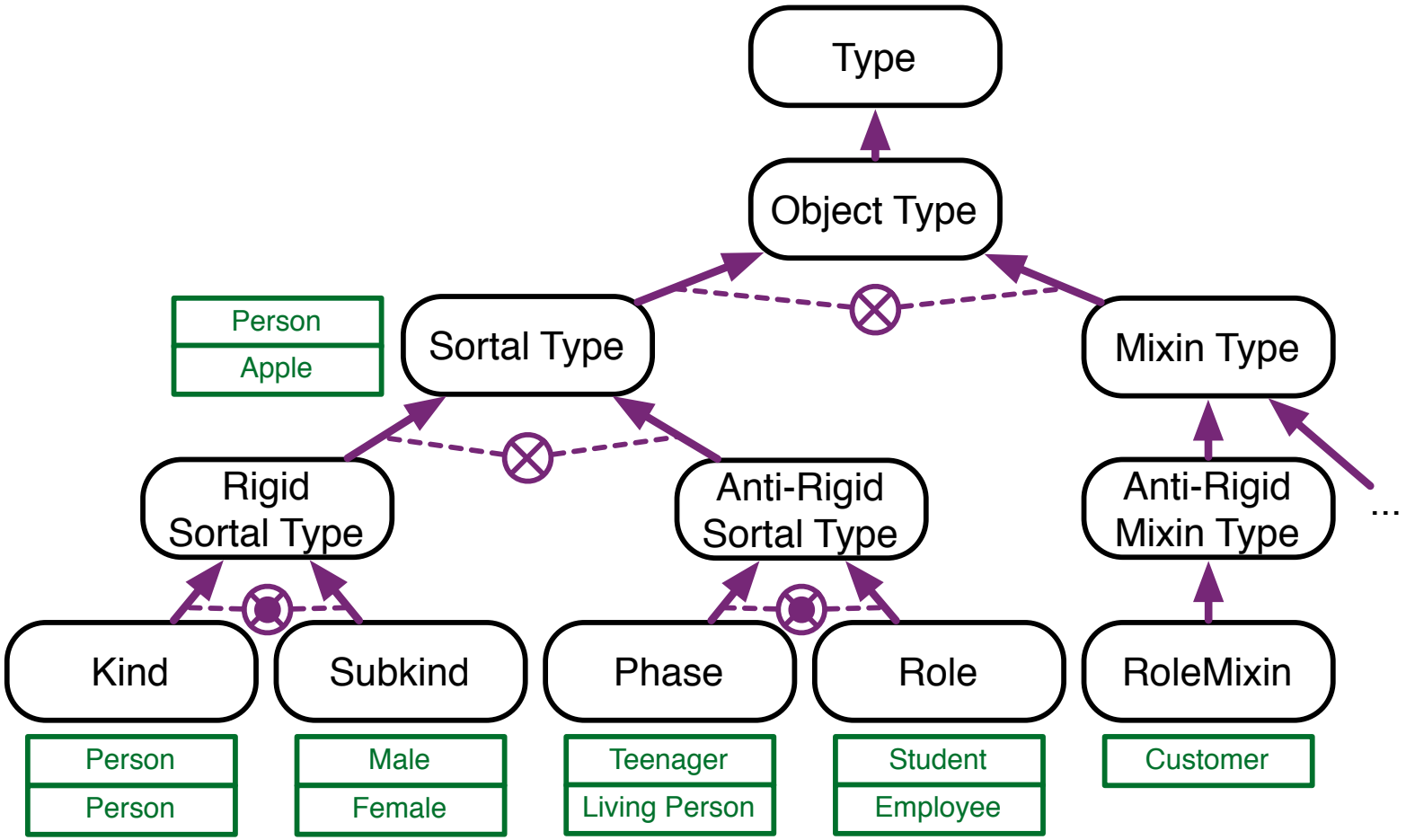
