



BFO Deep Dive Part 1

John Beverley

Assistant Professor, University at Buffalo

Co-Director, National Center for Ontological Research

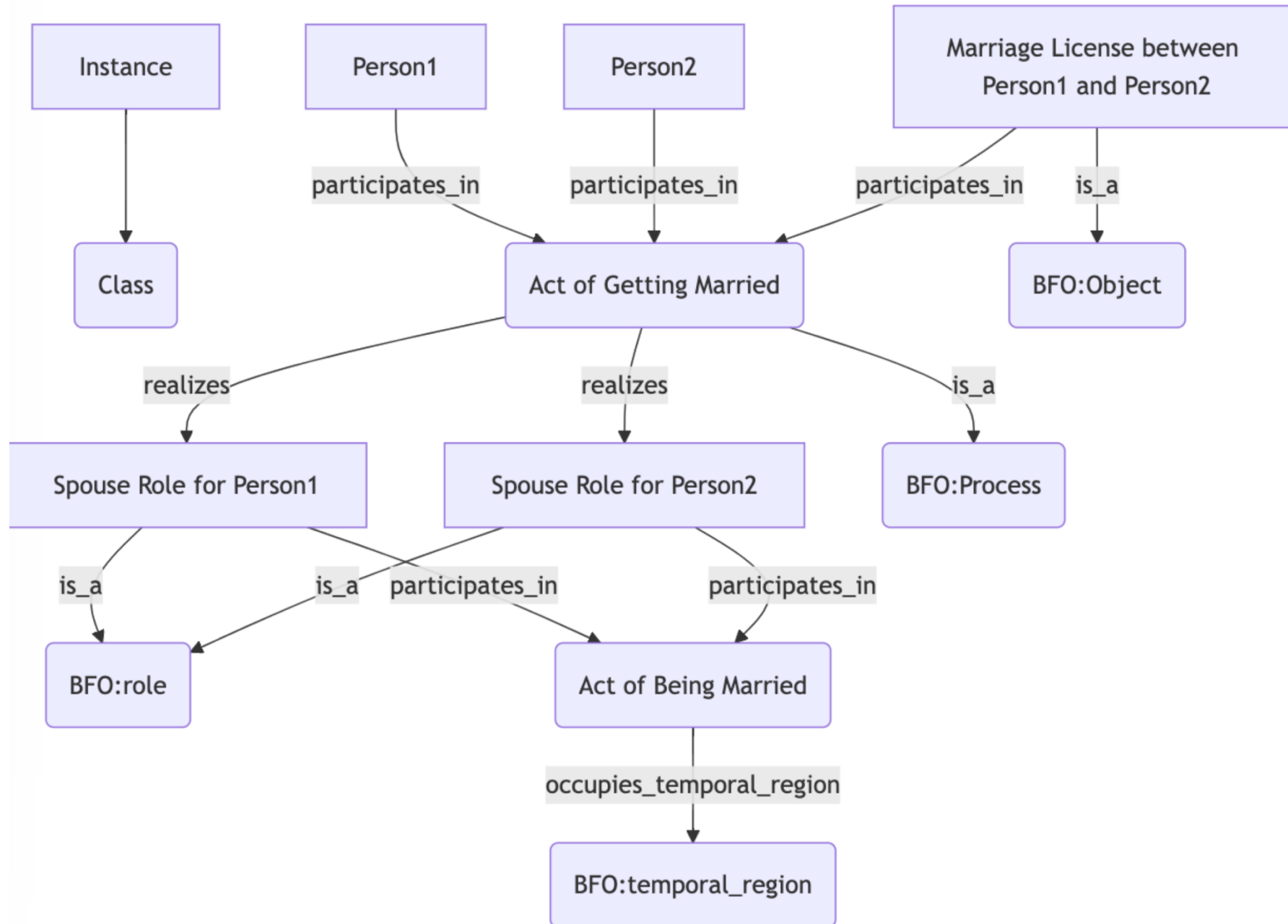
Affiliate Faculty, Institute of Artificial Intelligence and Data Science

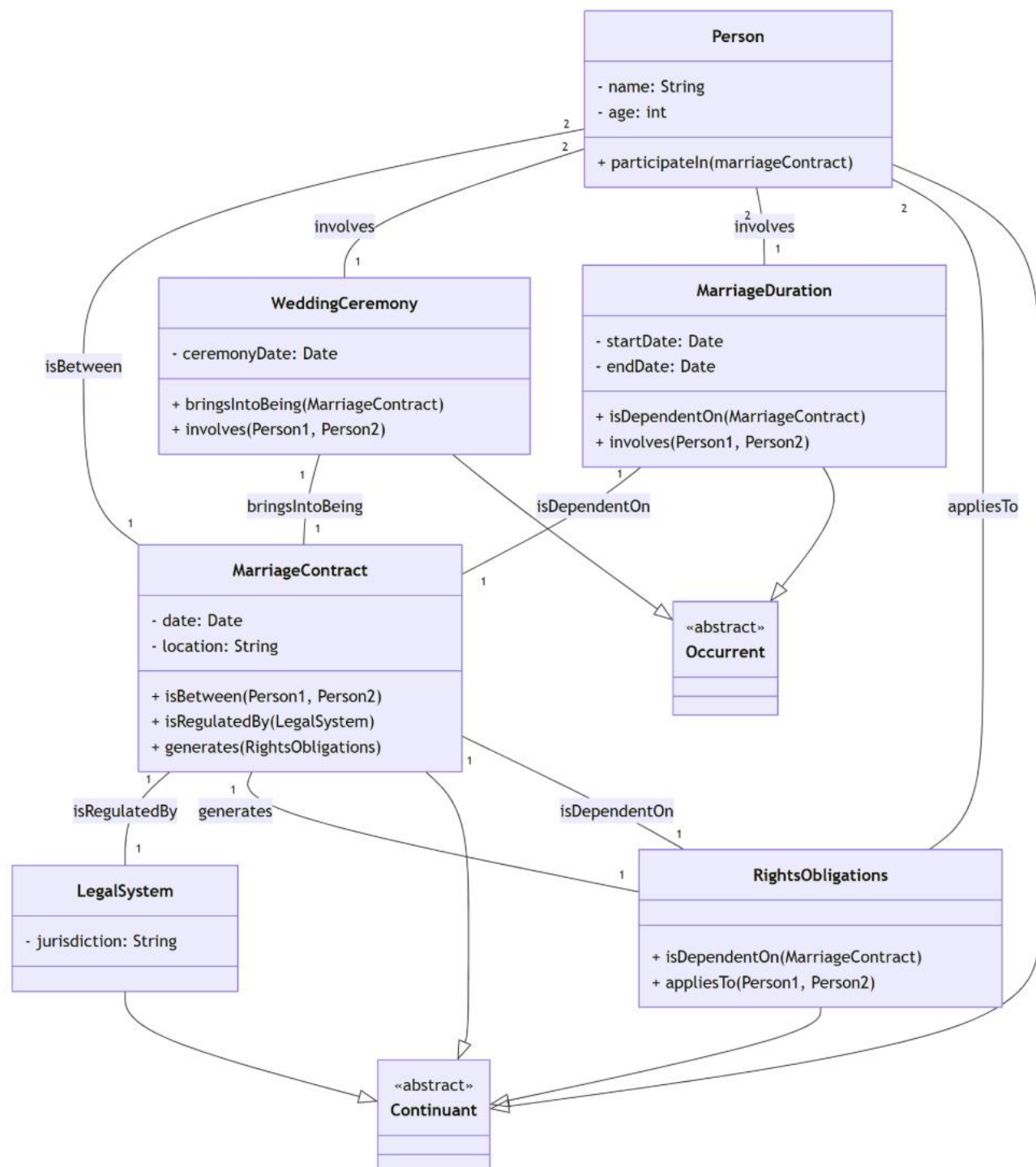
Outline

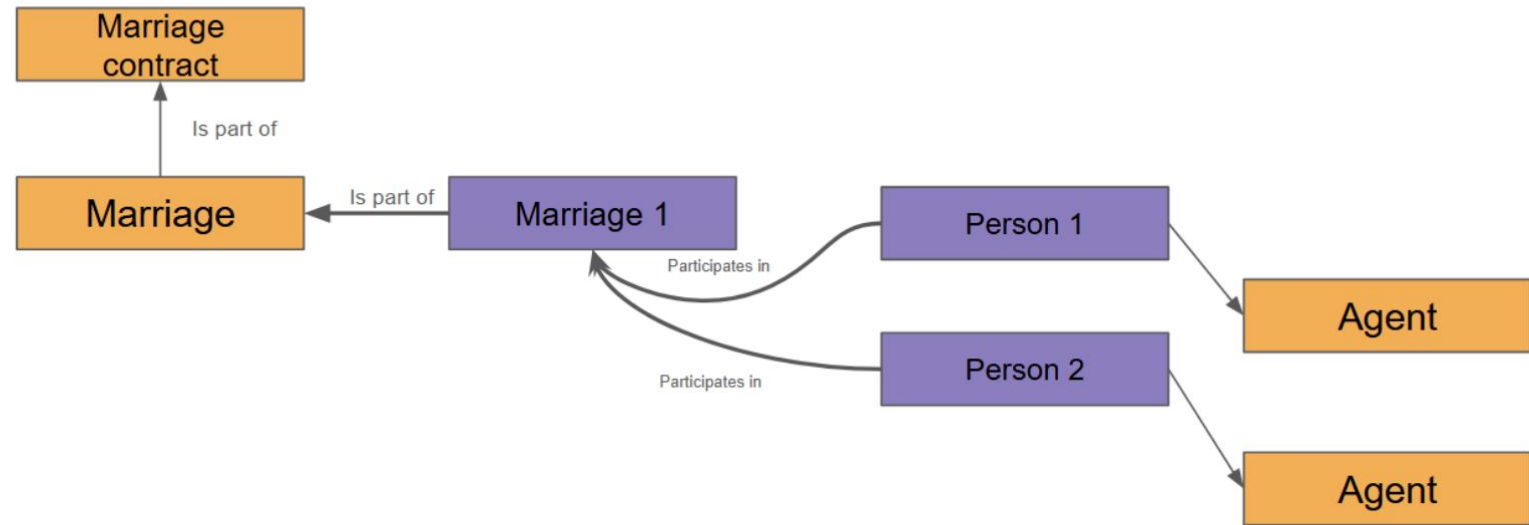
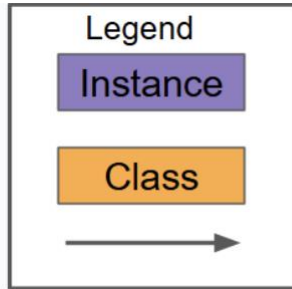
- Design Pattern Review
- Basic Formal Ontology Deep Dive
- The Gauntlet

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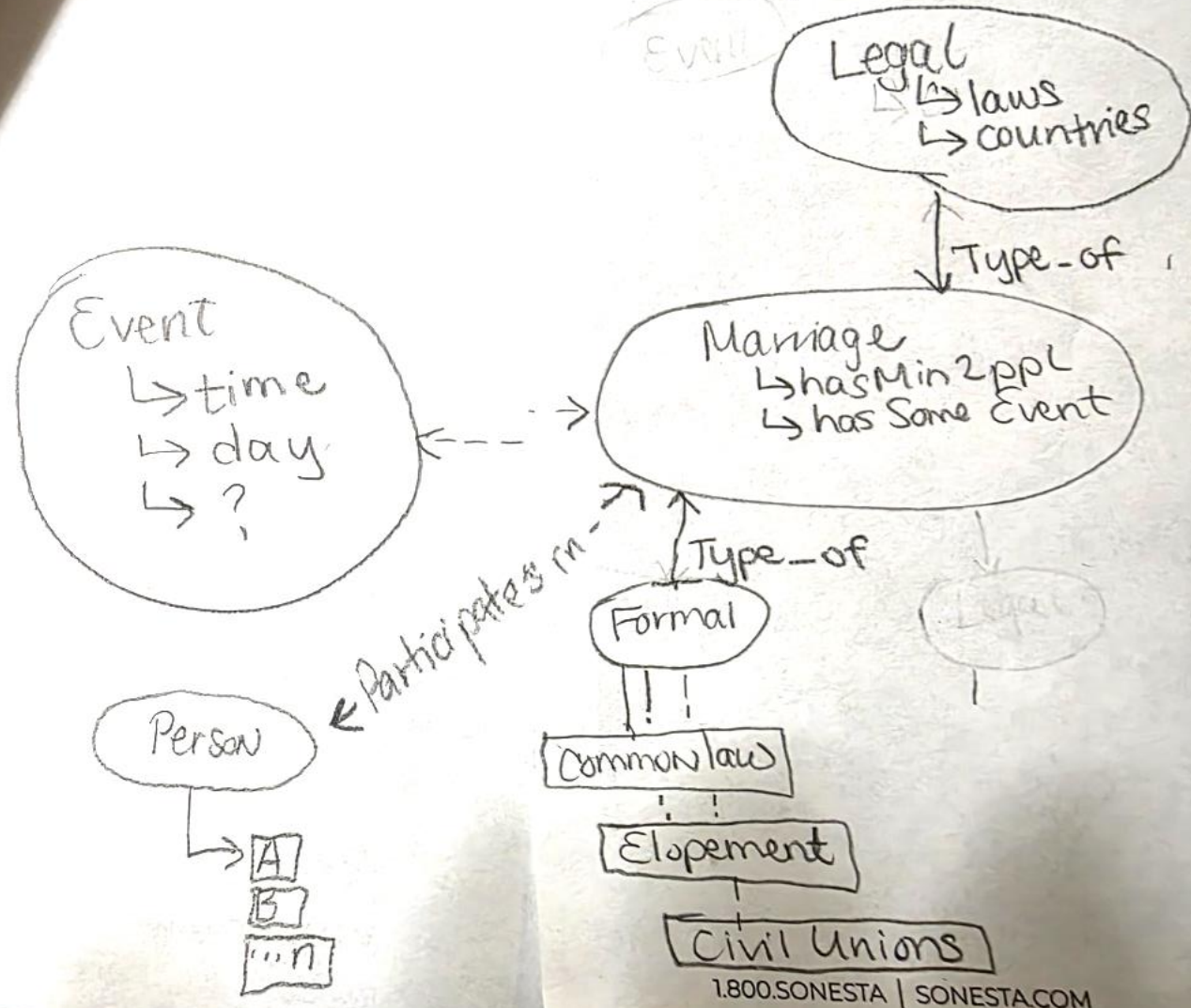
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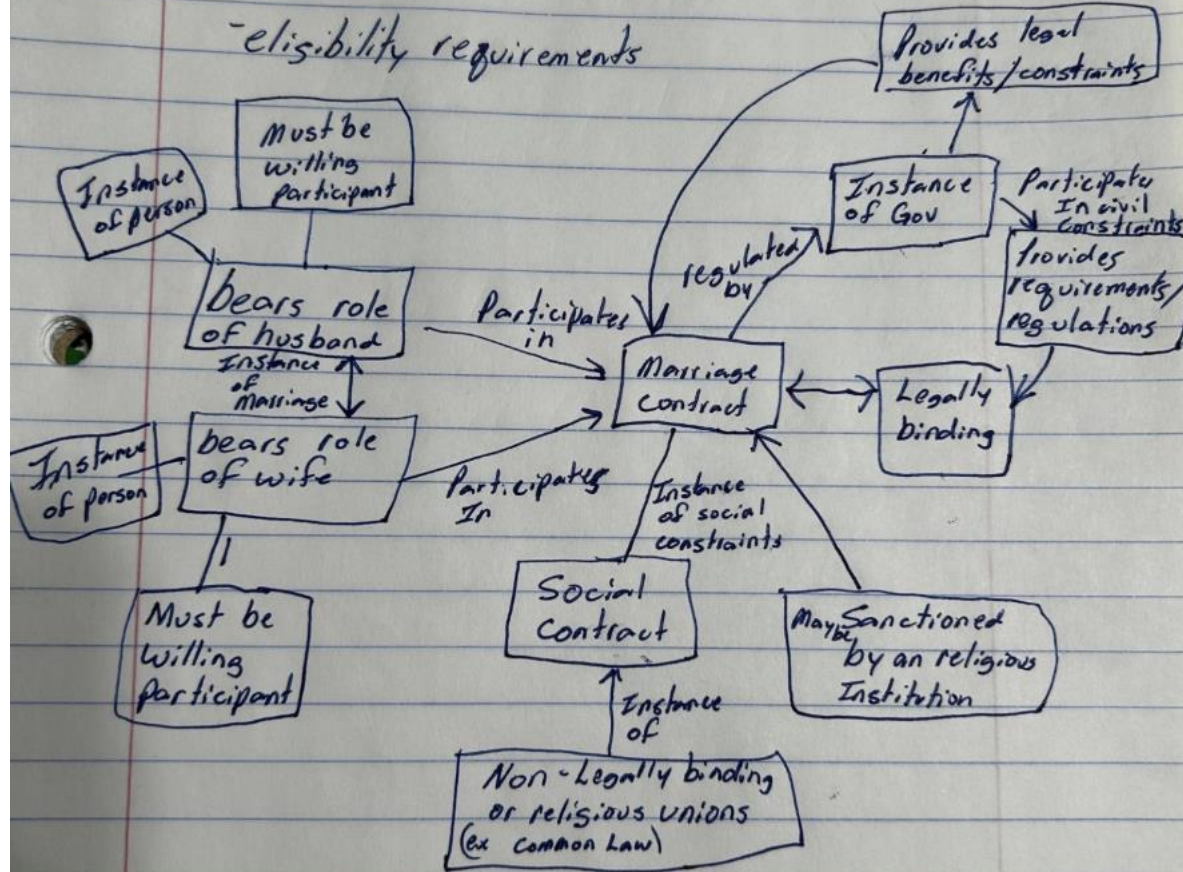


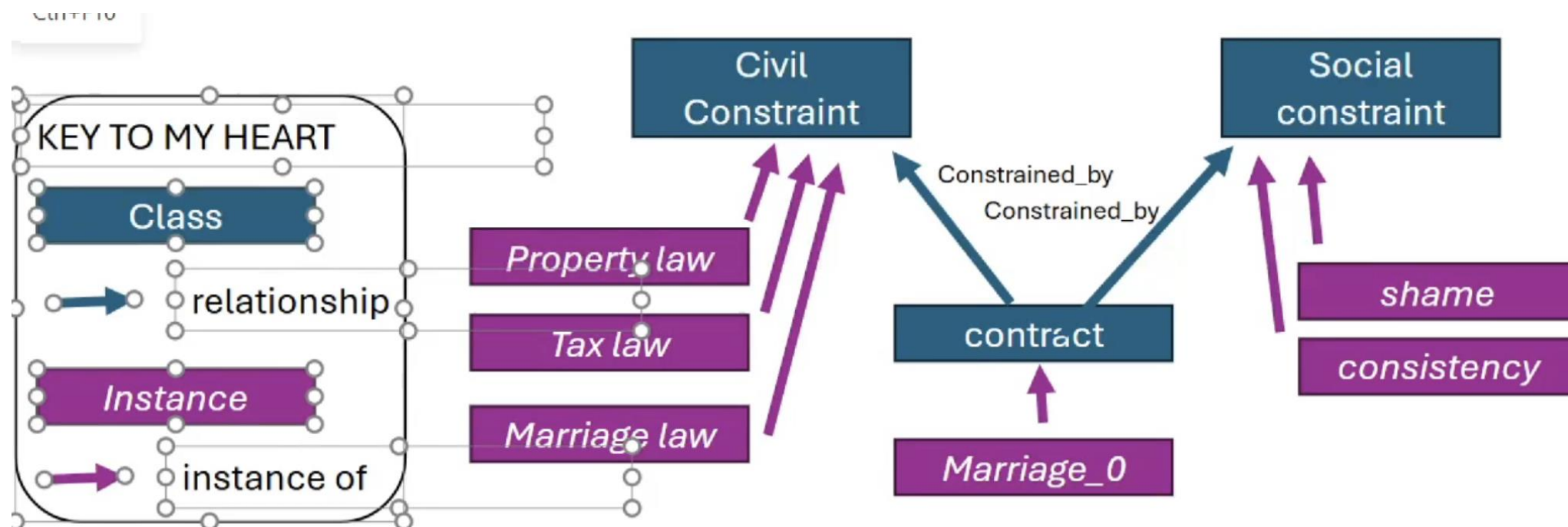
§/SONESTA



A marriage is a contract that is regulated by civil and social constraints. These constraints can change but the meaning of marriage continues over time.