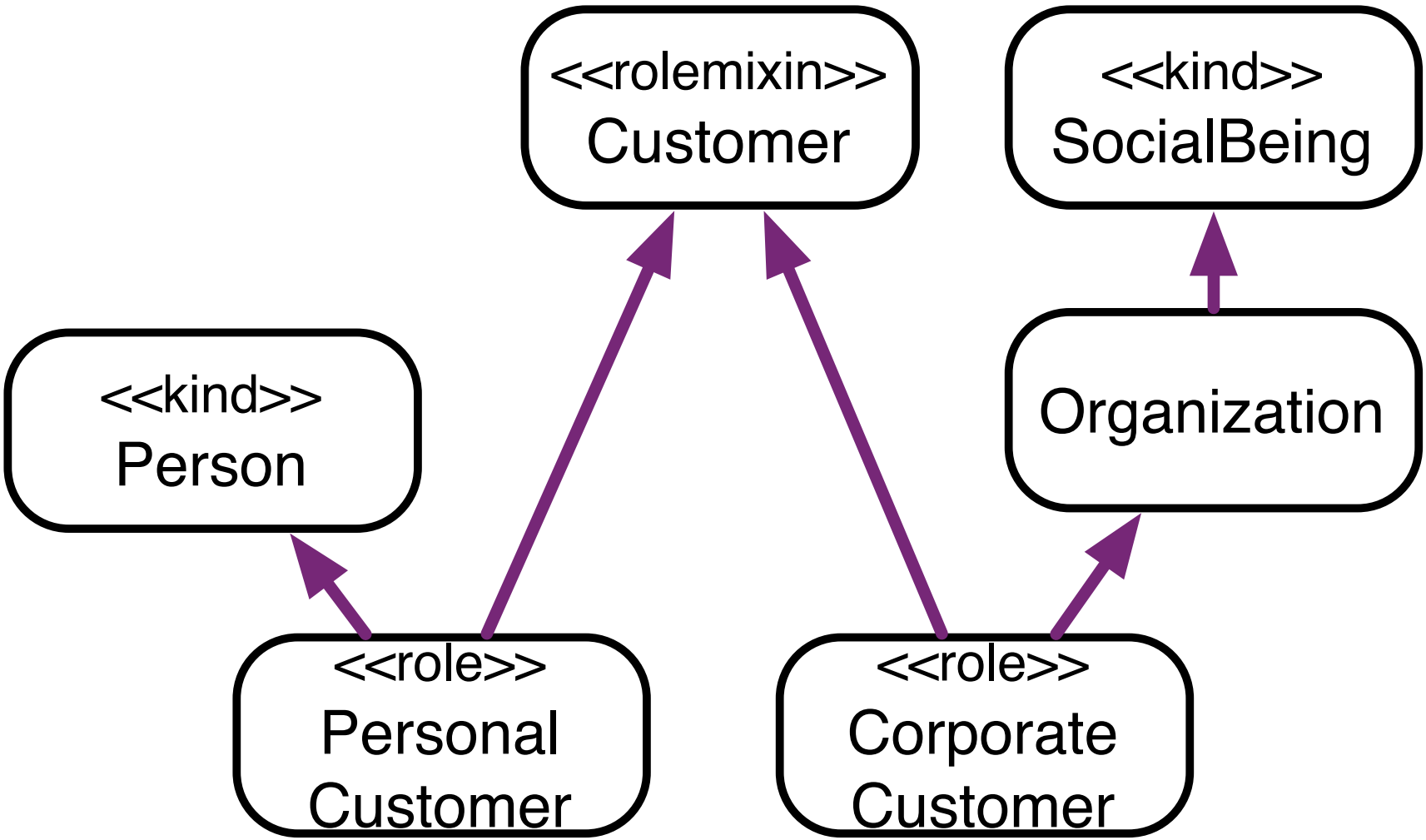


Mixin: *dispersive* concepts, i.e., they cover many concepts with different principles of identity.

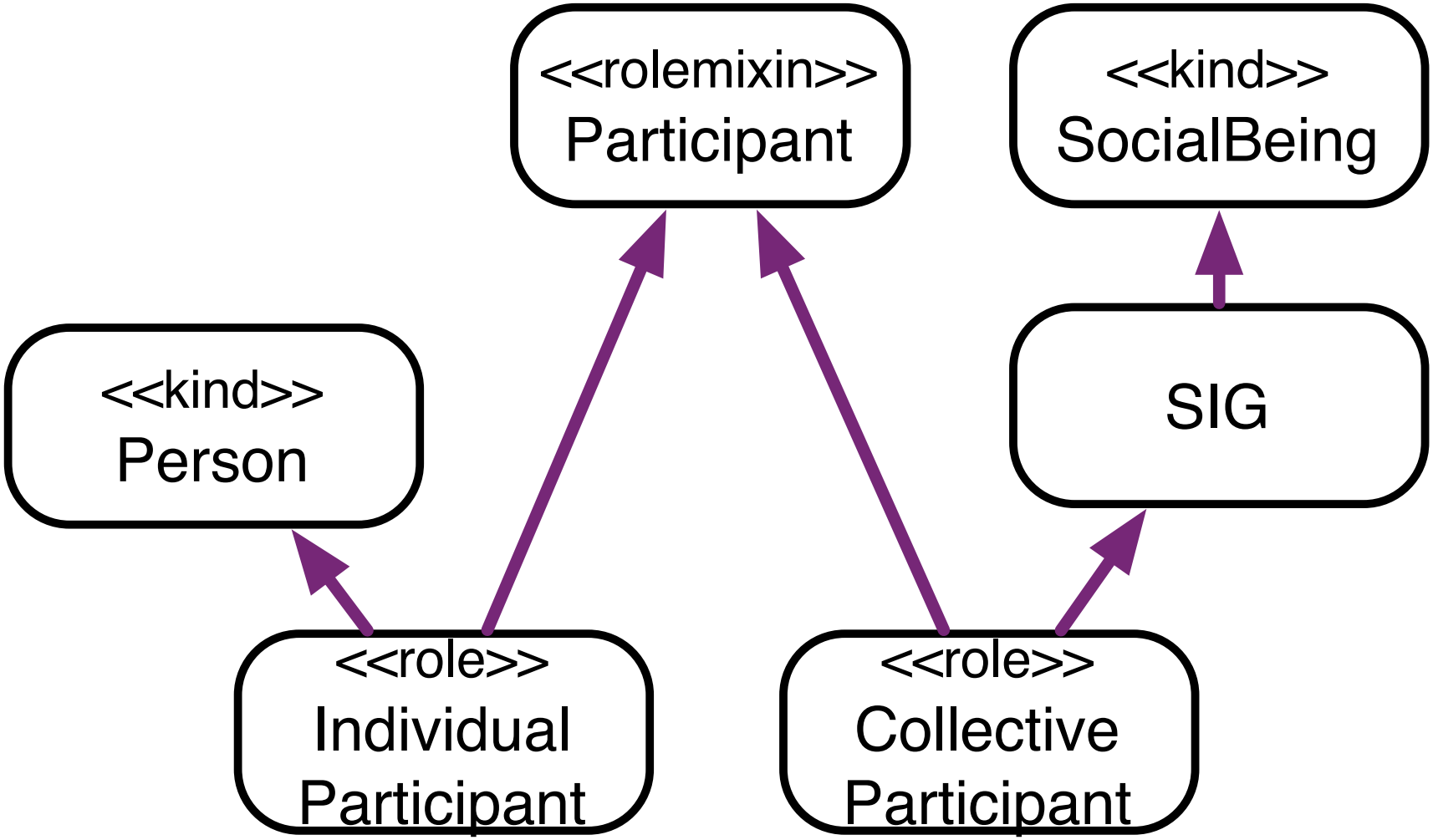
- We consider in particular role mixin.