- eligibility requirements





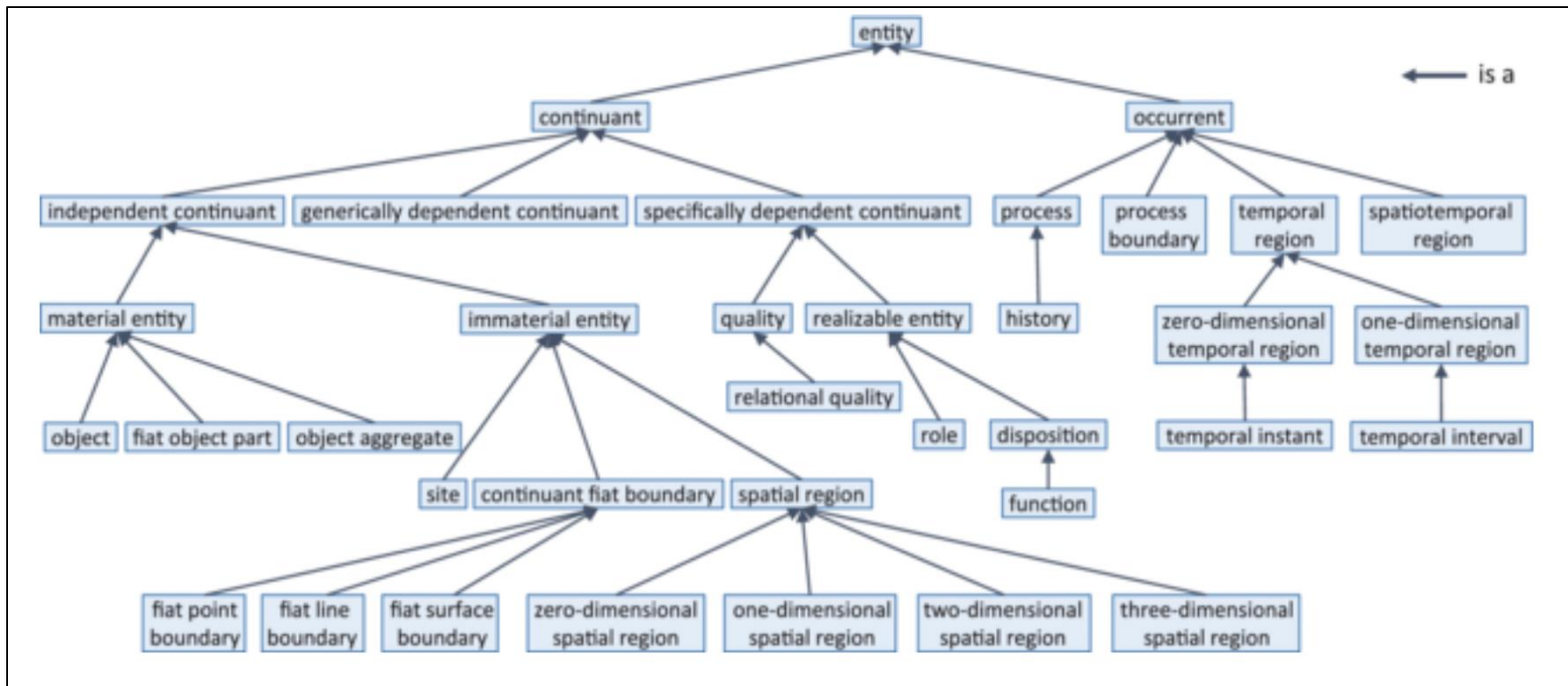
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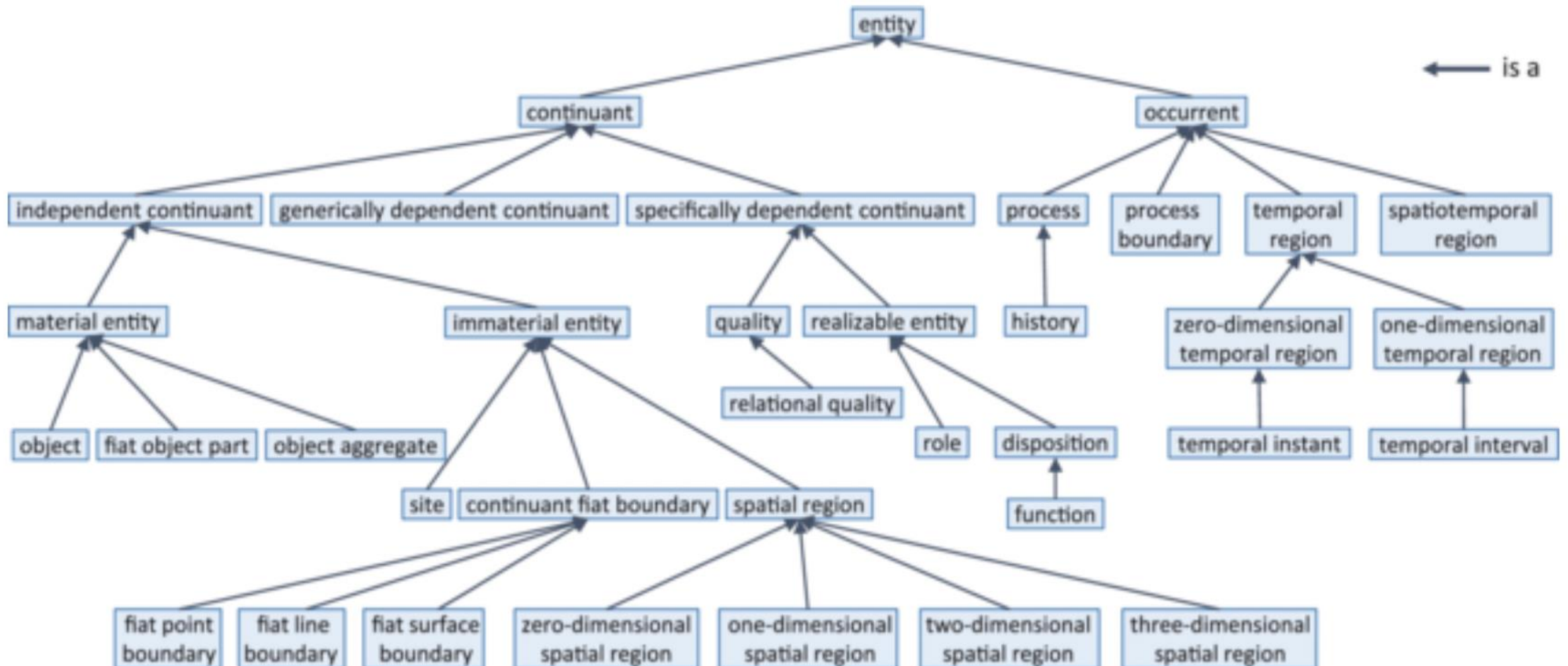
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Basic Formal Ontology

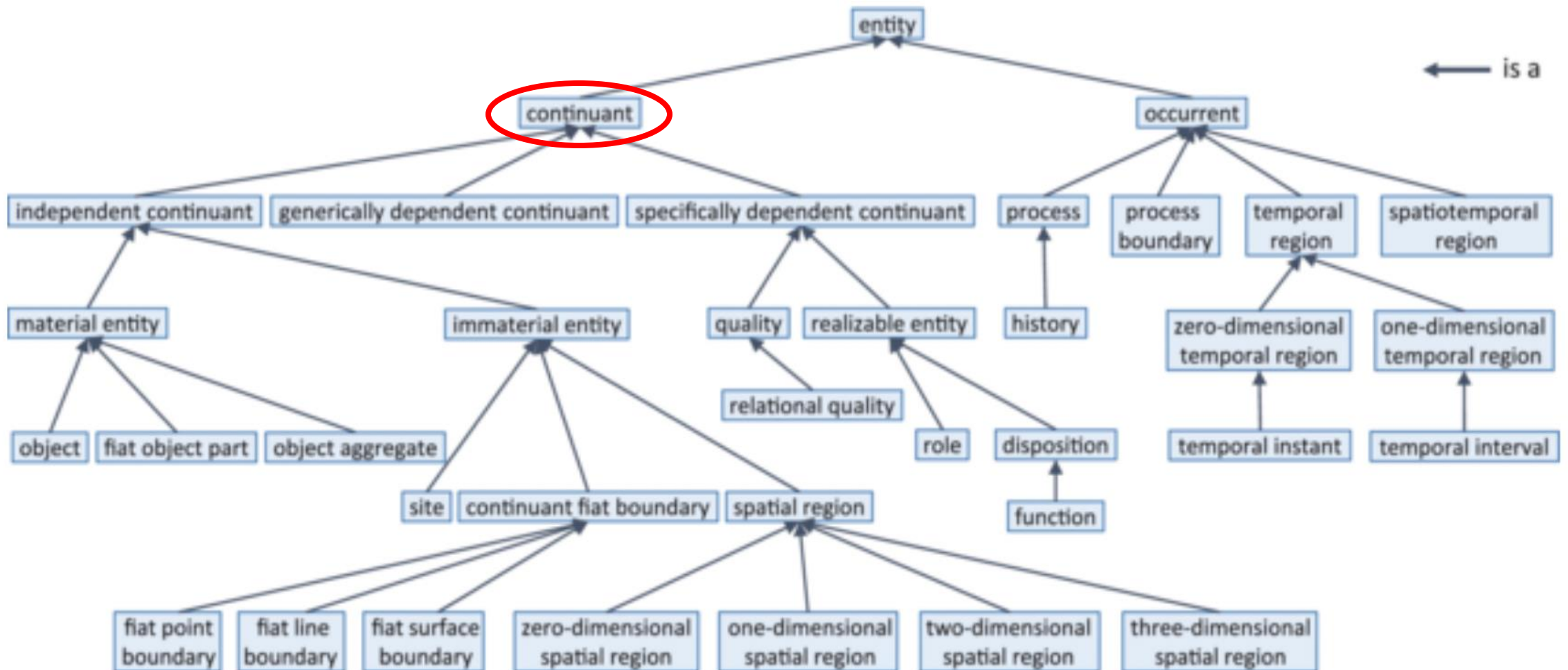
Created by **Barry Smith**, BFO is that top-level architecture, used by over 700 open-source projects, including various ontology Foundry efforts



Using BFO as a top-level architecture, ontologies covering more specific content, e.g. livers, food, computers, etc. can extend be easily extended from it

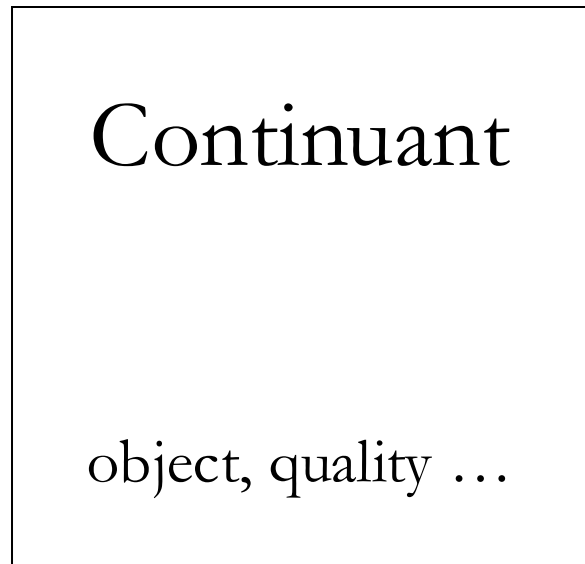


Continuant

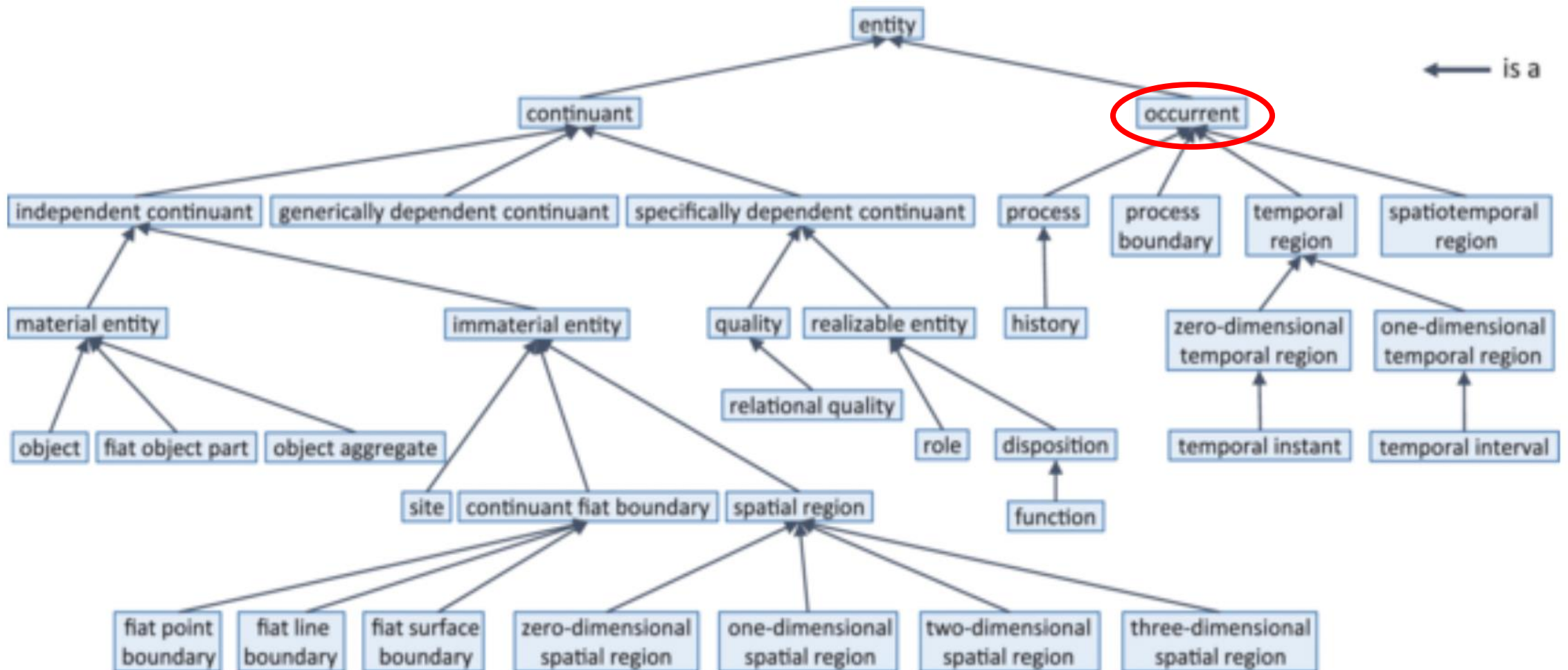


Continuant

- Continuants exist in time, wholly present whenever they exist at all; they are entities that lack temporal parts



Occurrent



Occurrent

- Occurrents exist over time, in that they have temporal parts

Continuant

object, quality ...

Occurrent

process, event

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Parthood

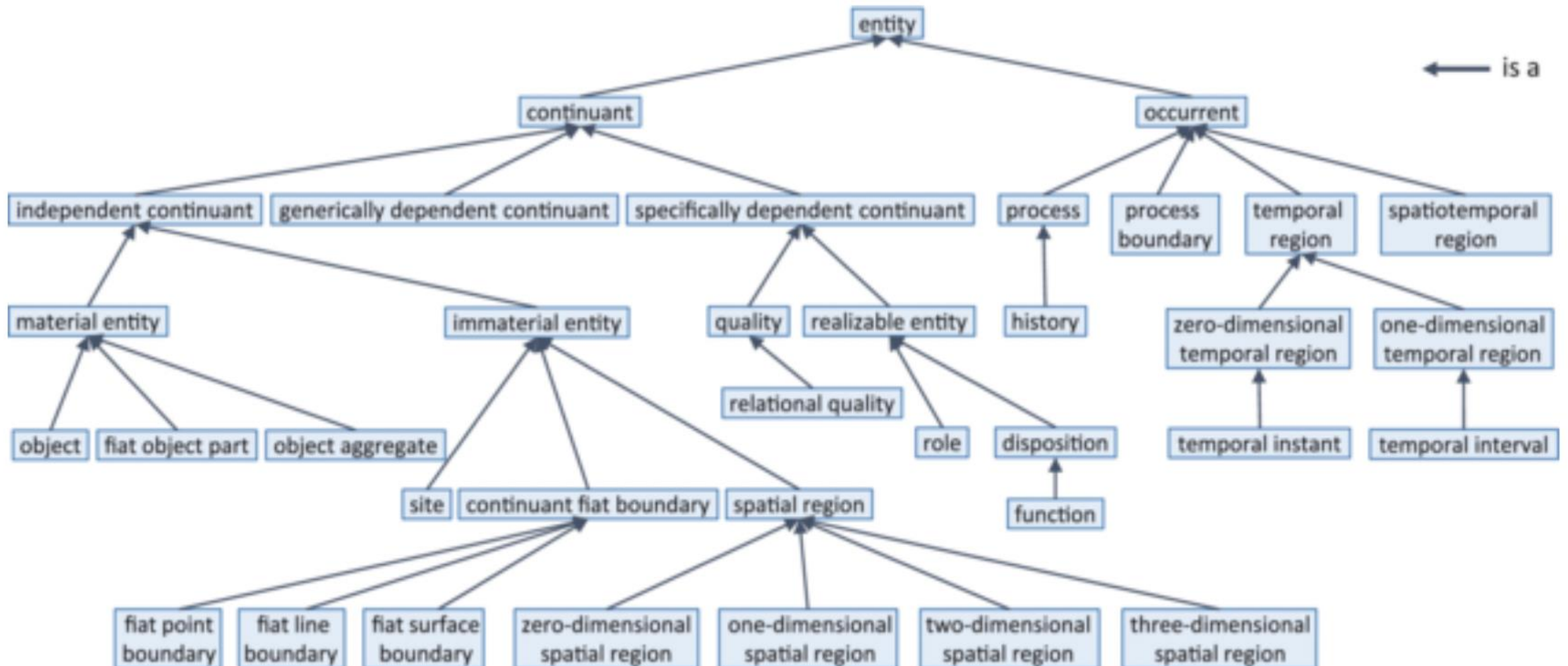
- Among the most important logical relationships is parthood
- Which in BFO comes in two flavors:
 - continuant parthood
 - occurrent parthood
- Reflecting that the class Continuant is closed under parthood, and Occurrent is as well

No continuant may have or be part of any occurrent

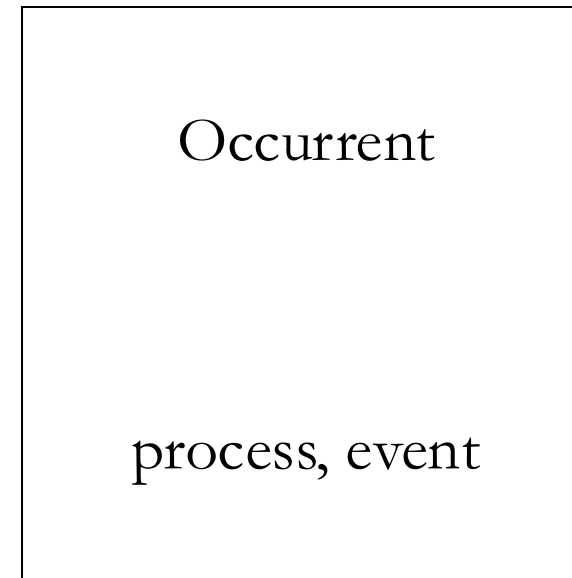
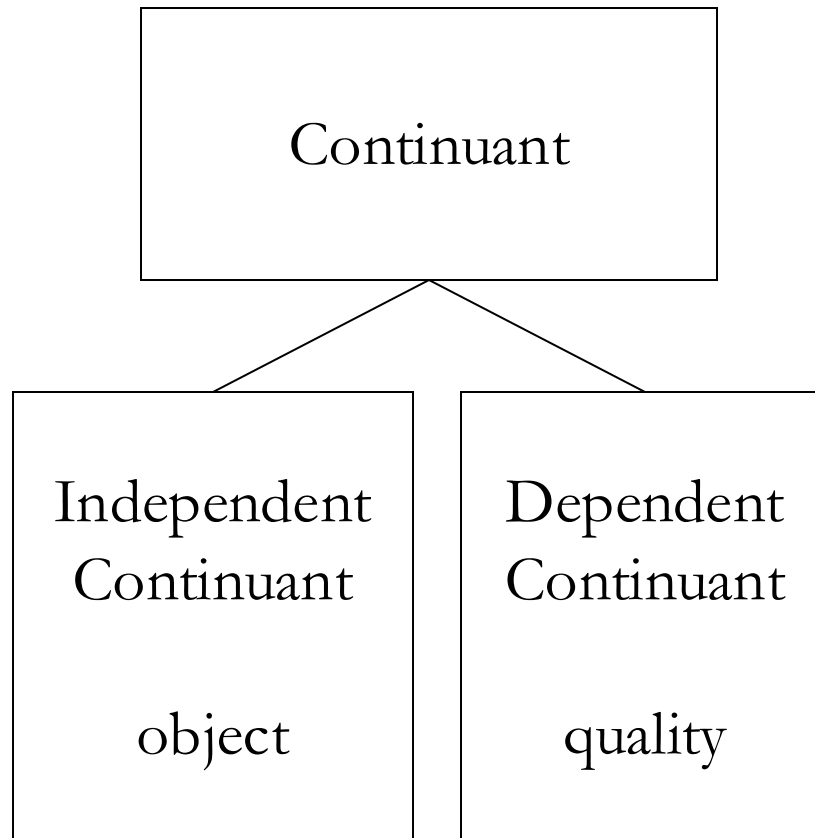
No occurrent may have or be part of any continuant

Classes represent collections of instances
For example: the class of *tables* falls under the class of *objects* and
your dinner table would be an instance of the former

Class A *is_a* Class B means any instance of
Class A is an instance of Class B



Types and Tokens



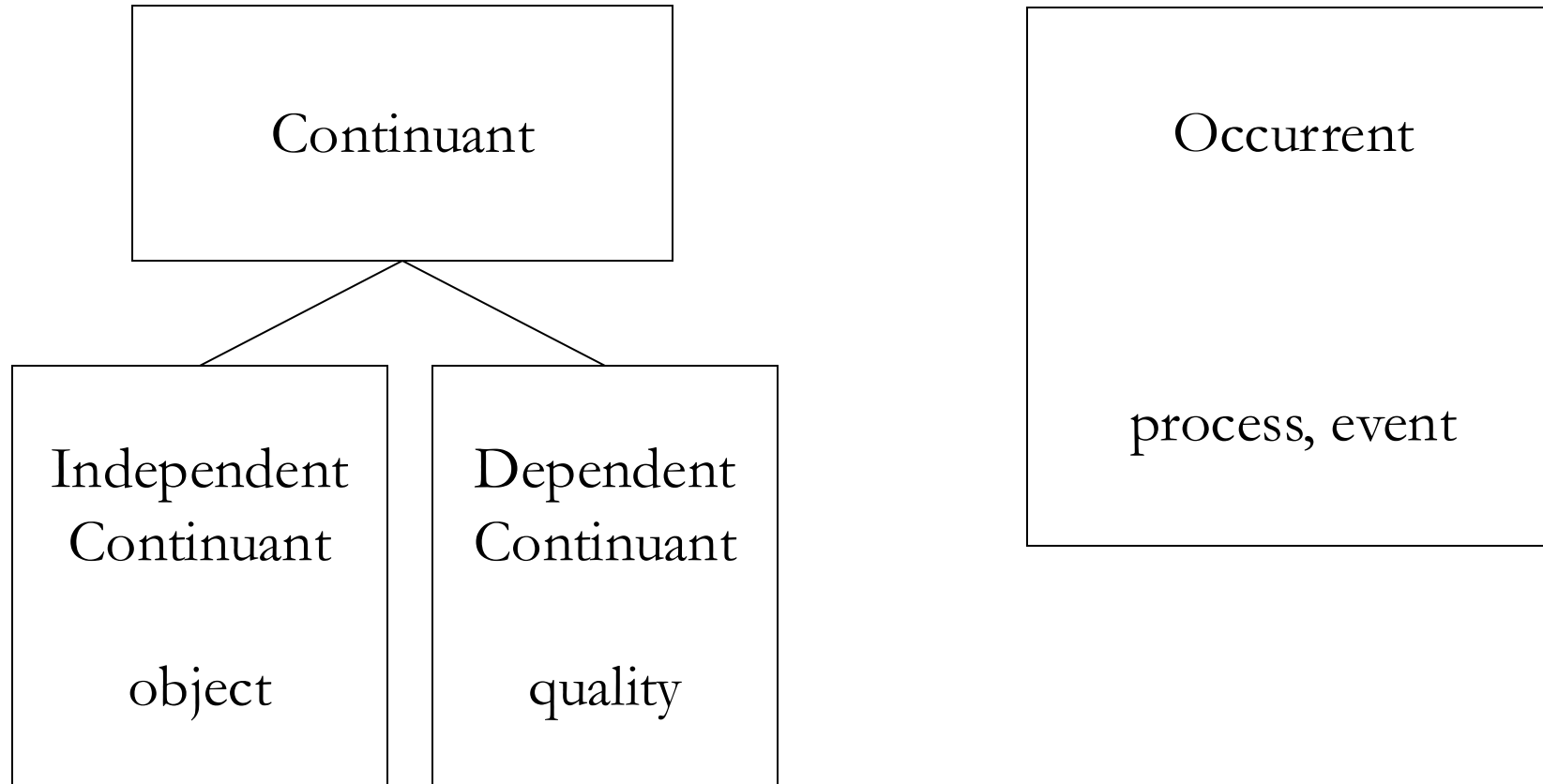
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Types and Instances