The Customer Schema

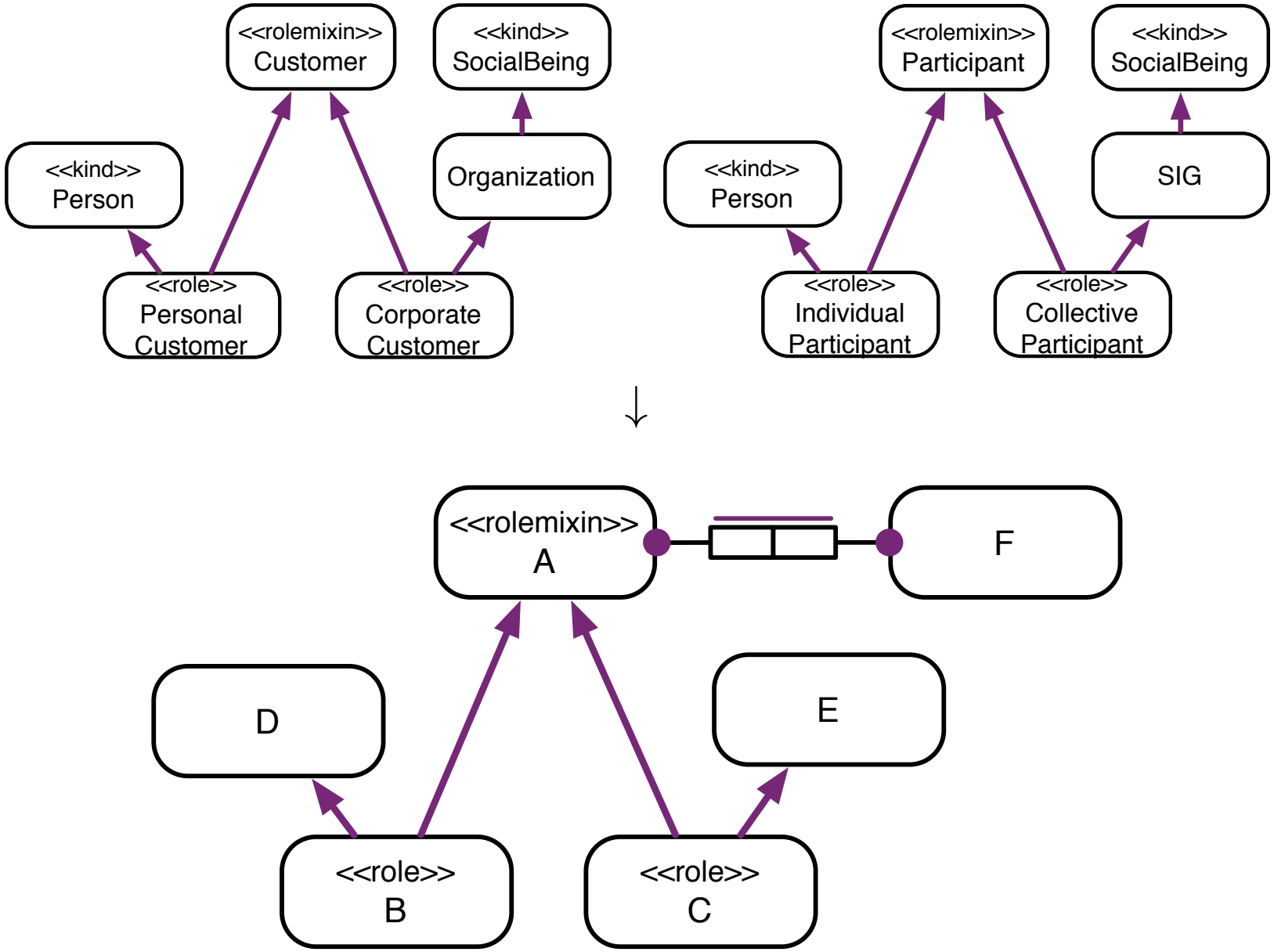


The Participant Schema

"Participants may be either individual persons, or special interest groups".



Towards Conceptual Modeling Patterns



Mereology

The theory of parts and wholes.

Deals with the recurring `is part of` fact type:

- Heart is part of Body.
- Wheel is part of Car.
- Person is part of Staff.
- Department is part of University.
- ...