TYPE



INSTANCE

• • •

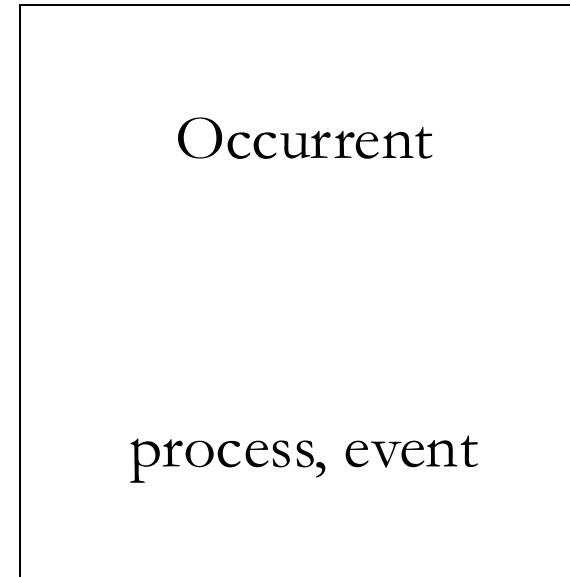
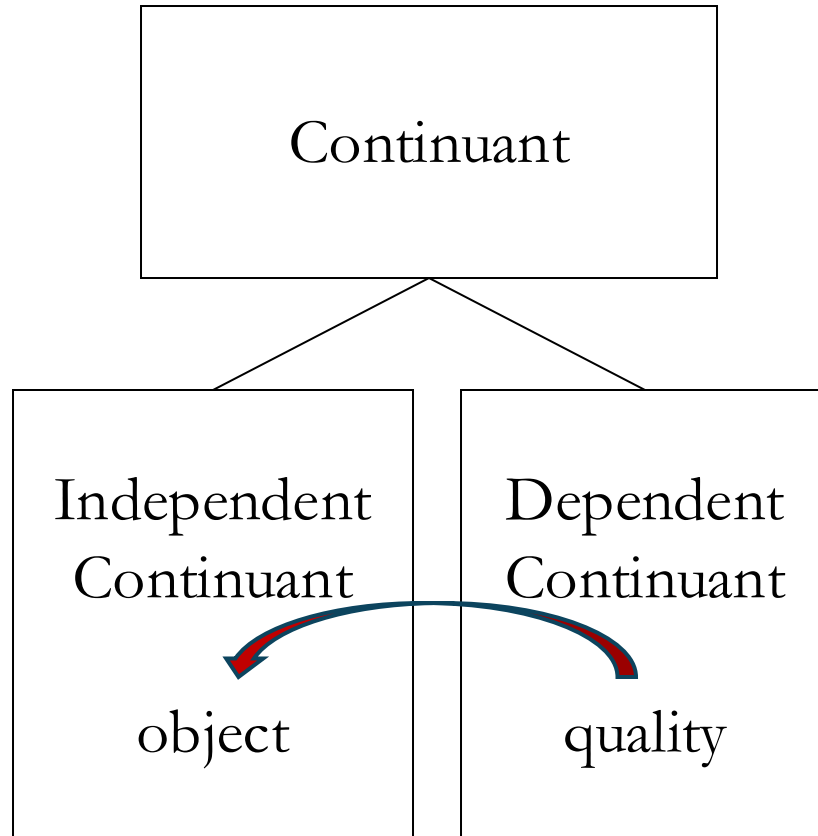
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(In)dependence



**Some continuants depend
for their existence on others**



Dependence

- For certain entities, their existence depends on the existence of something else
- Other entities do not depend on any other entities for their existence
- The latter are categorized in BFO as **independent continuants**
- The former include **specifically dependent** and **generically dependent entities**, as well as **processes**

Dependence

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Specifically Dependent Continuant



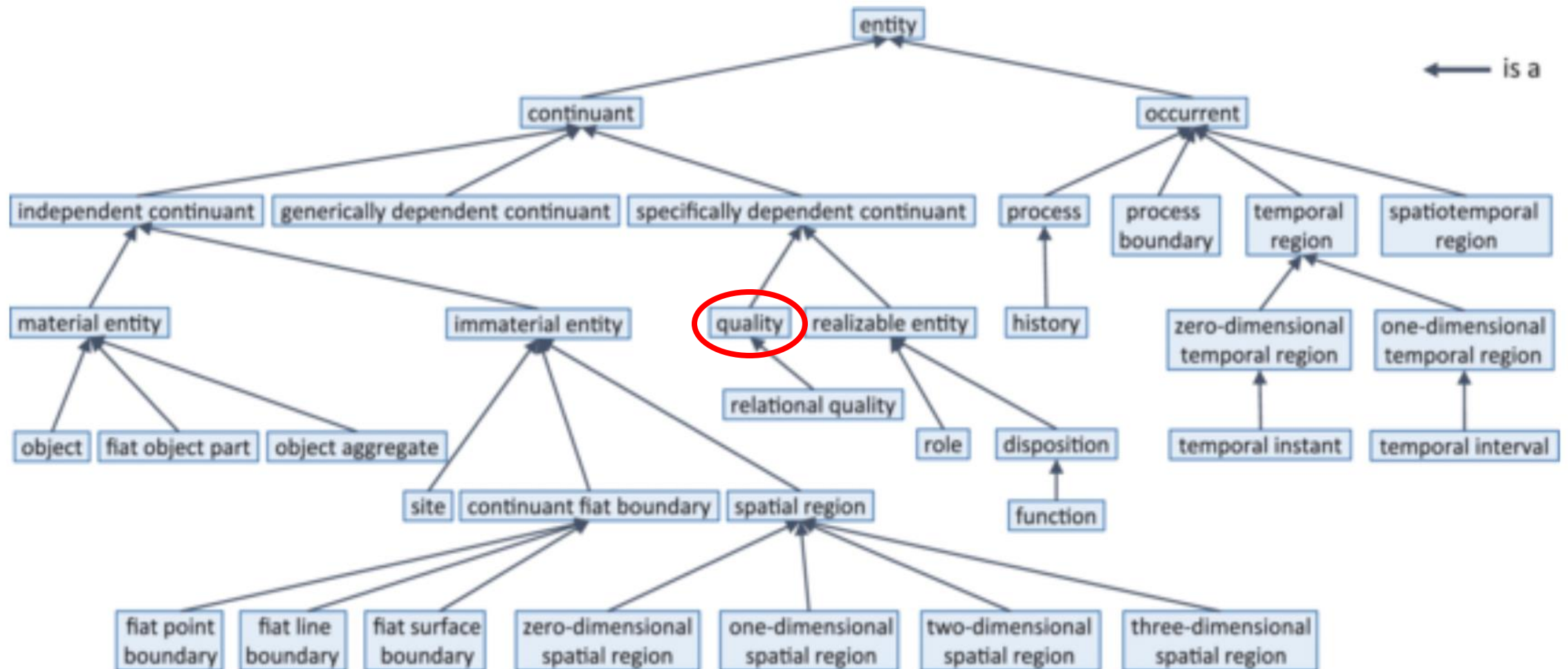
Specifically Dependent Continuant

- These are continuants that in every case **specifically depend on** some independent continuant for their existence
- For example, the mass of a tomato specifically depends on a given tomato, the shape of your smile depends on your face, and so on

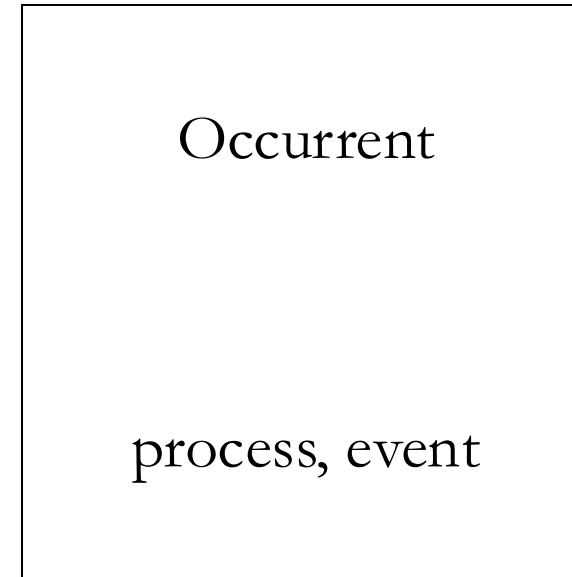
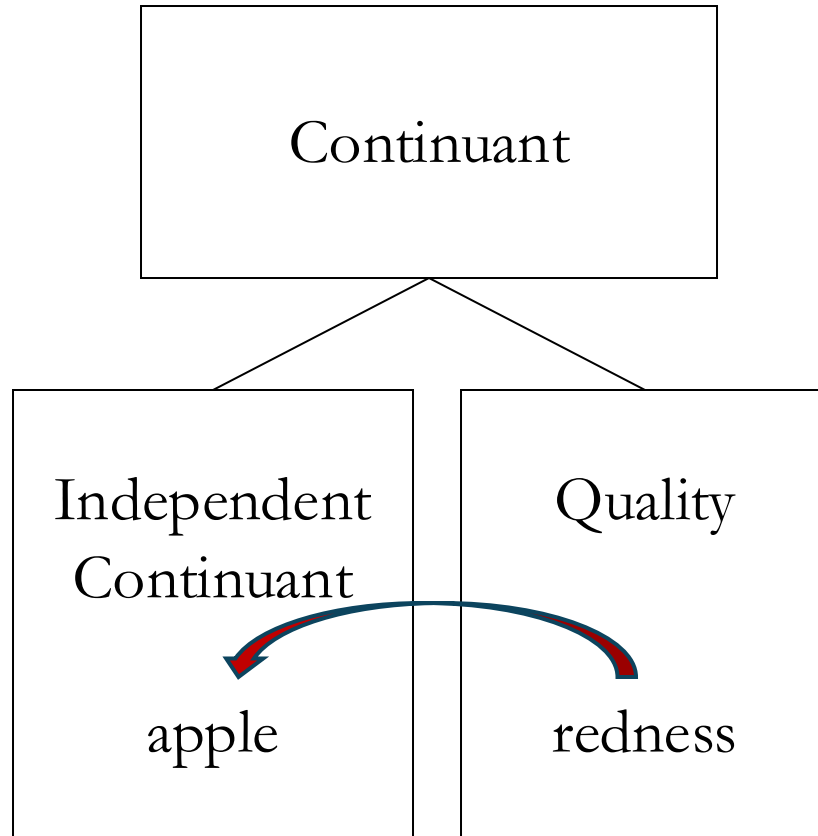
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- For example, the mass of a tomato specifically depends on a given tomato, the shape of your smile depends on your face, and so on
- Importantly, SDCs cannot migrate across bearers, i.e. the specific shape of your smile **depends on you** and so cannot **specifically depend on** me

Quality



Qualities



**Qualities inhere in
independent continuants**

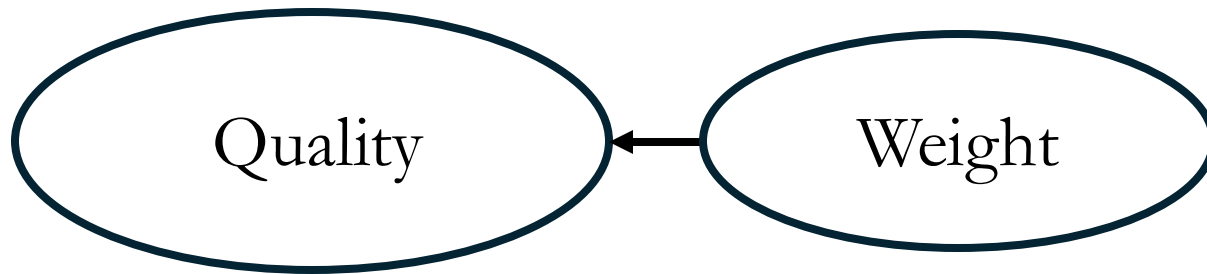


Quality

- In BFO, instances of Quality are said to manifest in full whenever they manifest at all
- For example, when an apple bears a redness quality, there is nothing more to that quality than the redness
- Similarly, the shape of the smile on your face is there for the world to see whenever it is there at all; there is nothing more to the shape than what is presented on your face

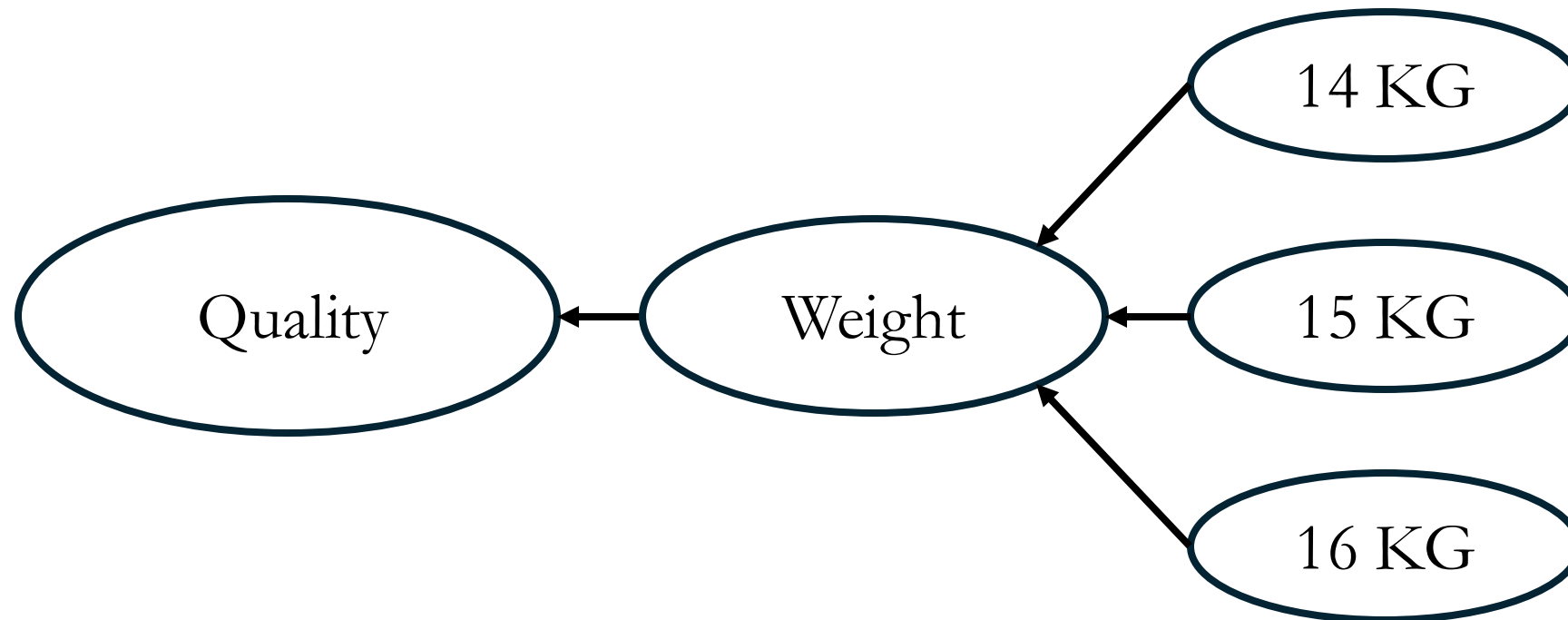
Subclasses of Quality

- That said, your various qualities and mine may be instances of the same subclass of the class Quality



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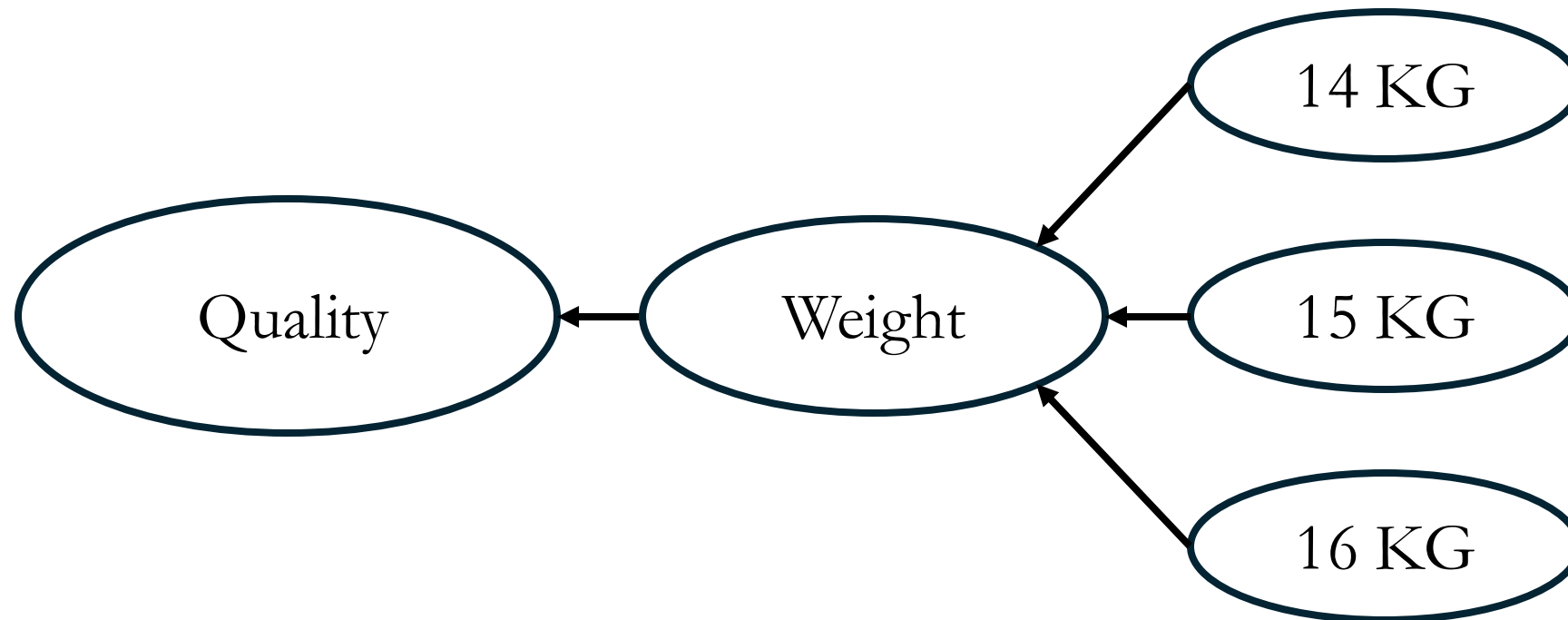


Subclasses of Quality

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TYPE

INSTANCE

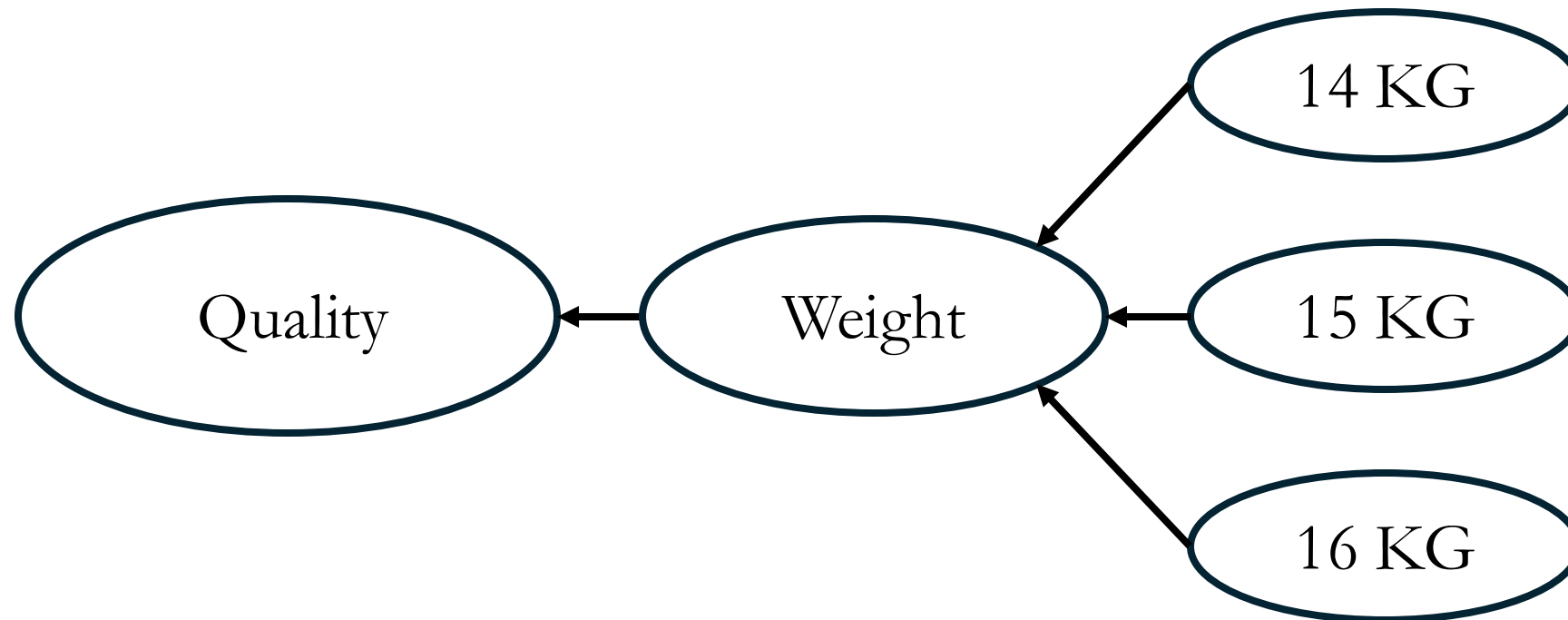


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Determinates and Determinibles

- Certain instances of Quality may fall under different specializations of subclasses of Quality

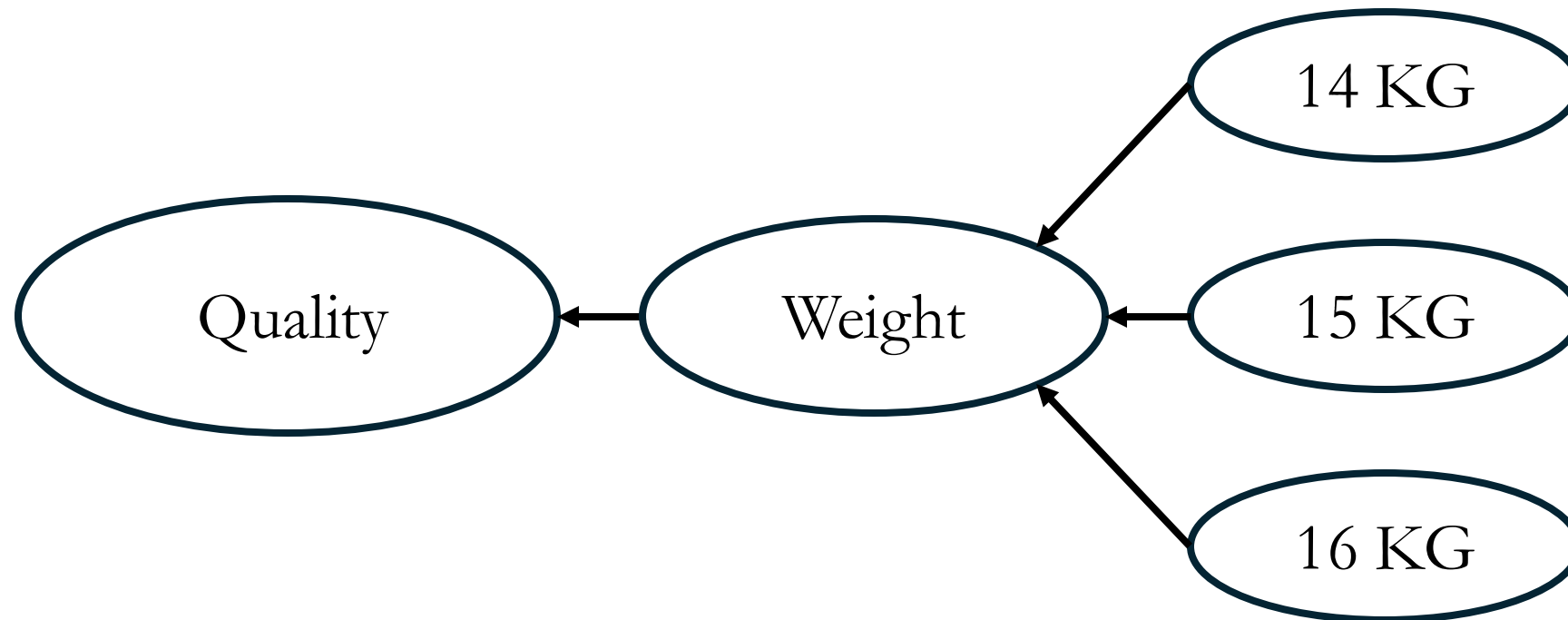


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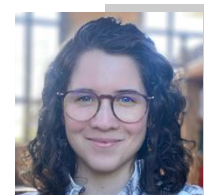
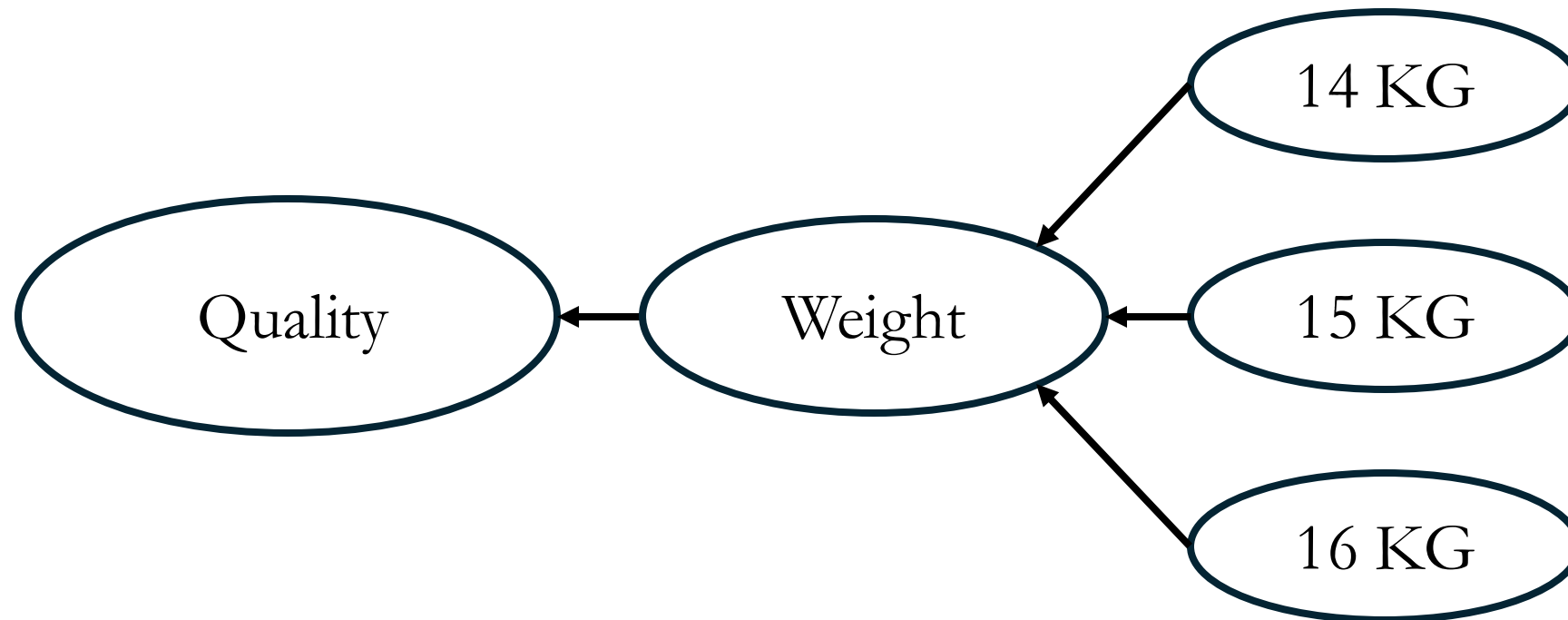
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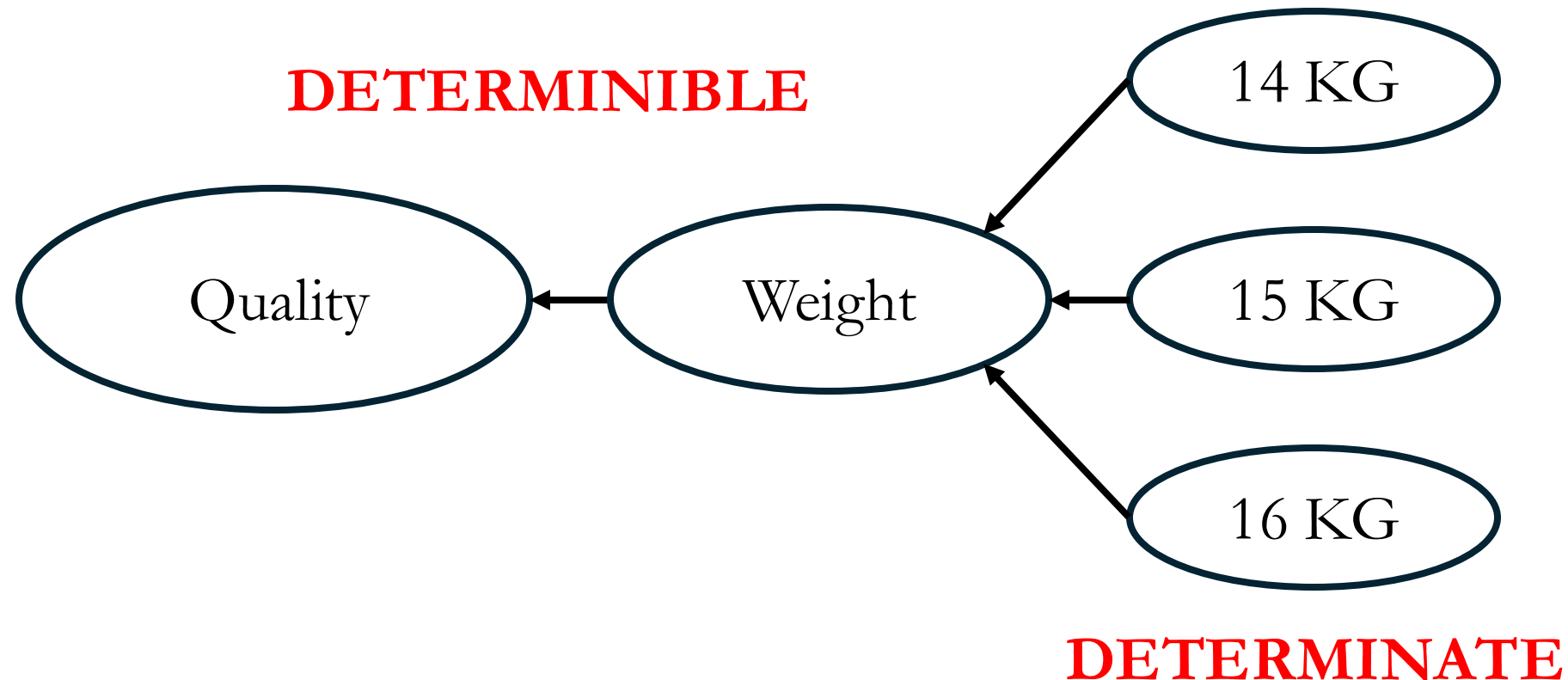
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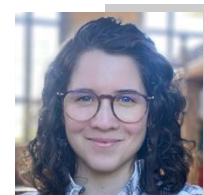
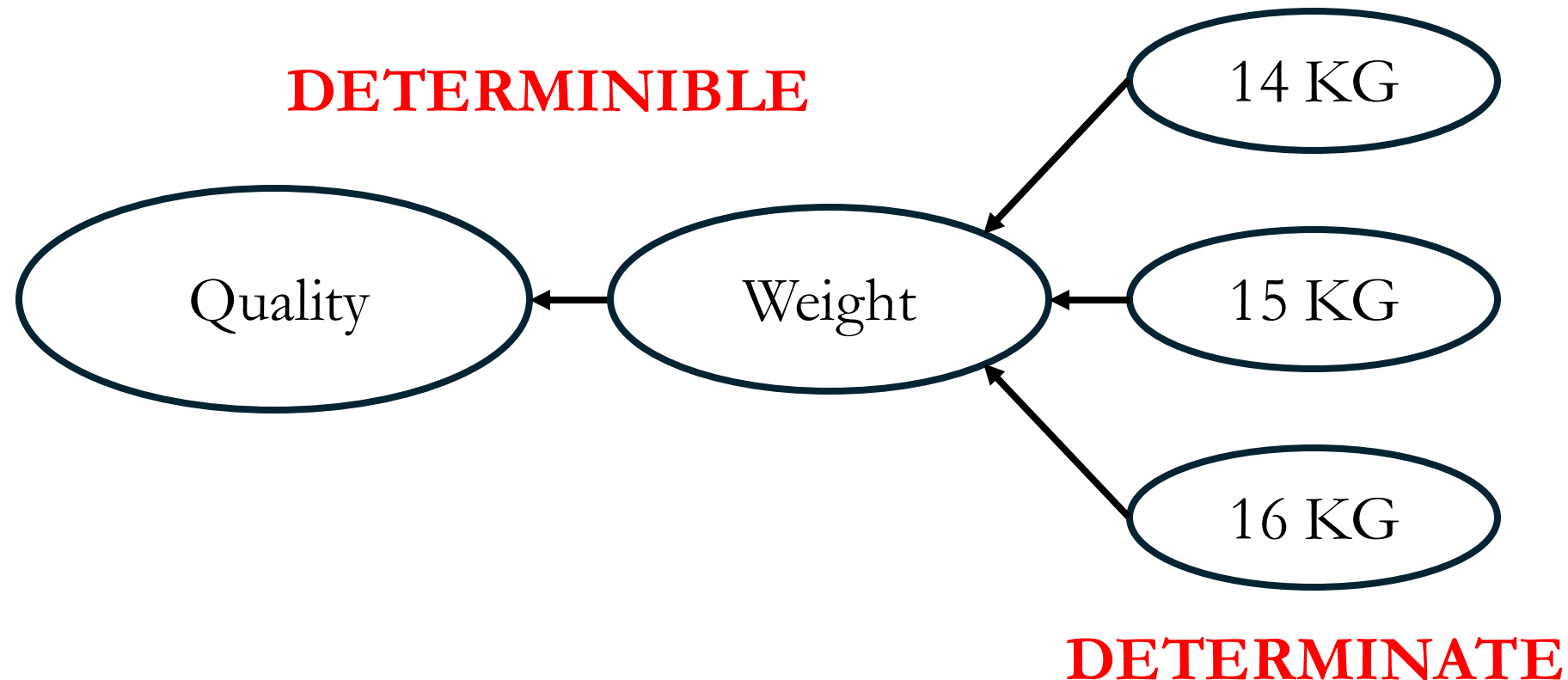
Determinates and Determinibles

- We call the subclasses of Quality that remain the same throughout **determinibles** and those specializations that change **determinates**



Determinates and Determinibles

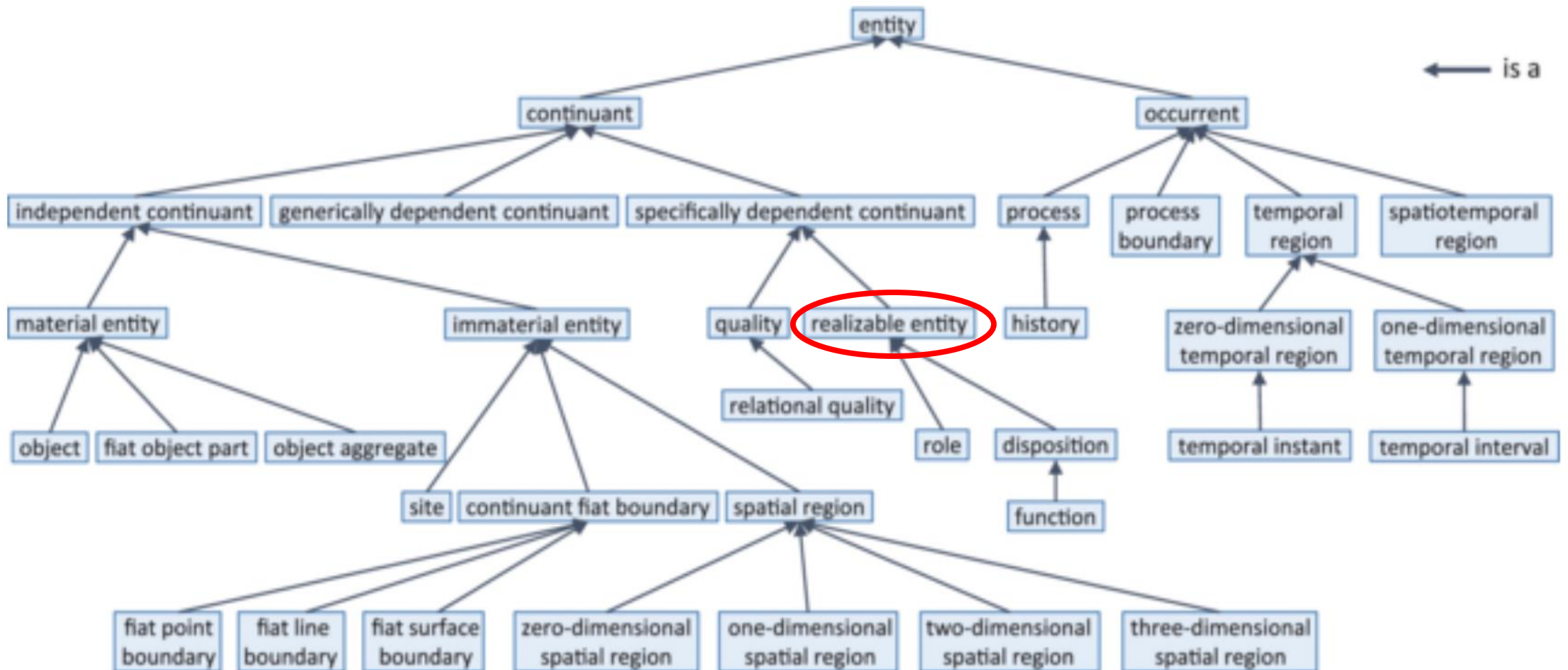
- Even with determinate change, however, at **no point** does an instance of Quality migrate to a new bearer; rather, there are **distinct instances**



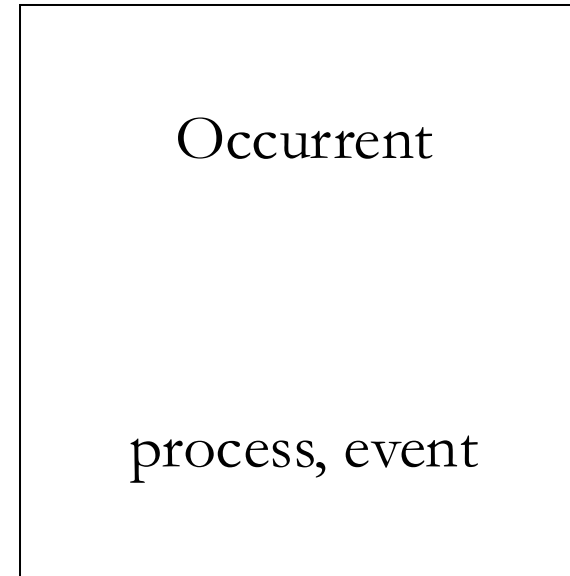
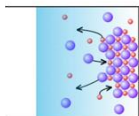
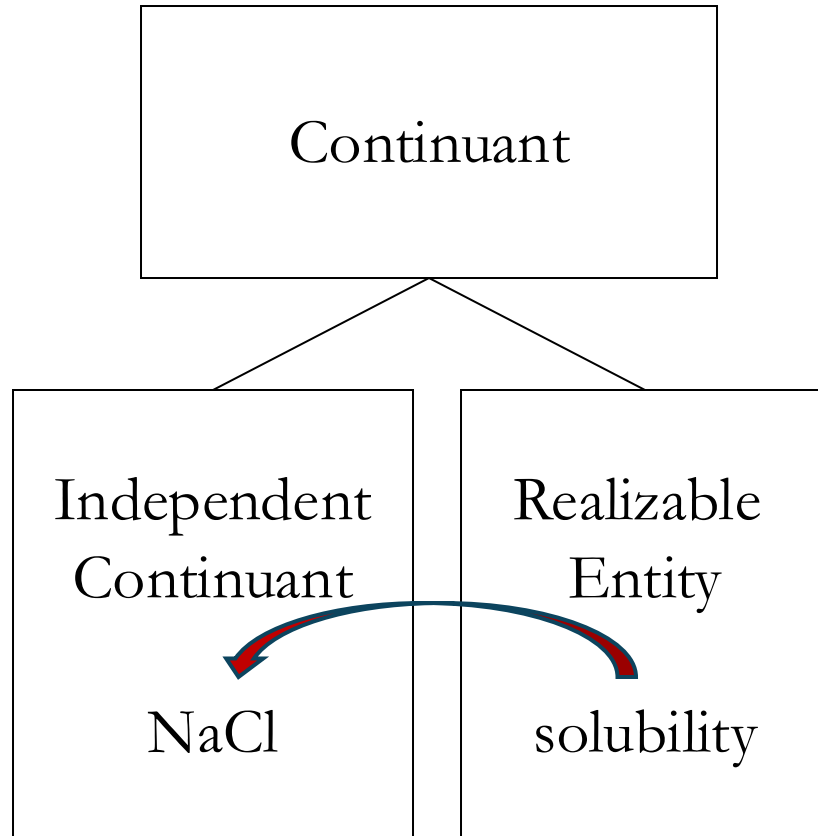
Determinates and Determinibles

- Traditionally, determinates exhibit some ordering relative to a given determinible
- If P is a determinate of determinible Q, then:
 - P is more specific than Q
 - There is a strict partial ordering of determination between P and Q
 - No two determinates P_1 and P_2 can causally exclude one another
 - Any two determinates P_1 and P_2 are comparable
- Caveat: The preceding is not official BFO, but from observation

Realizable Entity



Realizable Entity



**Not all dependent entities
fully manifest when they exist**



Realizable Entity

- Attributes of some material bearer that only become manifest under certain conditions
- Put another way, realizable entities underwrite what bearers can do

Rule of Thumb

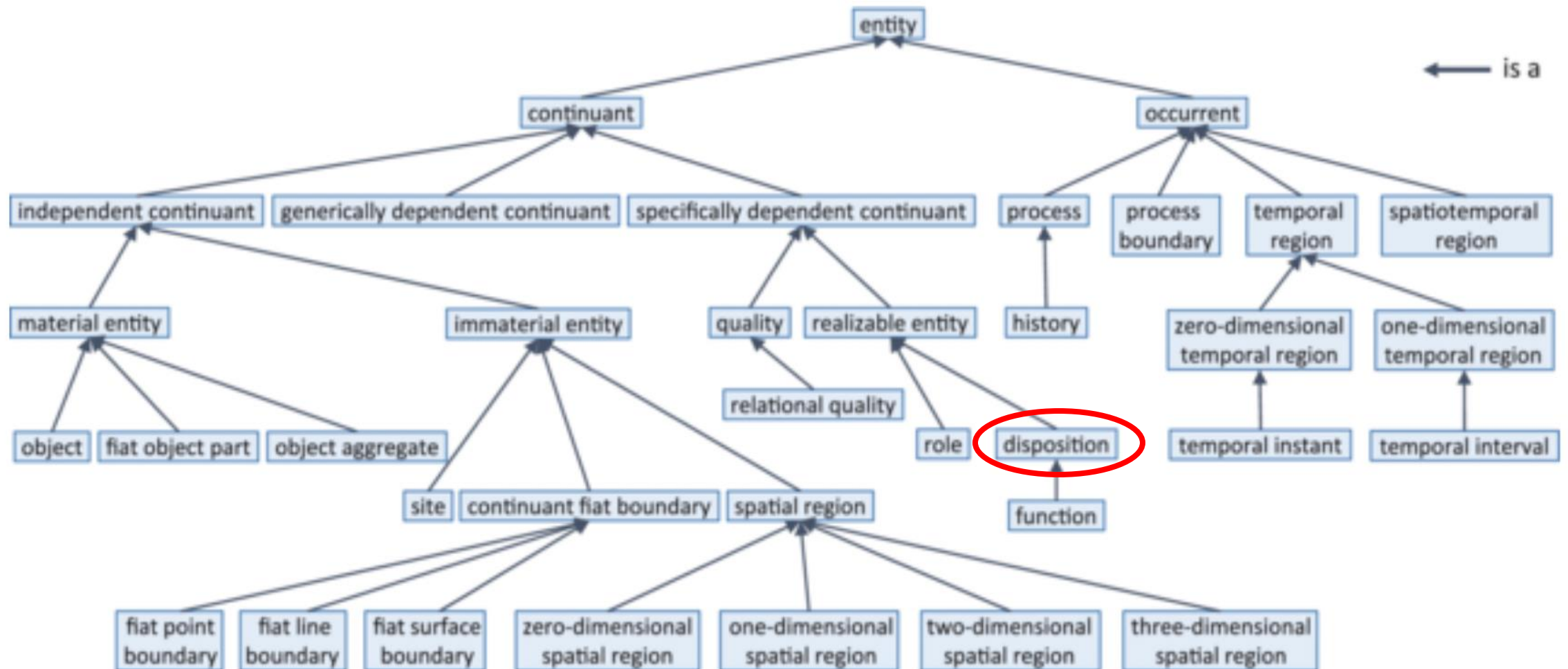
There is a portion of sodium chloride before you

- Suppose I ask “Does this portion exhibit a lattice structure?”
- You need only look at the salt to find an answer
- Suppose I ask “Is this portion soluble in unsaturated H_2O ?”
- You cannot simply look at the salt to find an answer

Modality

- Realizable Entities are how BFO represents **modality**
- The way the world is often differs from the way the world could be, could have been, and will be
- A yoga mat is black and you can see this; it could support a sleeping cat without you seeing it

Disposition



Disposition

- Attributes of some material bearer that only become manifest under certain conditions

Disposition

A realizable entity such that if it ceases to exist, then its bearer is physically changed, and its realization occurs when and because this bearer is in some special physical circumstances, and this realization occurs in virtue of the bearer's physical make-up