Ground and Minimum Mereology

Ground Mereology:

1. Parthood is irreflexive: $\forall x.\neg(x < x)$
2. Parthood is anti-symmetric: $\forall x, y.\neg(x < y) \rightarrow \neg(y < x)$
3. Parthood is transitive: $\forall x, y, z.((x < y) \wedge (y < z)) \rightarrow (x < z)$

Minimum Mereology:

4. Parthood satisfies the weak supplementation principle: $\forall x, y.(x < y) \rightarrow \exists z.(z < y) \wedge (x \texttt{ disjoint } z)$

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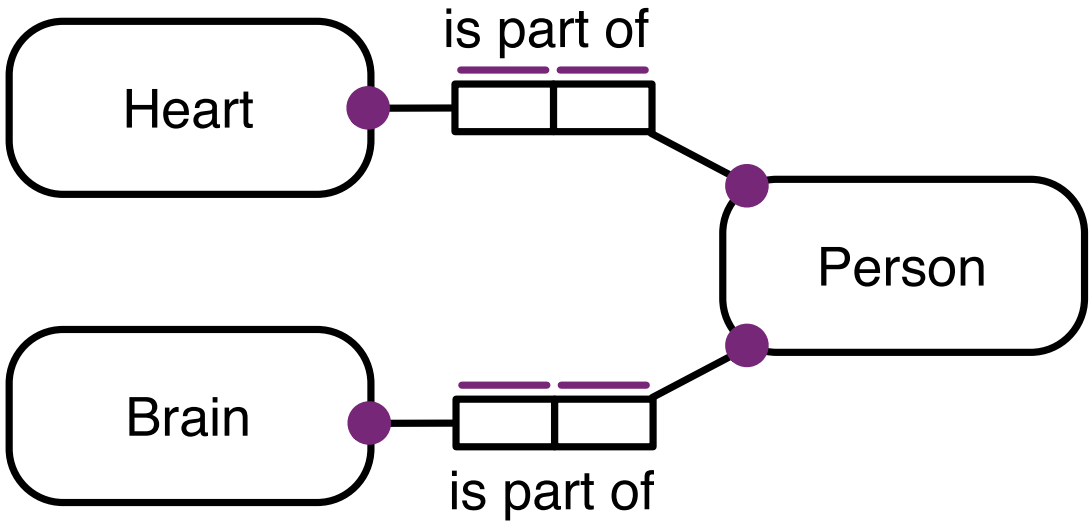
Conceptual issues:

- Heart is part of Body, Brain is part of Body.
  Do they carry the same meaning?
- The Hand is part of the Body, and the Body is part of the Person.
  Is it true that the Hand is part of the Person?
- The Hand is part of the Person, and the Person is part of the Computer Science Faculty.
  Is it true that the Hand is part of the CS Faculty?

Mandatory vs Essential PartOf



- Is it necessary for a person to have a heart to exist?
- Is it necessary for a person to have a brain to exist?
- Can a person change her heart while existing? And her brain?

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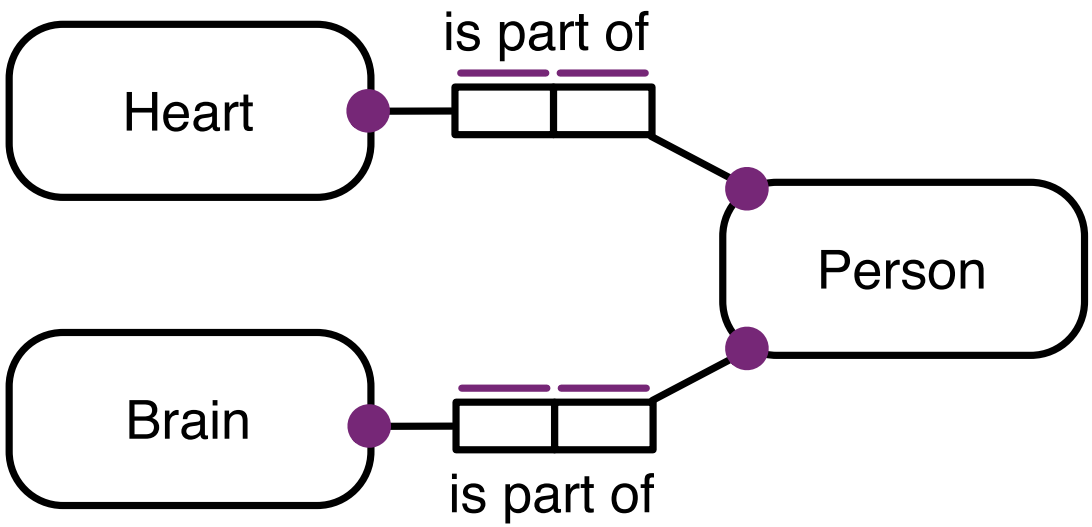