NaCl dissolving in H₂O Process

NaCl bearer of
dissolving
disposition

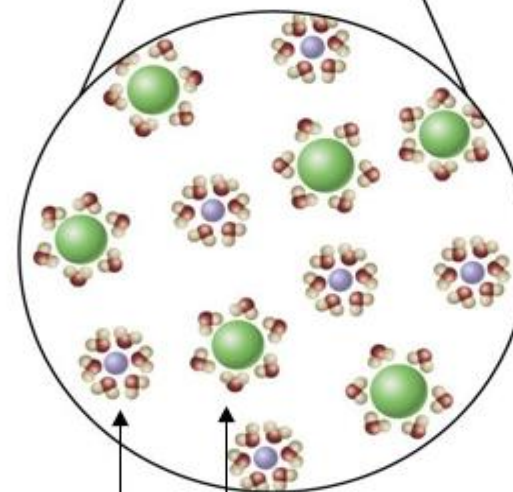
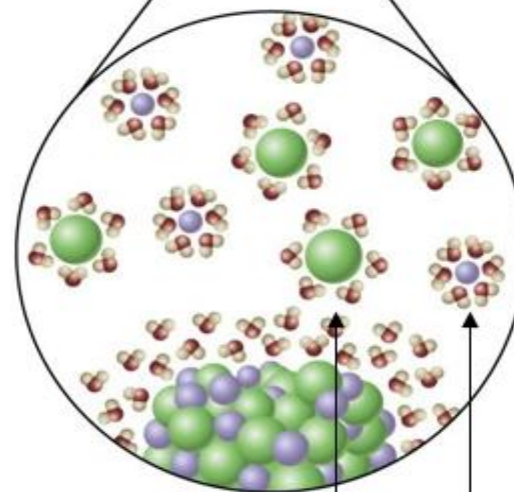
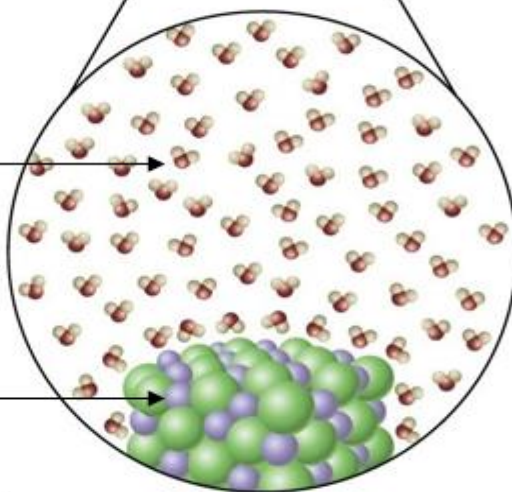
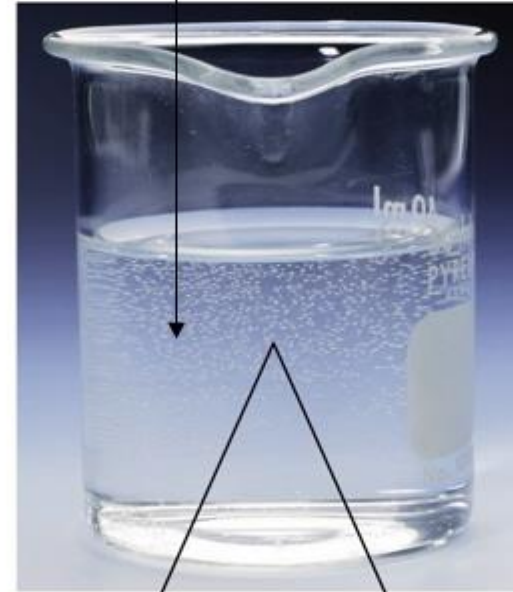
H₂O molecule
bearing
electronegative
attraction disposition

NaCl molecule
bearing
electropositive
attraction disposition

Macroscopic

Microscopic

Realizations of electronegative and
electropositive attraction dispositions



Disposition

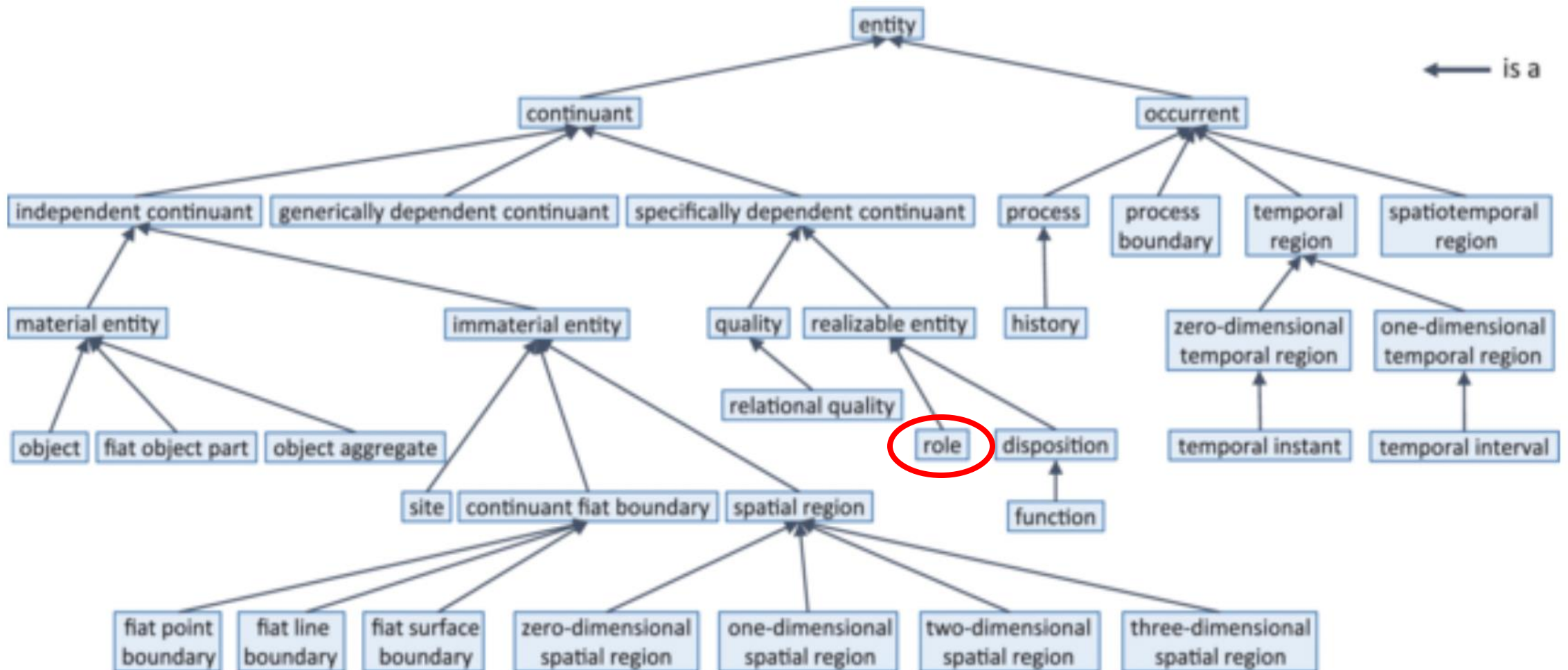
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INTERNALLY GROUNDED

Role



Role

- Attributes of some material bearer that only become manifest under certain conditions

Role

A realizable entity that exists because there is some single bearer that is in some special physical, social, or institutional set of circumstances in which this bearer does not have to be, and is not such that, if it ceases to exist, then the physical make-up of the bearer is thereby changed.



Role

- Attributes of some material bearer that only become manifest under certain conditions

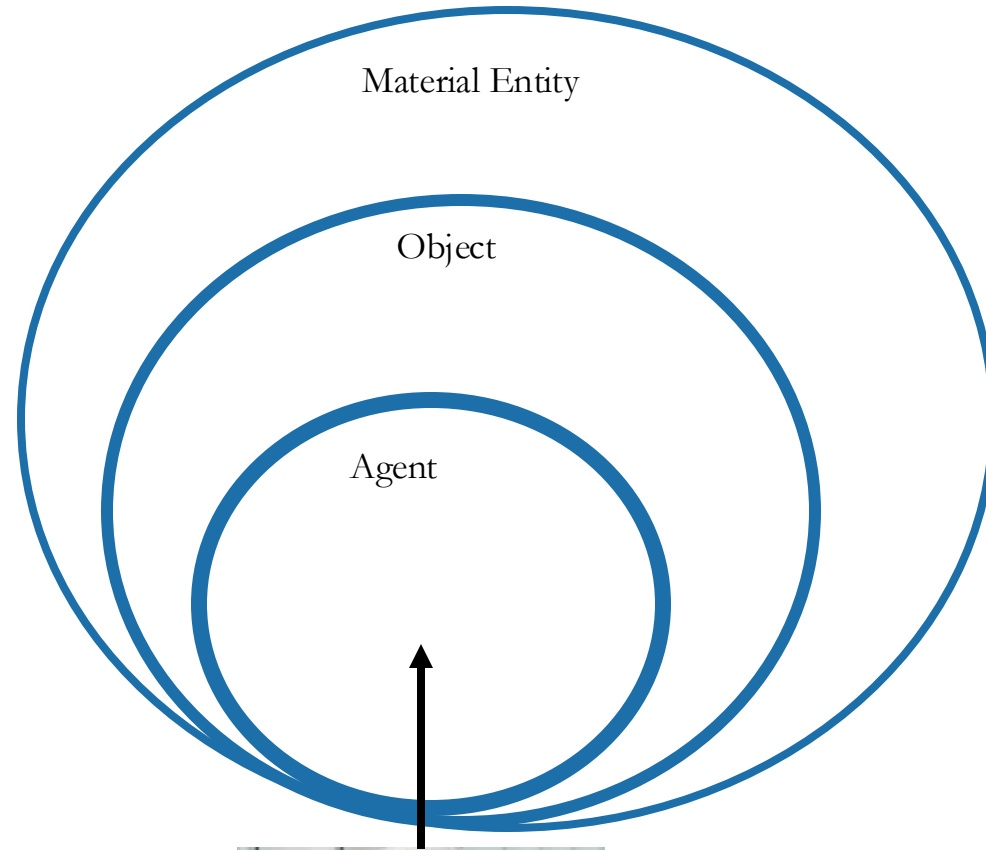
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EXTERNALLY GROUNDED

Barry Smith instance_of Agent

CLASSES



INSTANCES

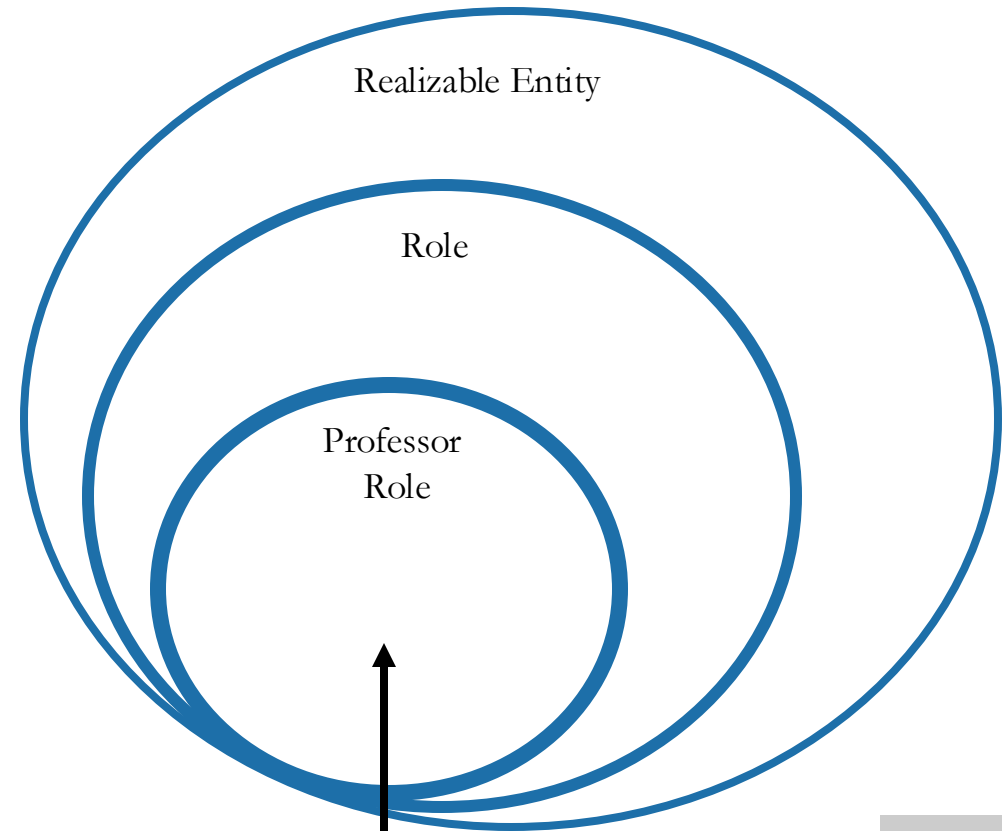
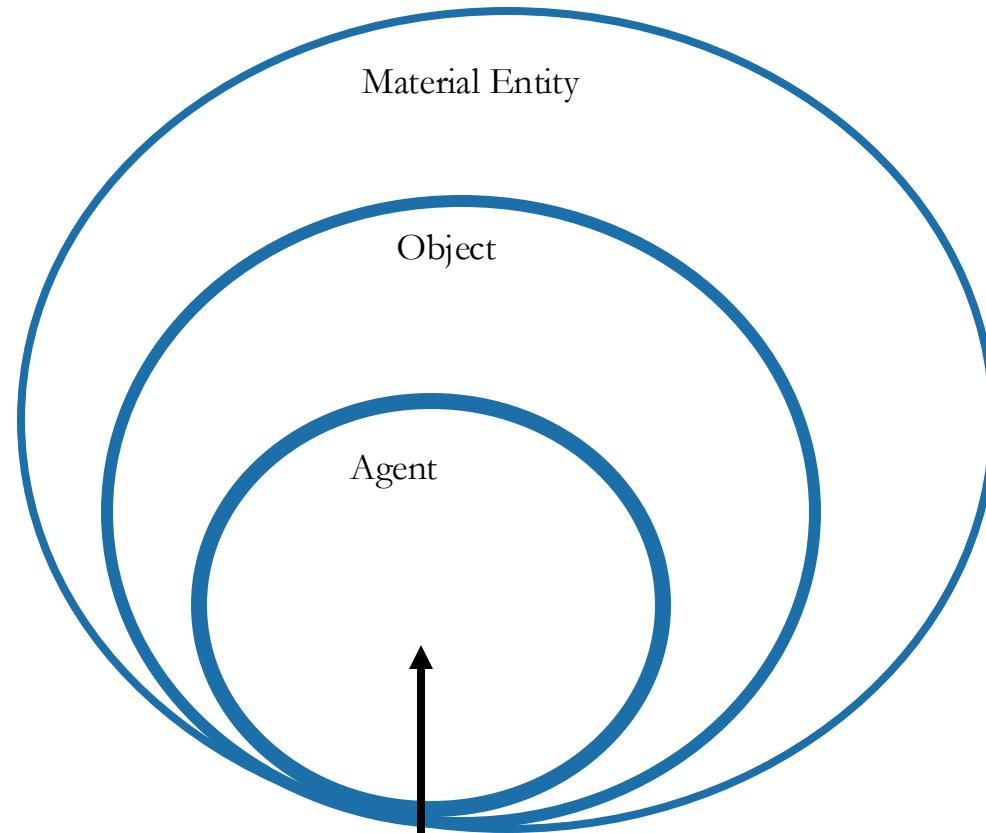


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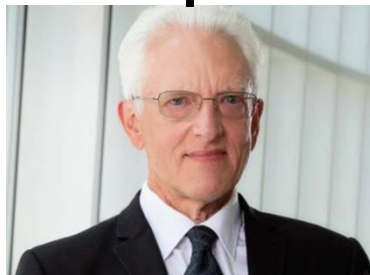
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SUNY Professor instance_of Professor Role

CLASSES



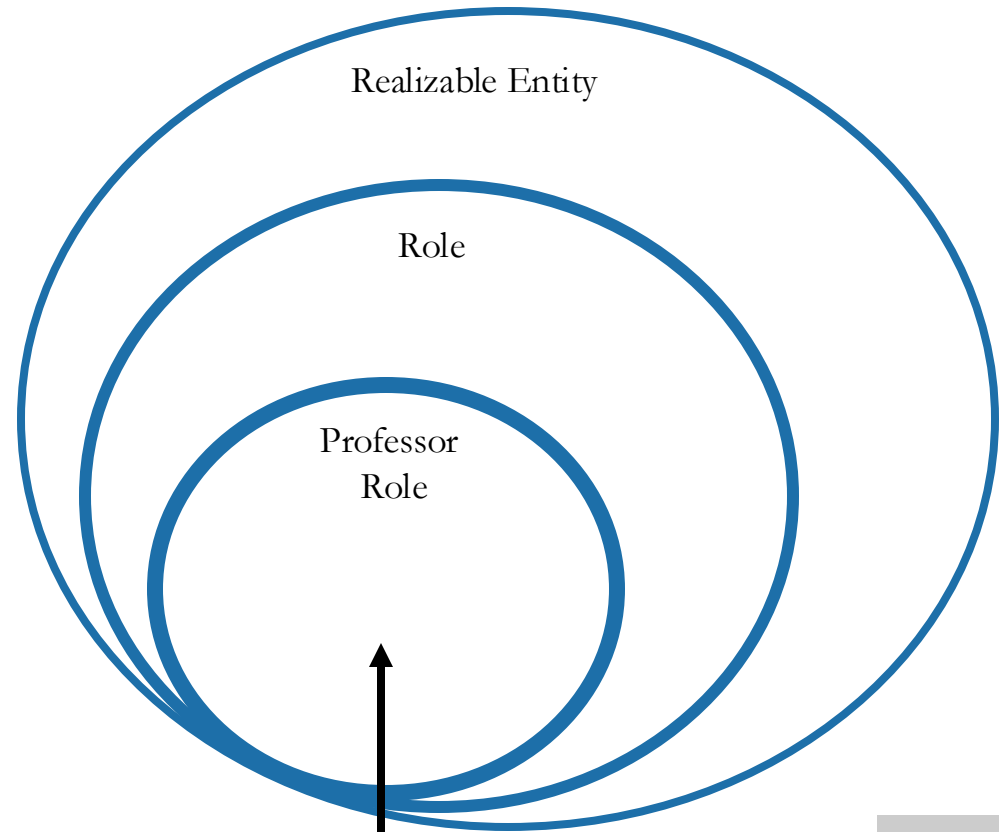
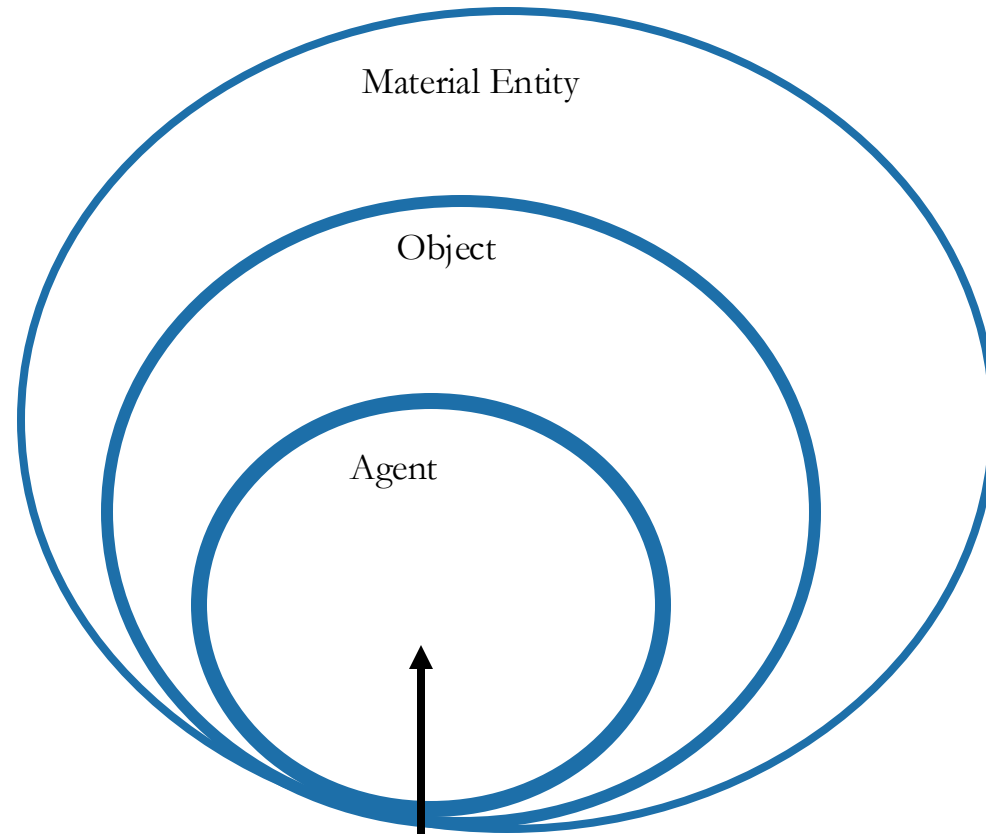
INSTANCES



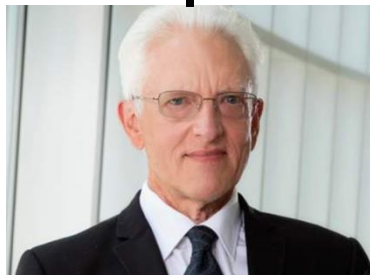
SUNY Distinguished Professor of Philosophy
Julian Park Chair

Barry Smith bearer_of SUNY Professor

CLASSES

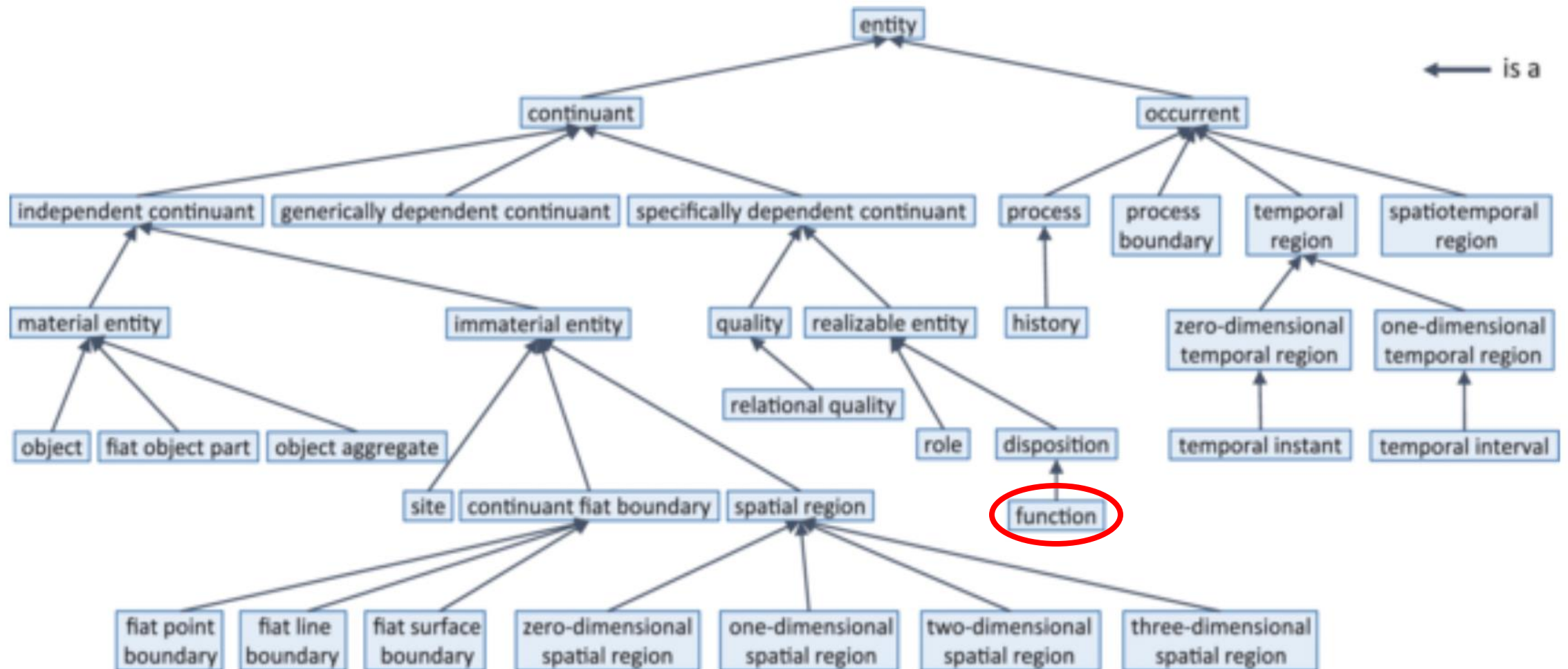


INSTANCES



SUNY Distinguished Professor of Philosophy
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Function



Function

- Attributes of some material bearer that only become manifest under certain conditions

Function

A disposition that exists in virtue of the bearer's physical make-up and this physical make-up is something the bearer possesses because it came into being, either through evolution (in the case of natural biological entities) or through intentional design (in the case of artefacts), in order to realize processes of a certain sort.



Function

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Function

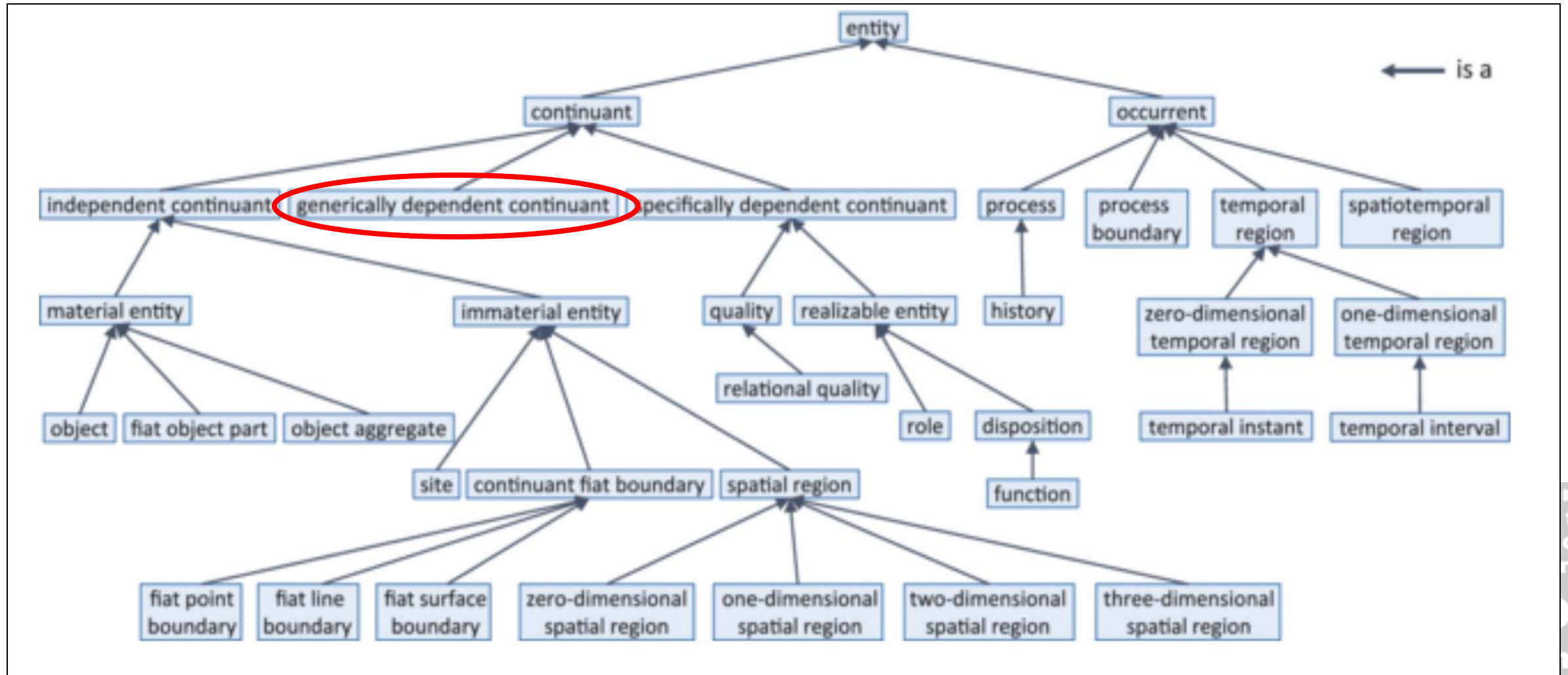
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PURPOSE GROUNDED

Dependence

- For certain entities, their existence depends on the existence of something else
- Other entities do not depend on any other entities for their existence
- The latter are categorized in BFO as **independent continuants**
- The former include **specifically dependent** and **generically dependent entities**, as well as **processes**

Generically Dependent Continuant



Pattern Recognition

- We're disposed to recognize patterns with our perceptual faculties...



Pattern Recognition

- We're disposed to recognize patterns with our perceptual faculties...
- ...and with our cognitive faculties...

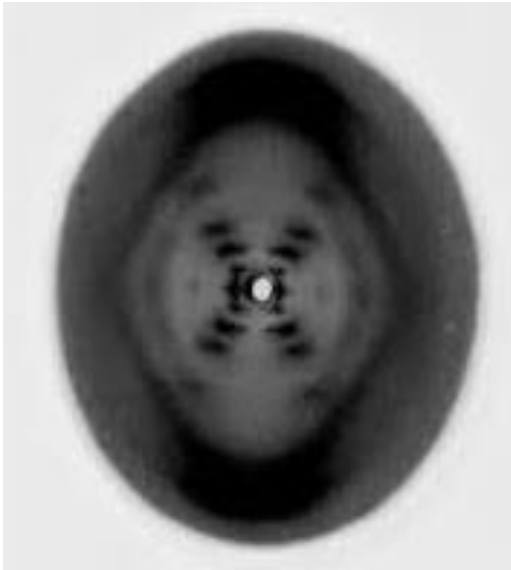


Photo 51 crystallography
image by Rosalind

Double-helix hypothesized
by Watson and Crick



BFO 1.0

- Earlier versions of BFO did not permit dependent entities to migrate from bearer to bearer
- This is true in current versions of BFO for many cases, e.g. your smile is dependent on your face
- As mentioned, dependent continuants that cannot migrate fall under the class **Specifically Dependent Continuant**

Patterns

- A need arose to represent dependent entities that could migrate across bearers
- This need led to **generically dependent continuants**, continuants that are in some sense copyable, i.e. patterns
- For example, “Snow is white” and “Schnee ist weiß” may be used to express numerically identical content, i.e. the same pattern

Real Patterns

- Some patterns are necessarily **about** something; some patterns are not
- “Snow is white” expresses content that is **about** snow
- “cm” or “.” are not necessarily **about** anything; they are nevertheless patterns
- Most **generically dependent entities** represented in BFO extensions are patterns that are **about** something

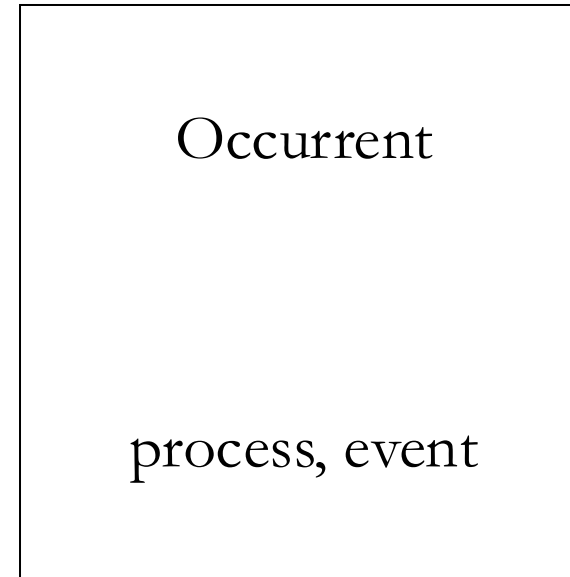
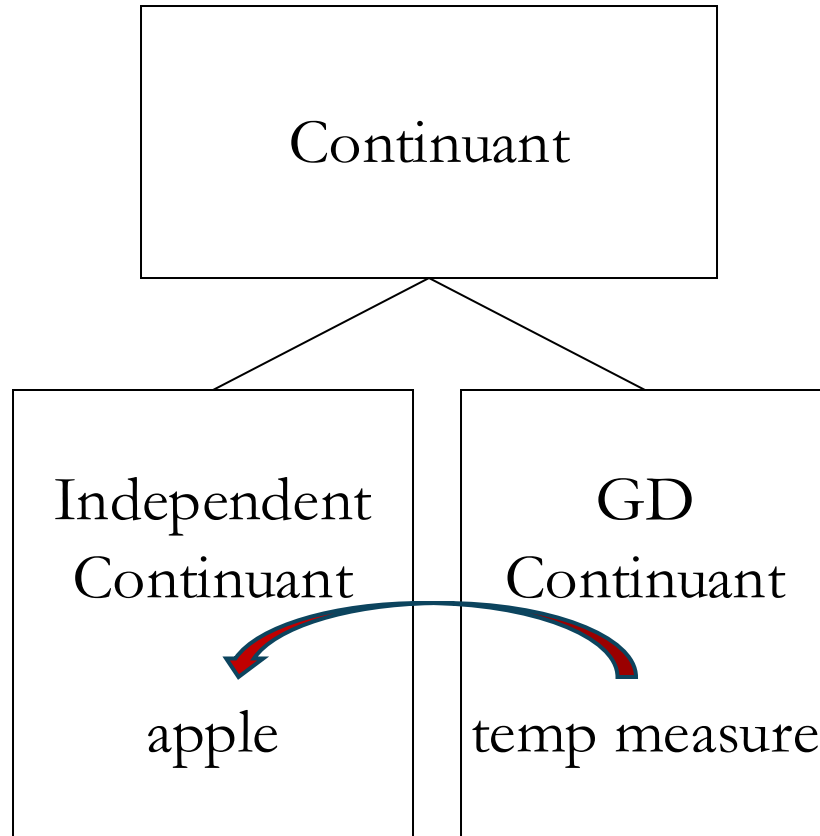
Aboutness

- **Information** is a pattern that is **about** something
- In BFO extensions - such as the Information Artifact Ontology and the Information Entity Ontology - information is represented by the class **Information Content Entity**
- Where the “is about” relation is understood to be primitive:

definition [language: en]

A primitive relationship between an Information Content Entity and some Entity.

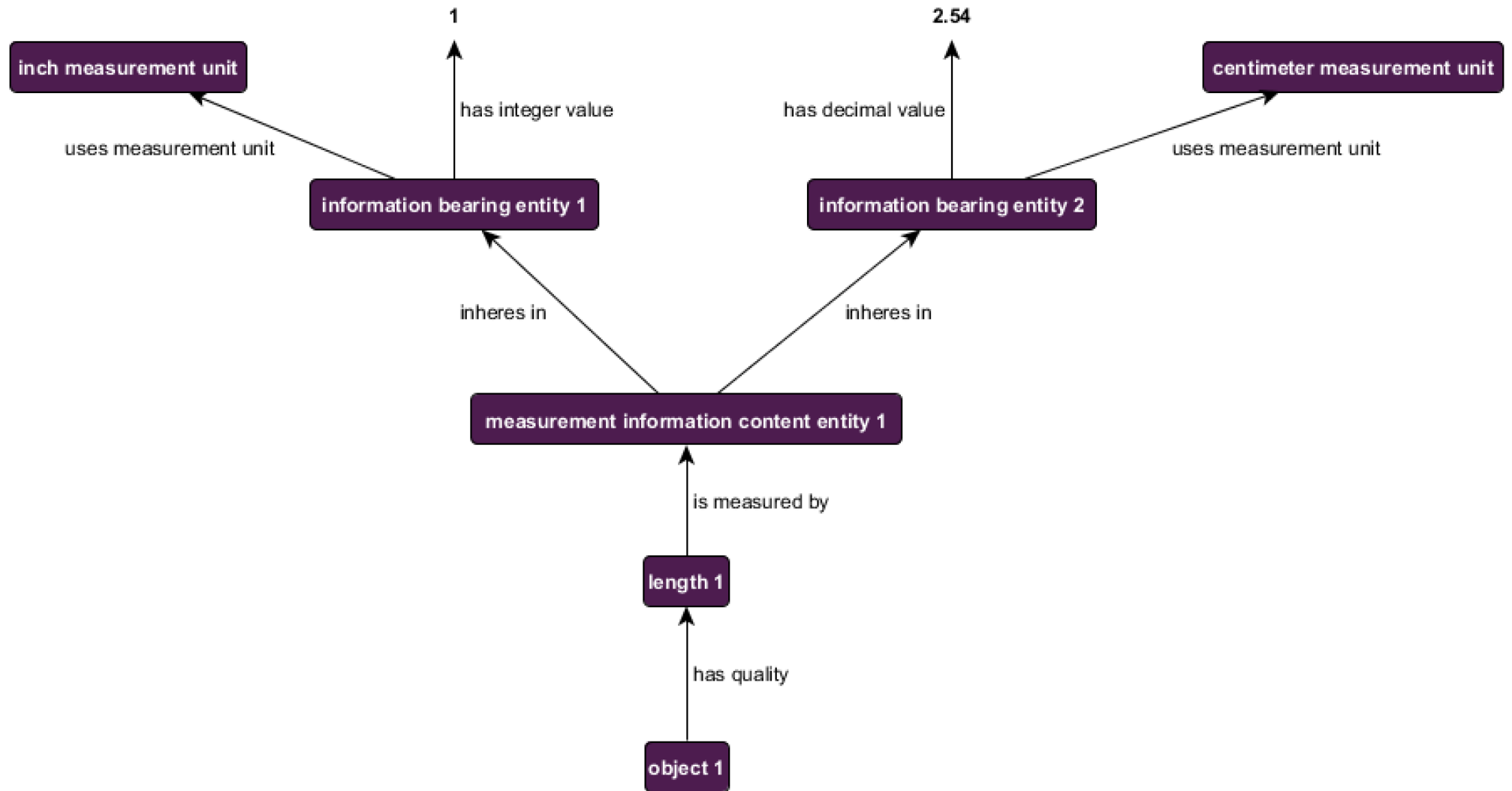
Generically Dependent Continuant



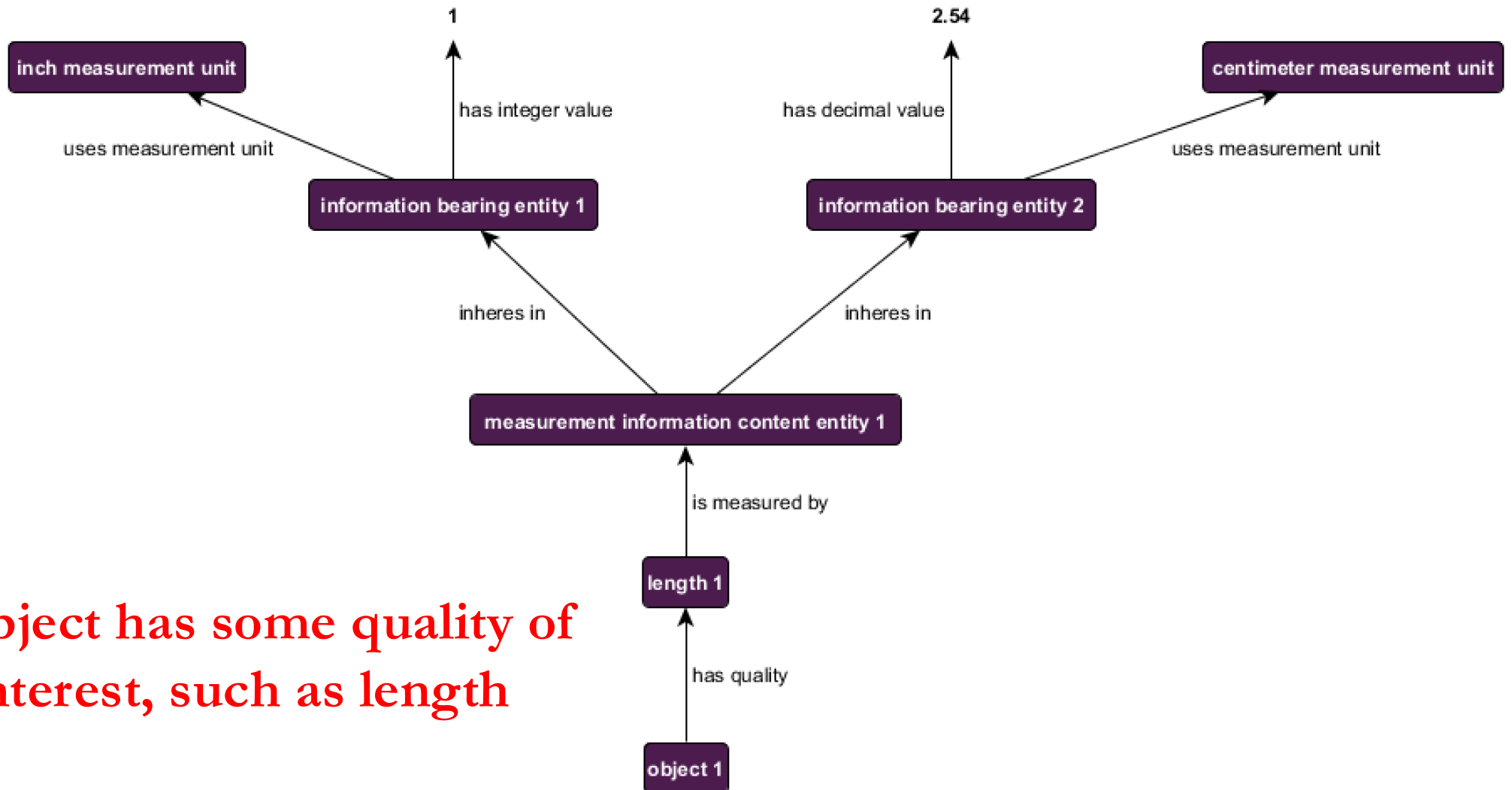
Many measures are about independent continuants



CCO Measurement

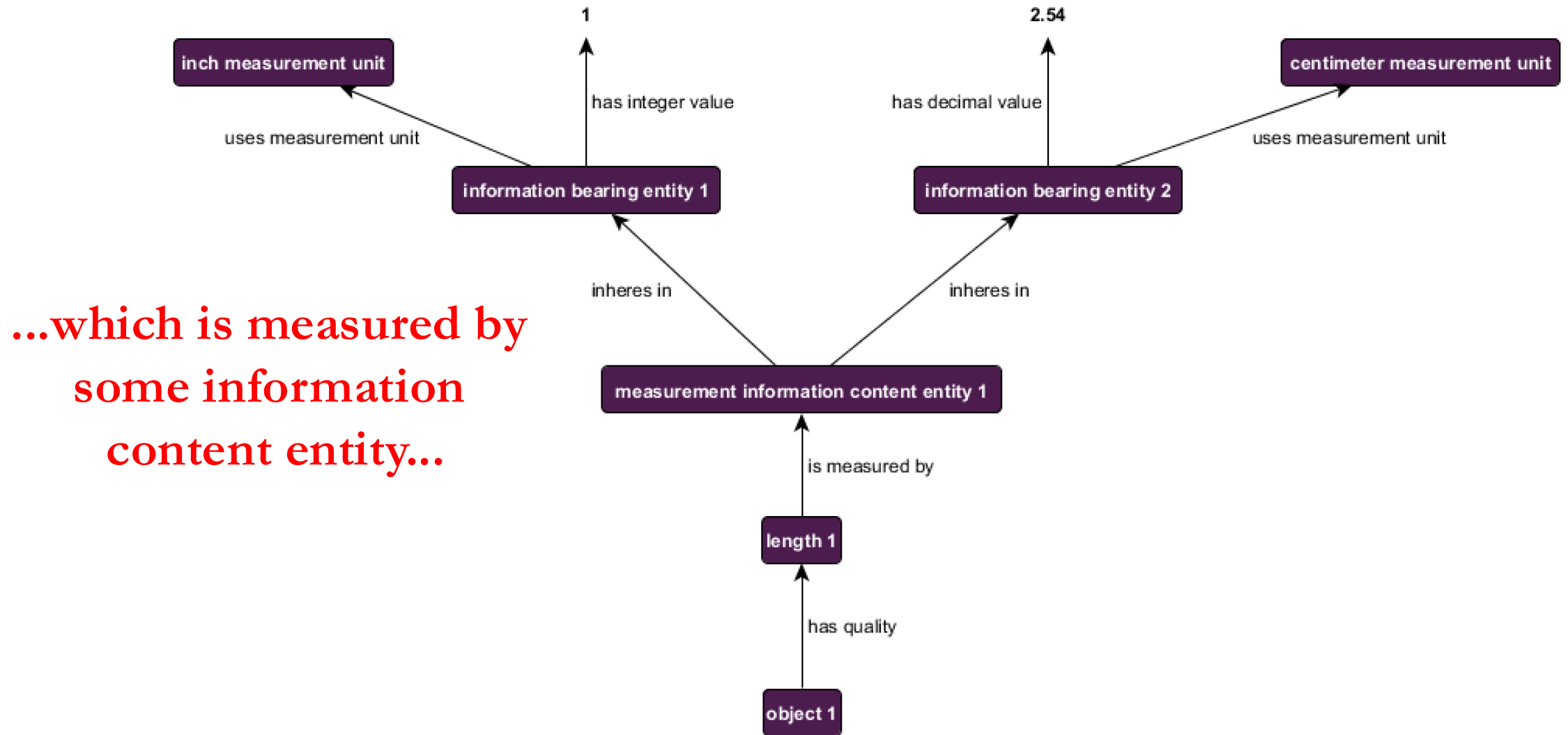


CCO Measurement



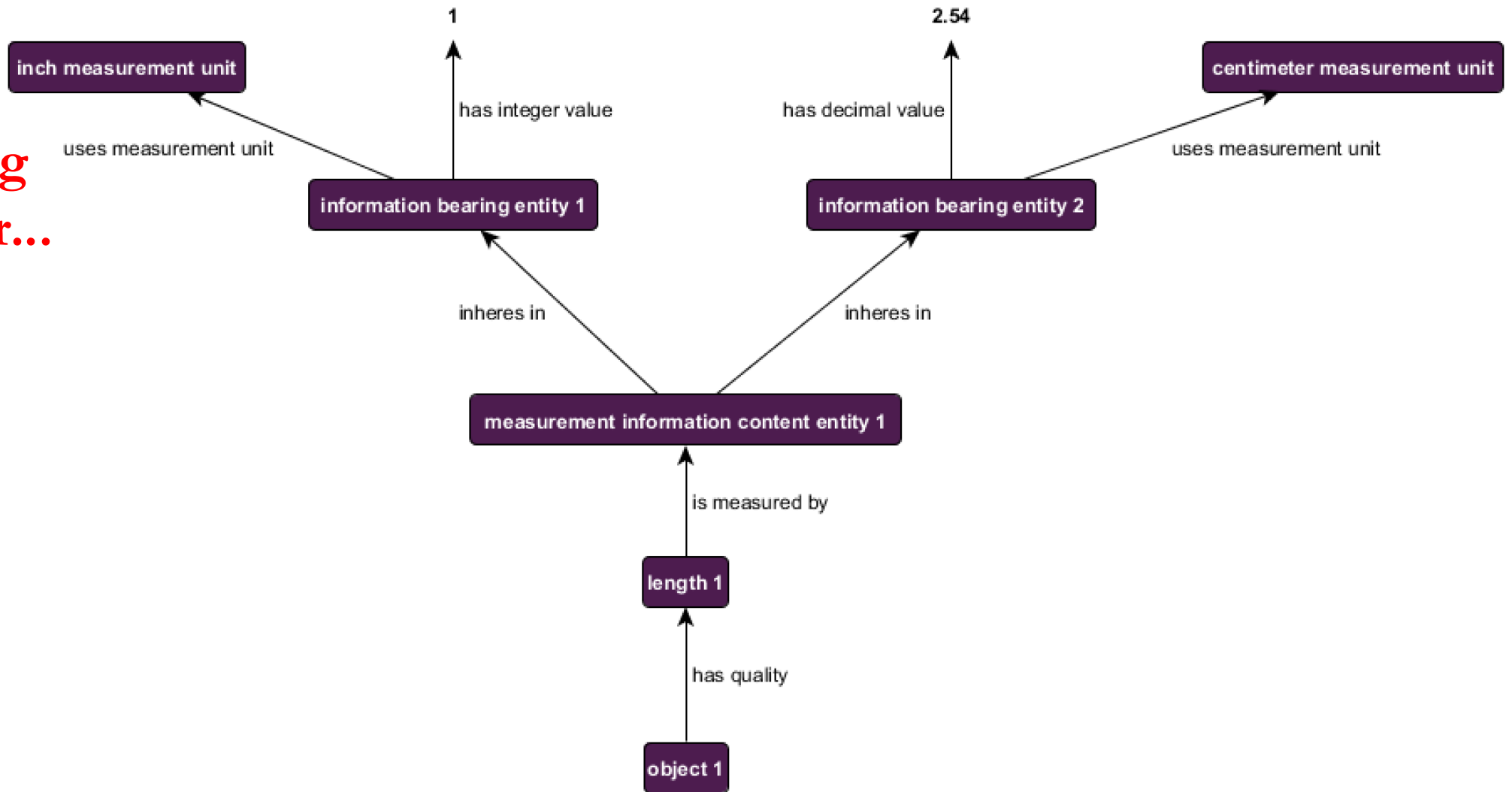
An object has some quality of interest, such as length