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The two part of relations carry different *dependence* principles:

- Mandatory part: whenever the whole exist, there must necessarily be an instance of the part.
- Essential part: for the whole to exist, the same part must necessarily be connected to the whole.

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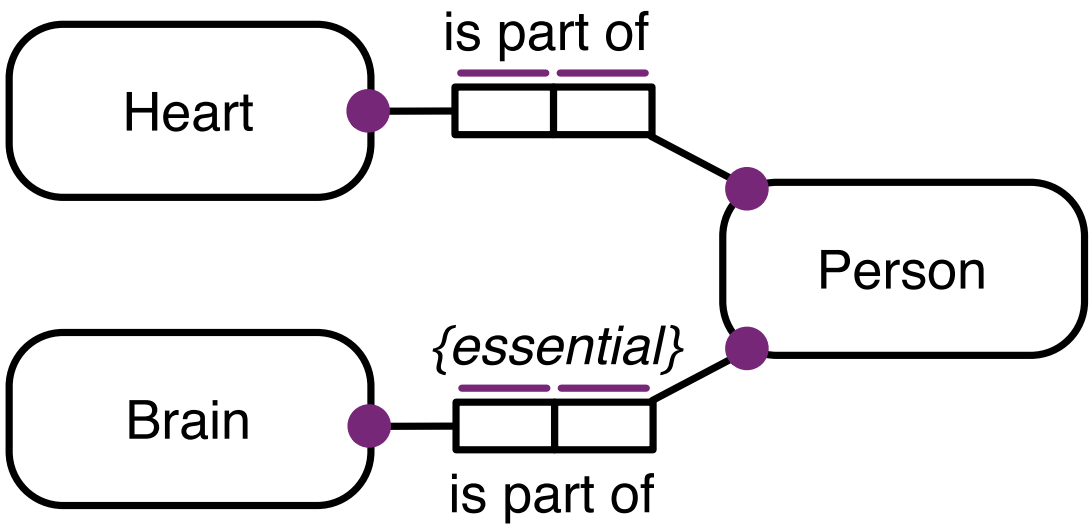

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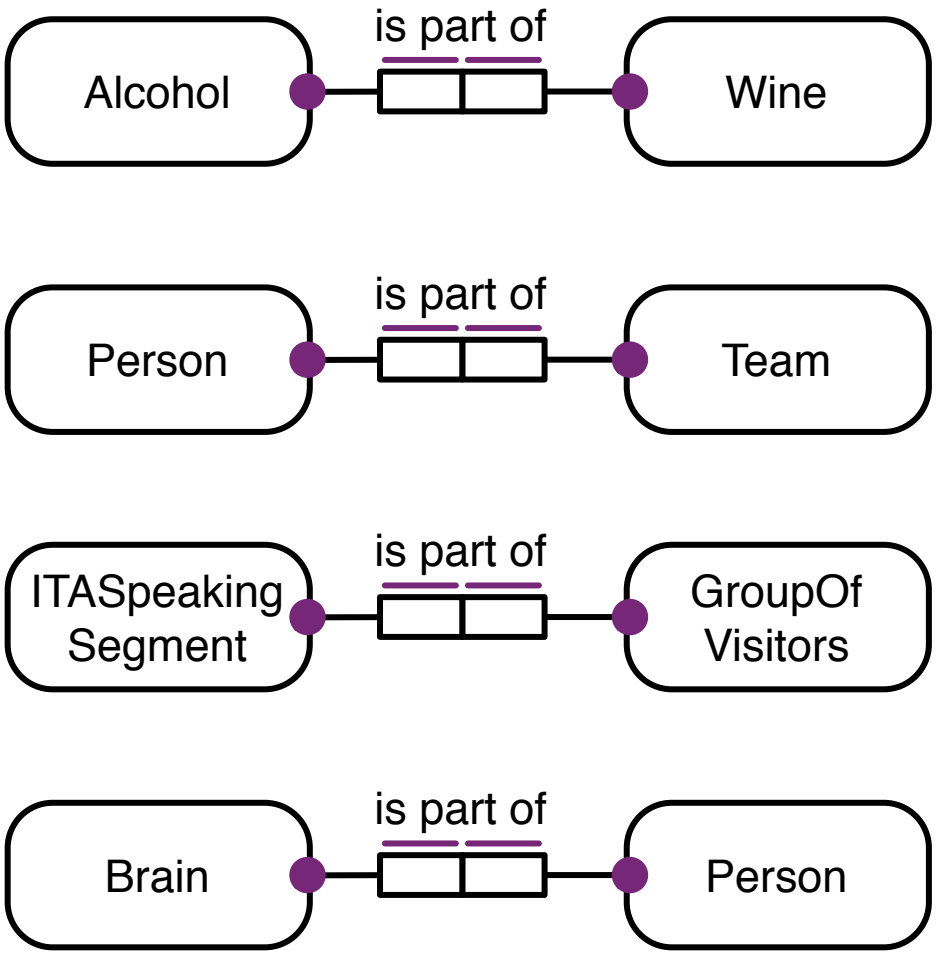