CCO Measurement



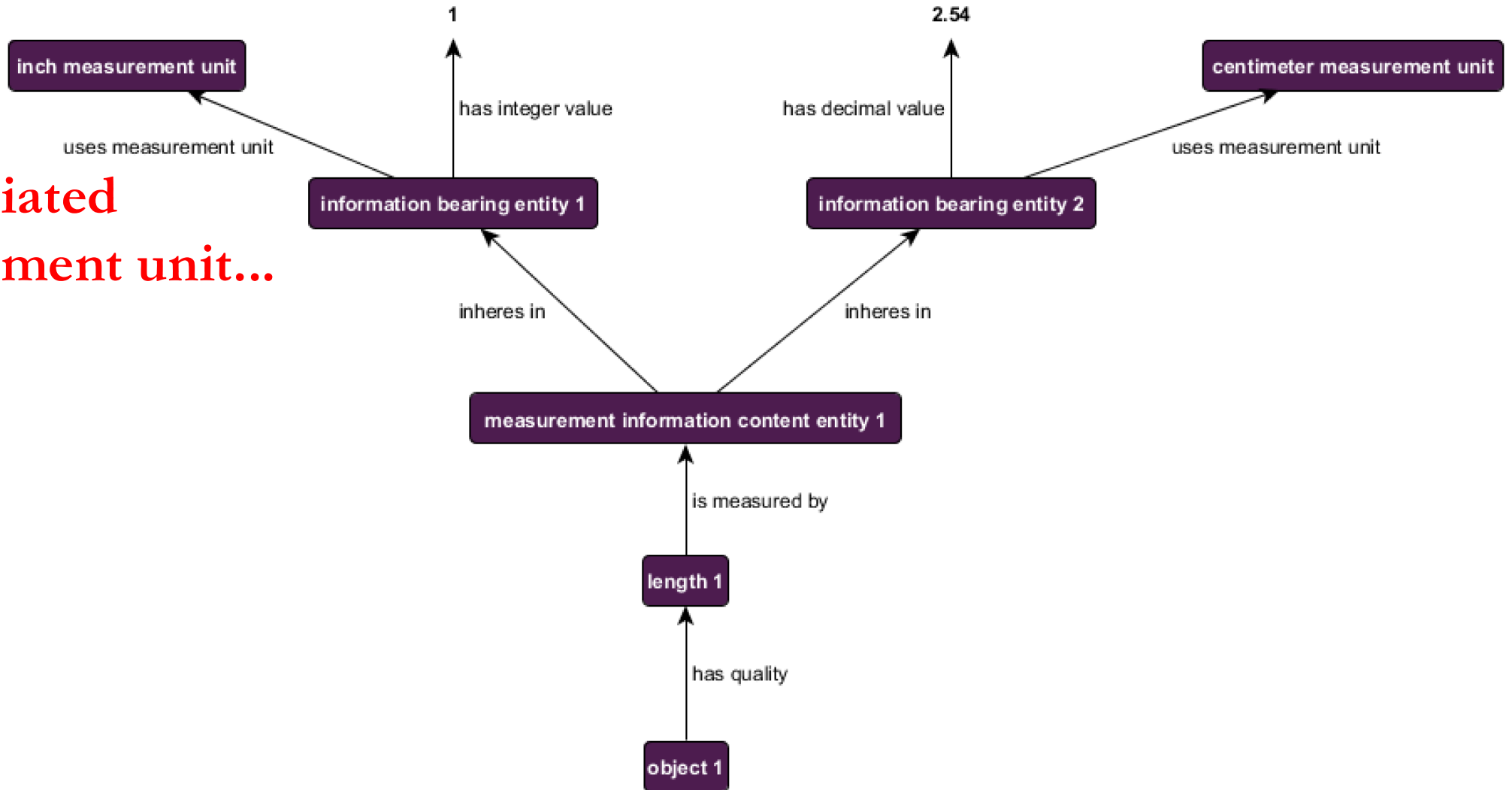
CCO Measurement

...inhering
in a bearer...

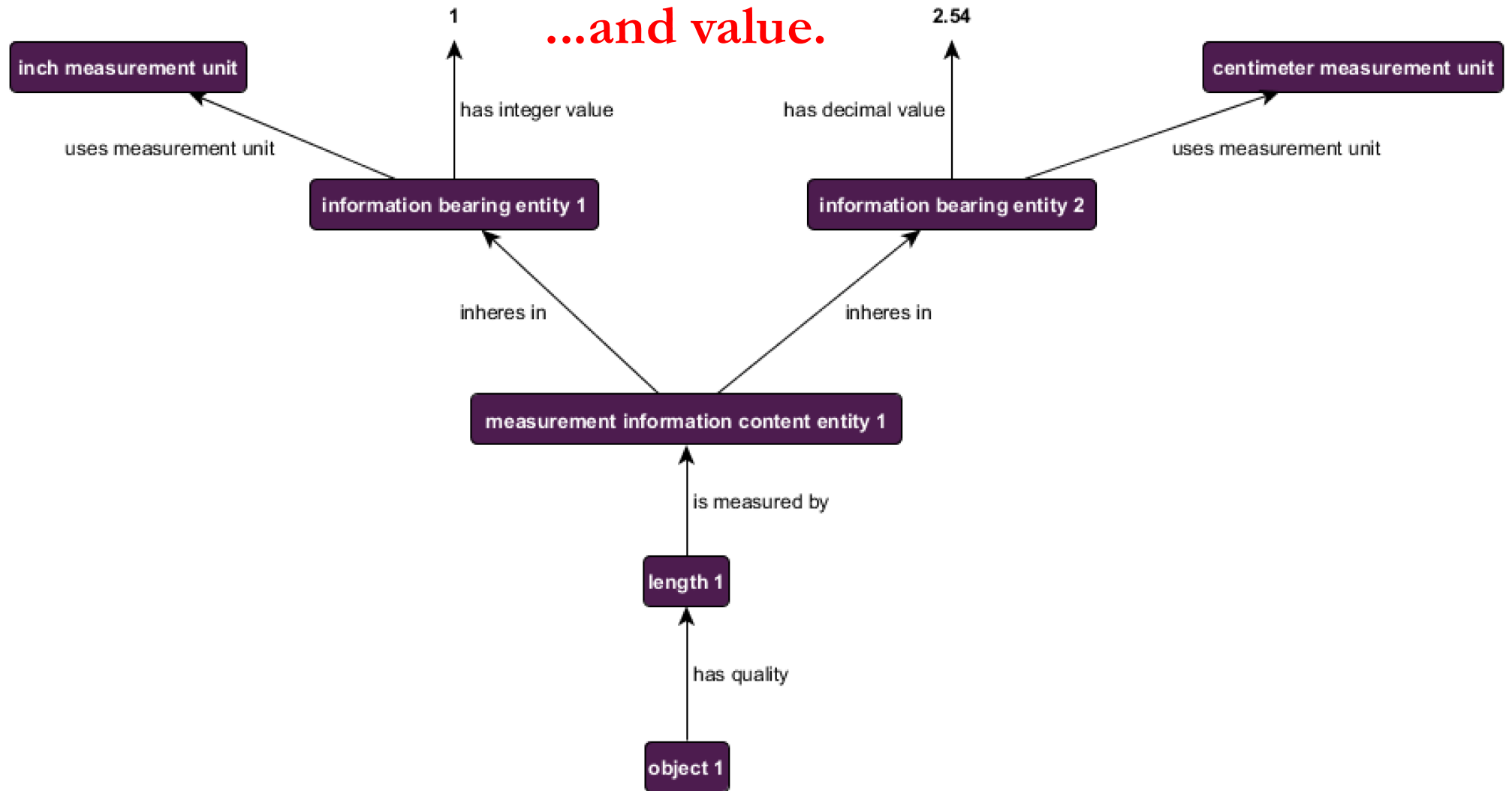


CCO Measurement

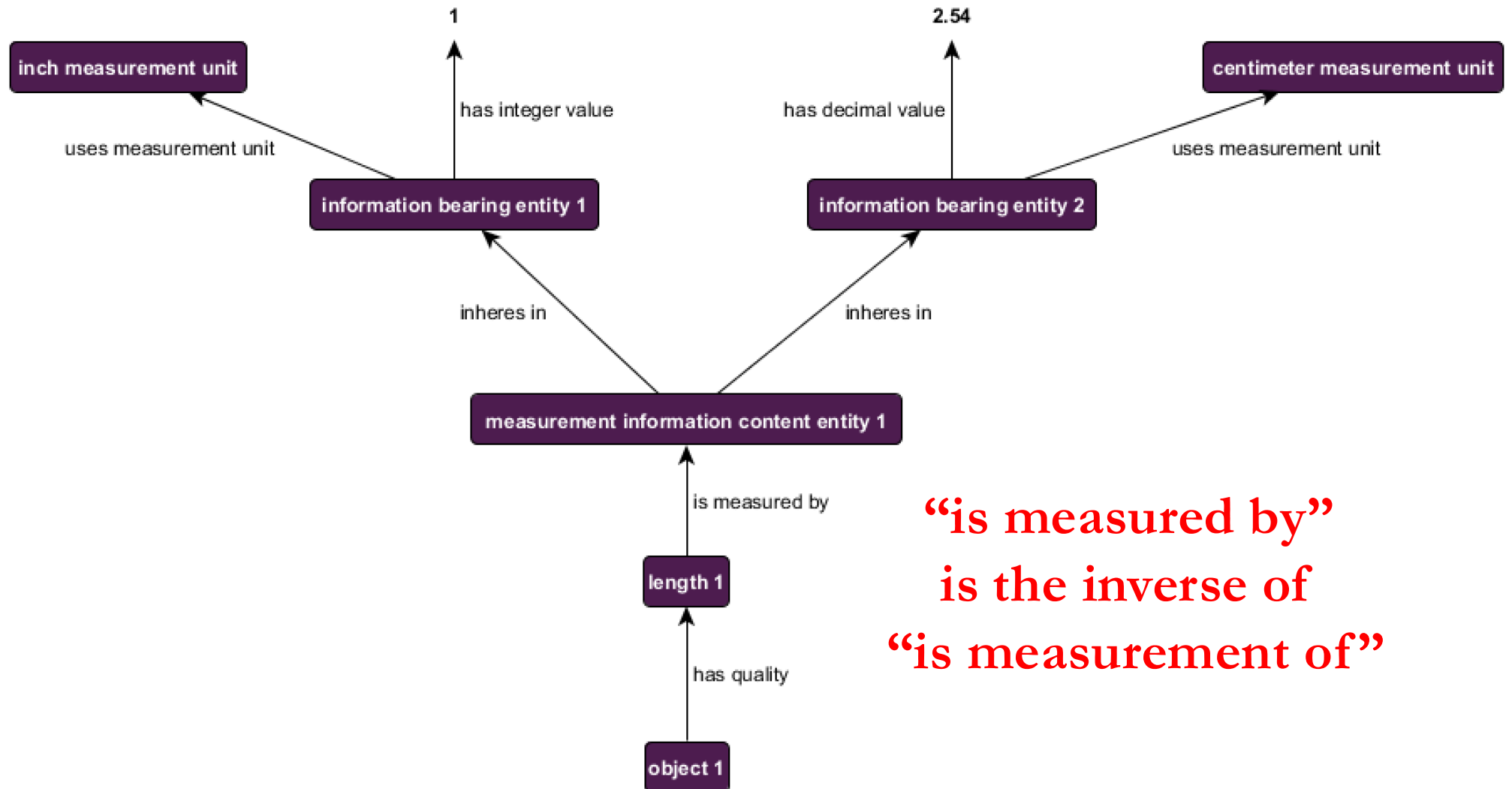
...with
an associated
measurement unit...



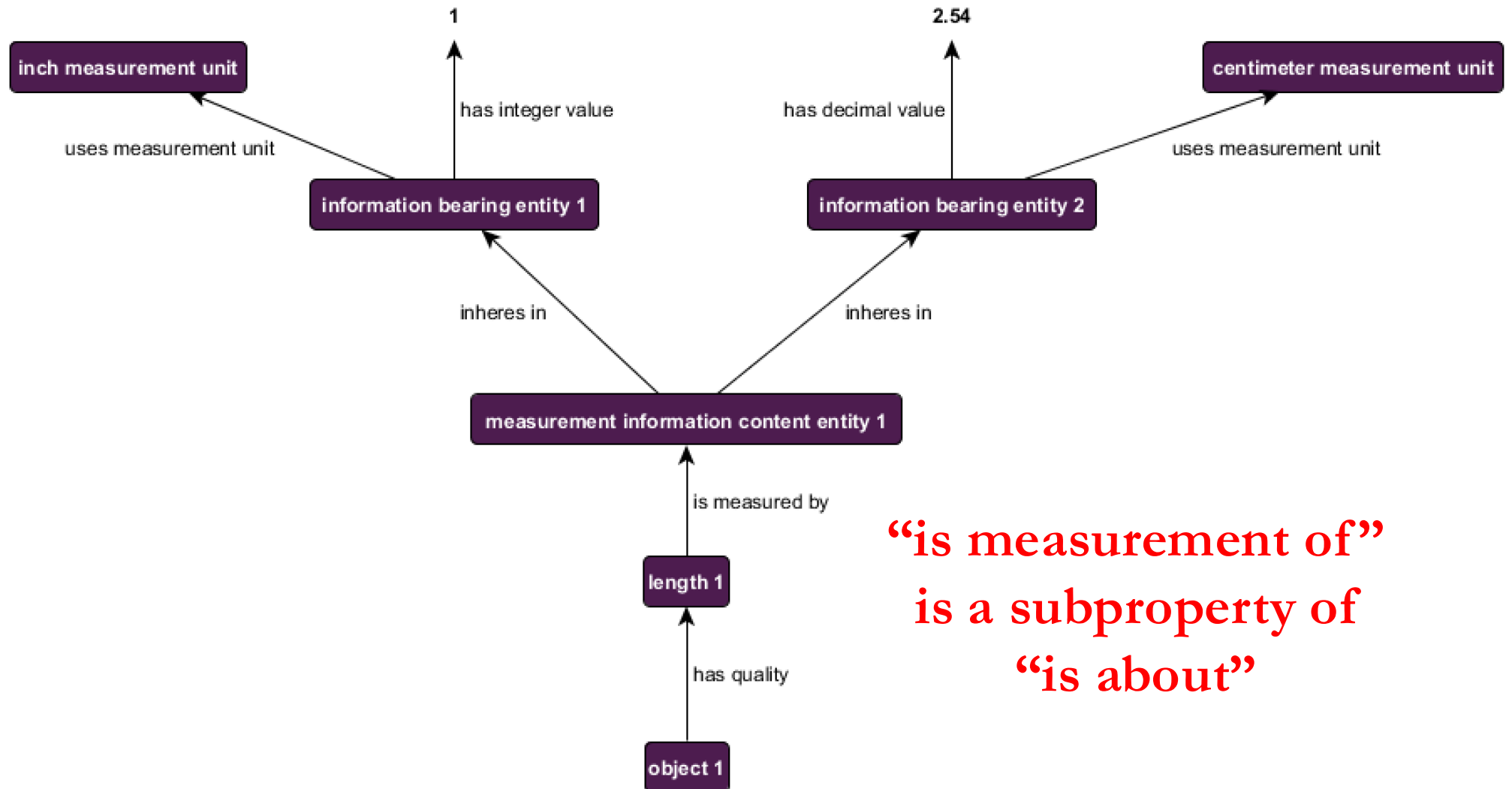
CCO Measurement



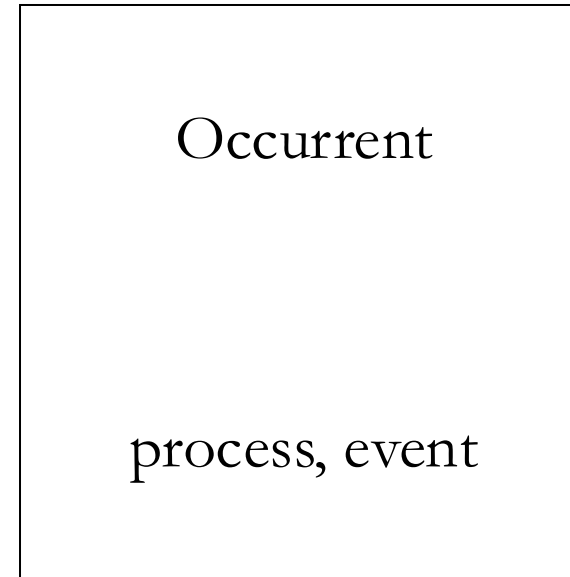
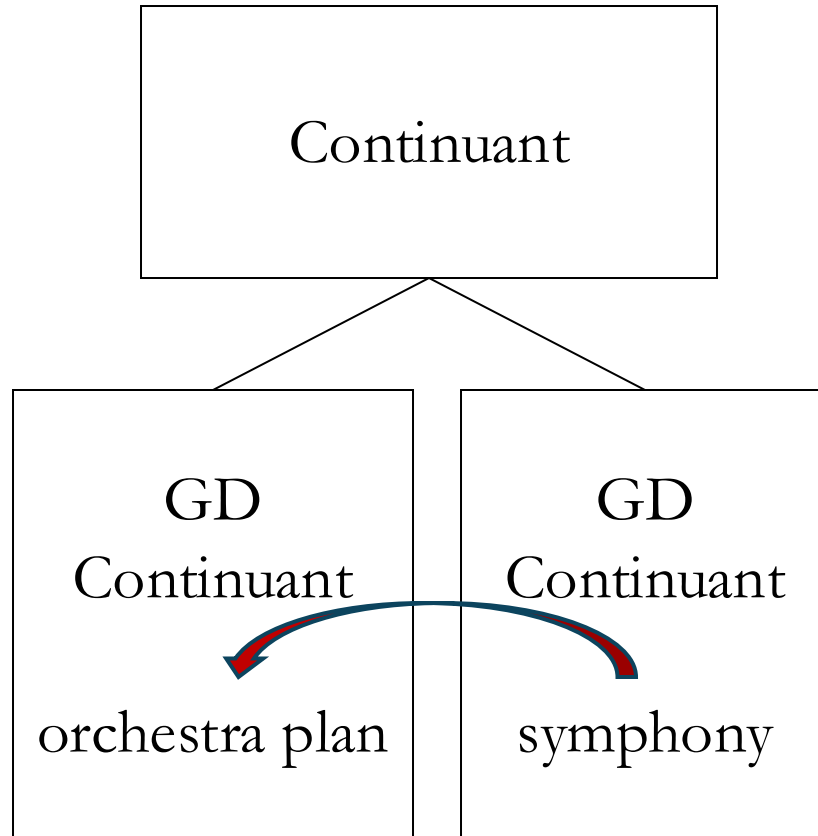
CCO Measurement



CCO Measurement



Generically Dependent Continuant



GDCs may be about other GDCs



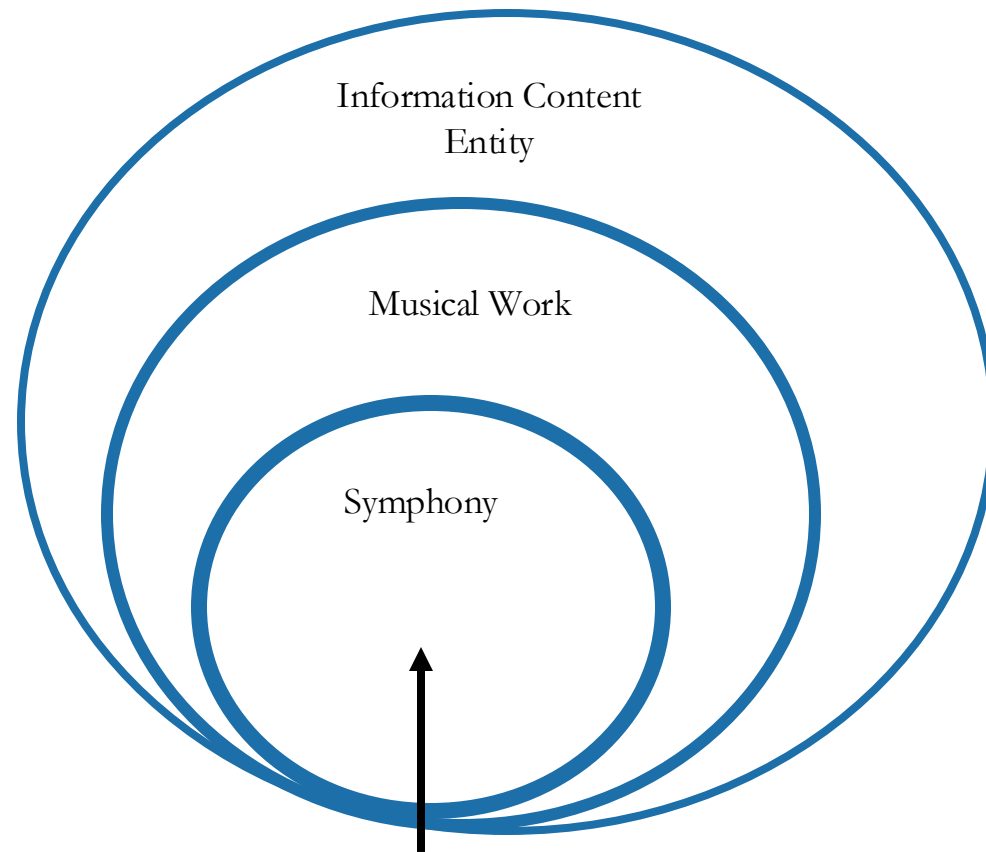
Beethoven's #9



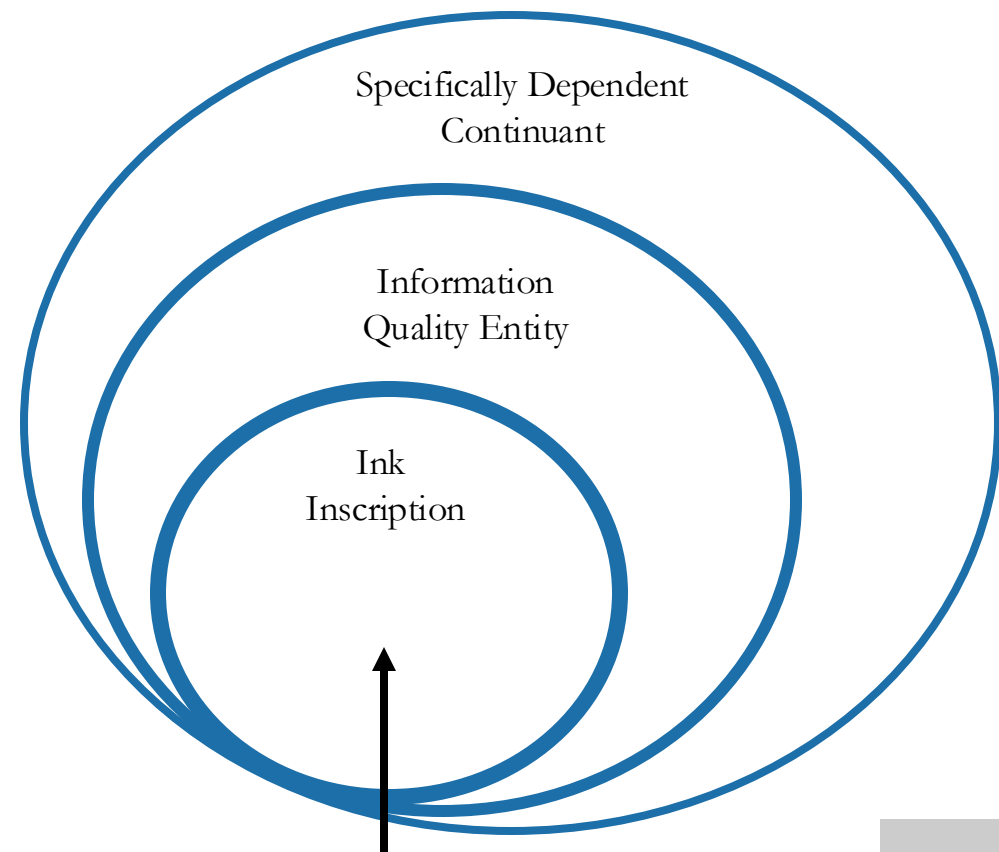
#9 Concretized in Ink Inscription

CLASSES

INSTANCES



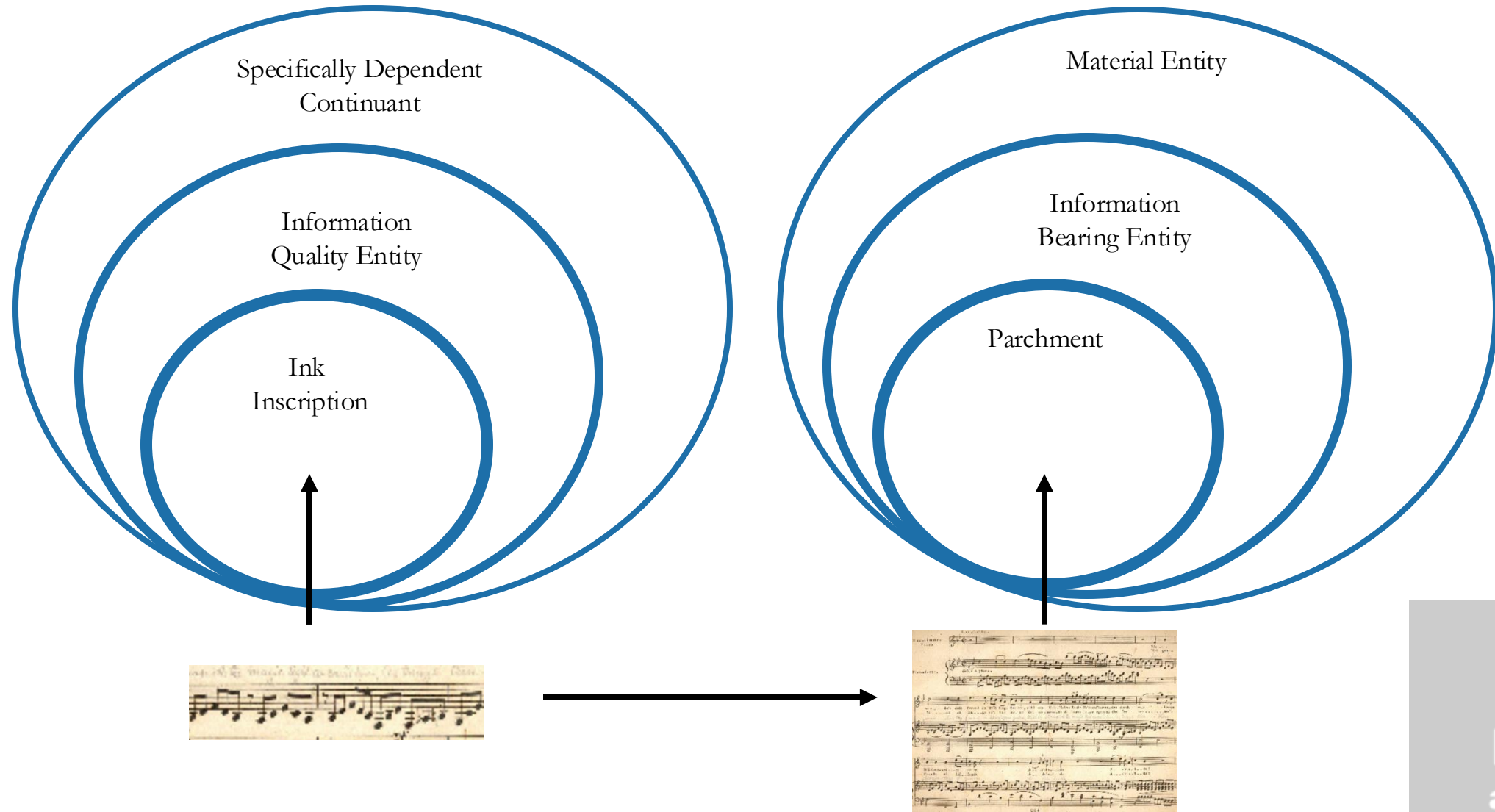
Beethoven's #9



Ink Inscription inheres in Parchment

CLASSES

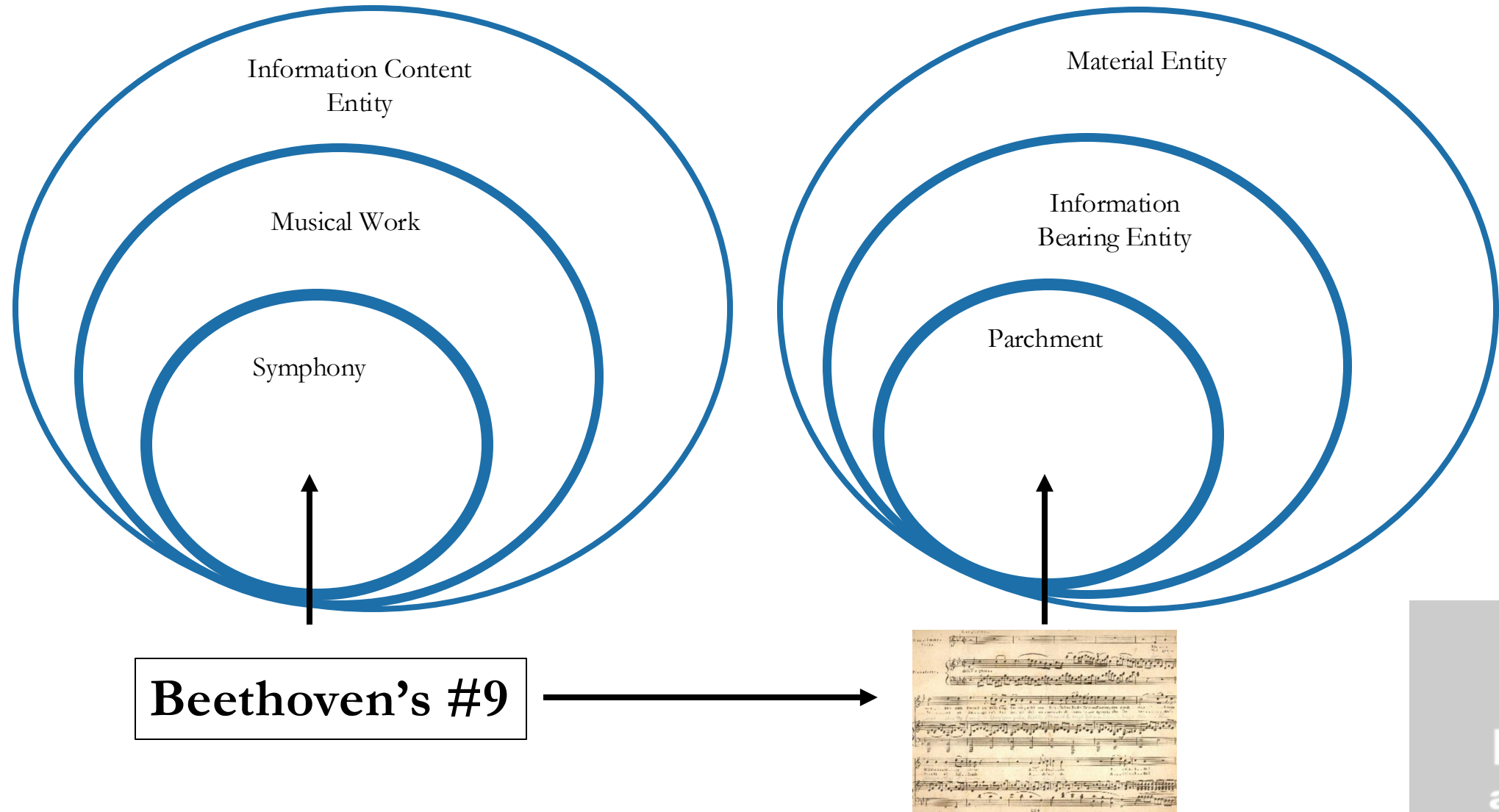
INSTANCES



#9 Generically Dependent On Parchment

CLASSES

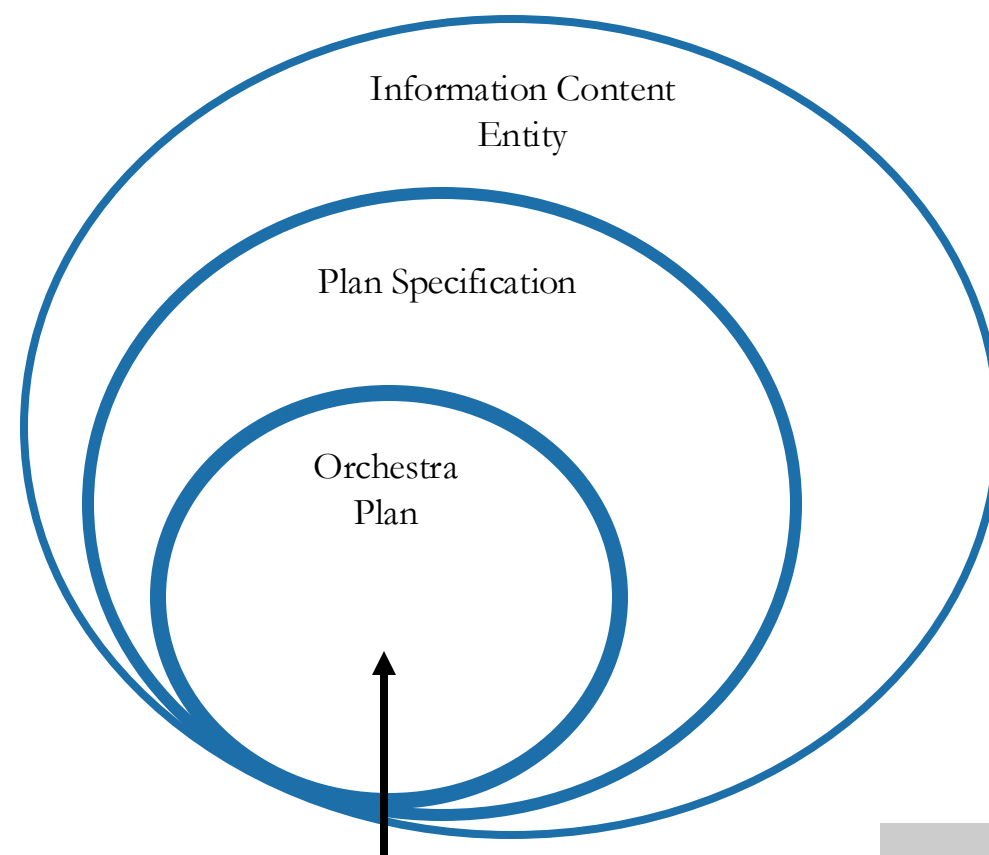
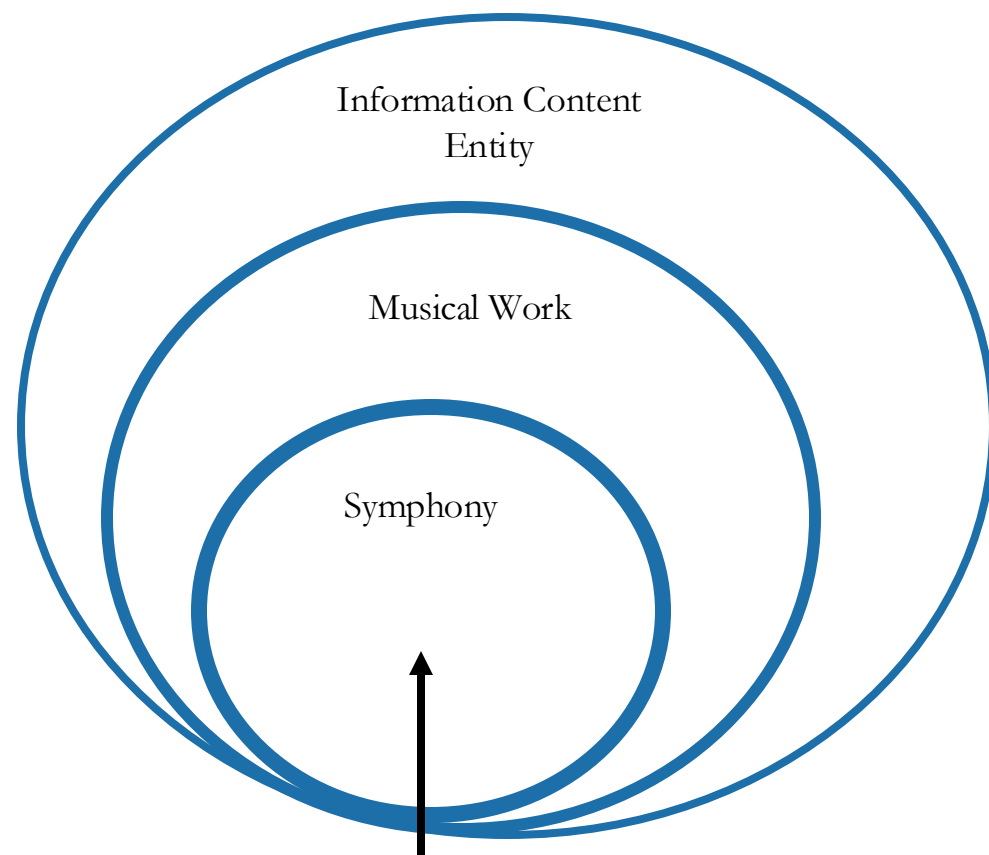
INSTANCES



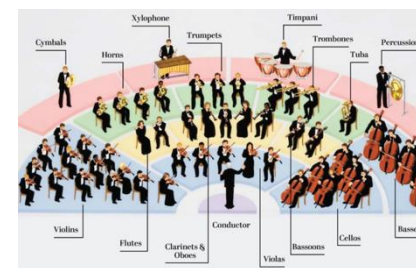
#9 is about Orchestra Plan

CLASSES

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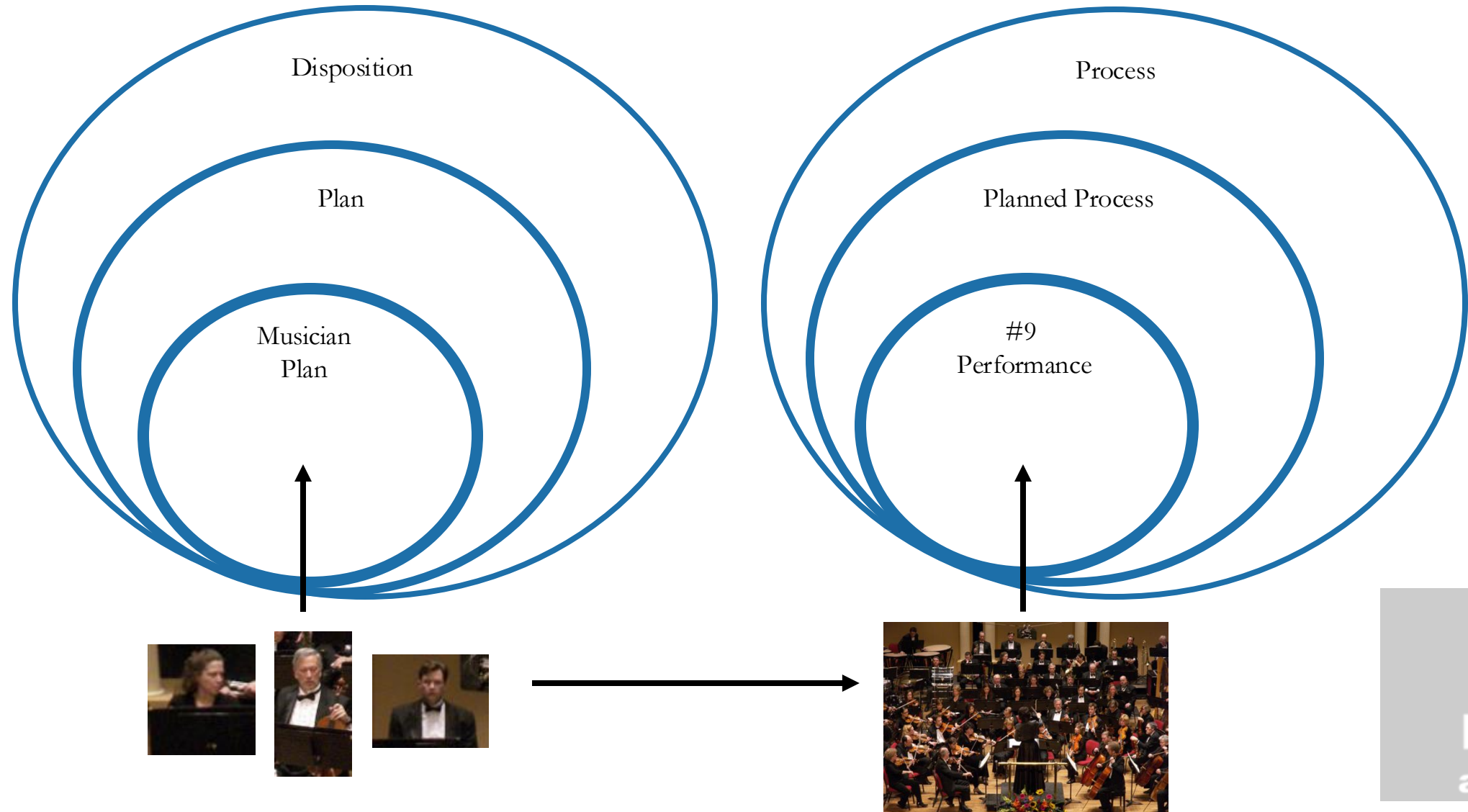
Beethoven's #9



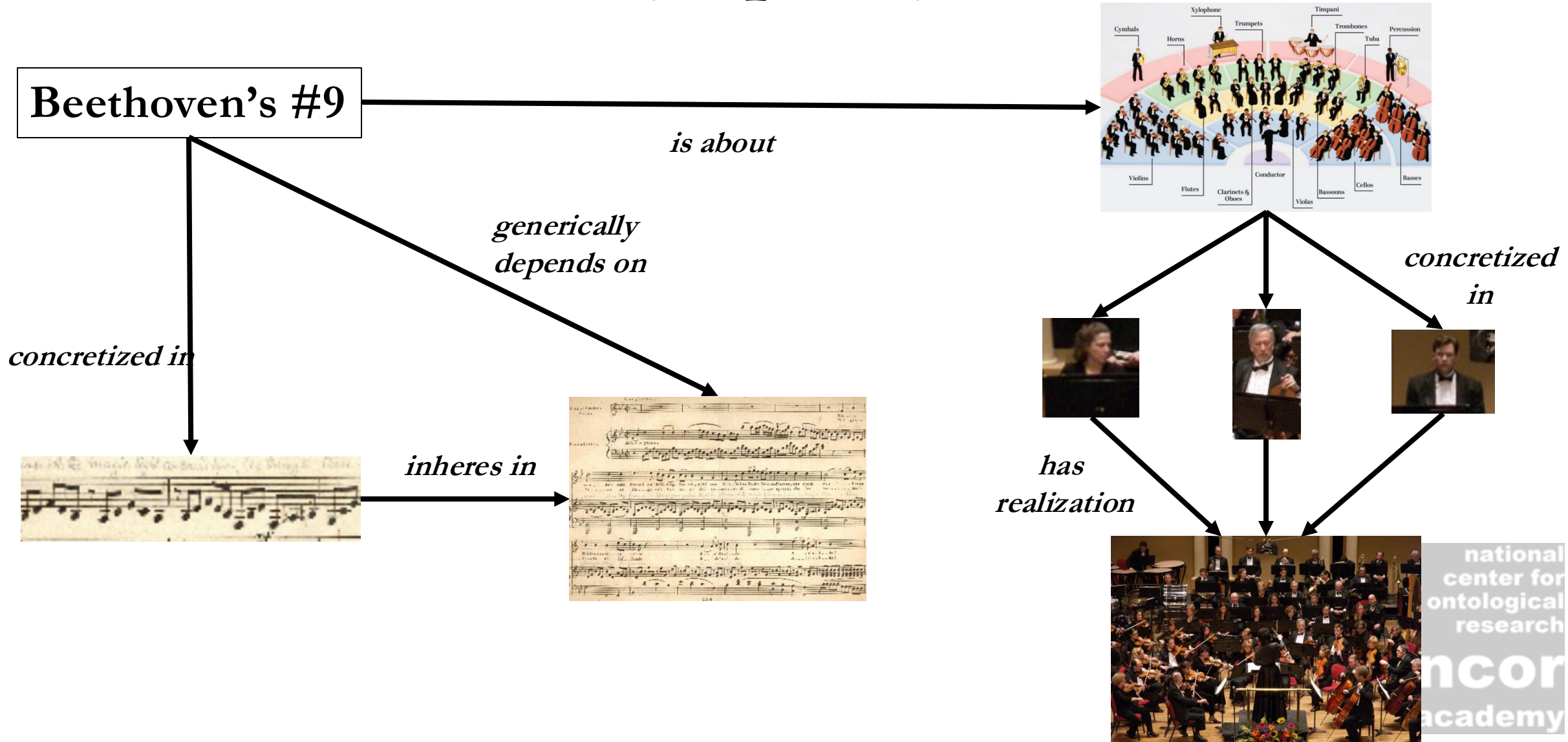
Musician Plan realized in #9 Performance

CLASSES

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Beethoven's #9th Symphony



Outline

- Design Pattern Review
- Basic Formal Ontology Deep Dive
- The Gauntlet