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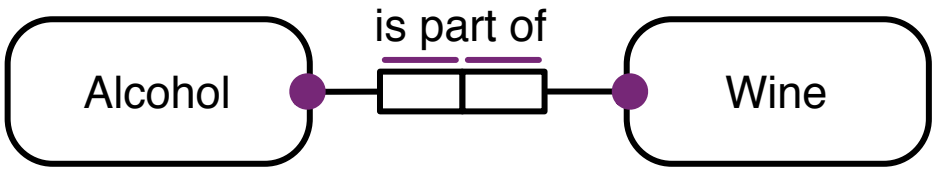
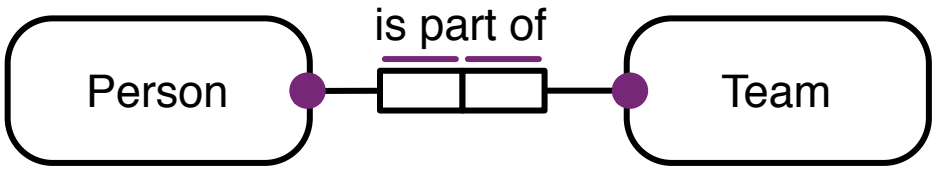
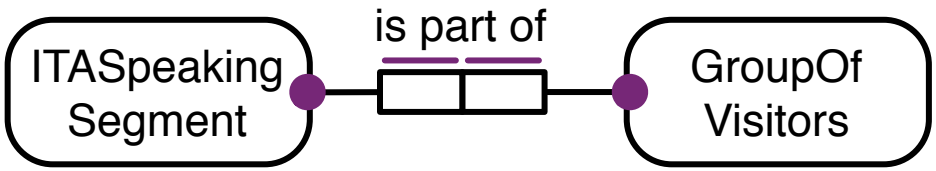


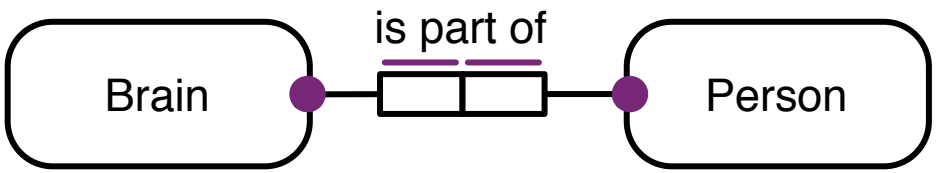
Mass-Quantity



Member-Collection



Subcollection-Collection



Component-Functional

- Helps to understand to which extend transitivity has to be applied.
- Provides the basis for transitivity patterns (on the whiteboard).