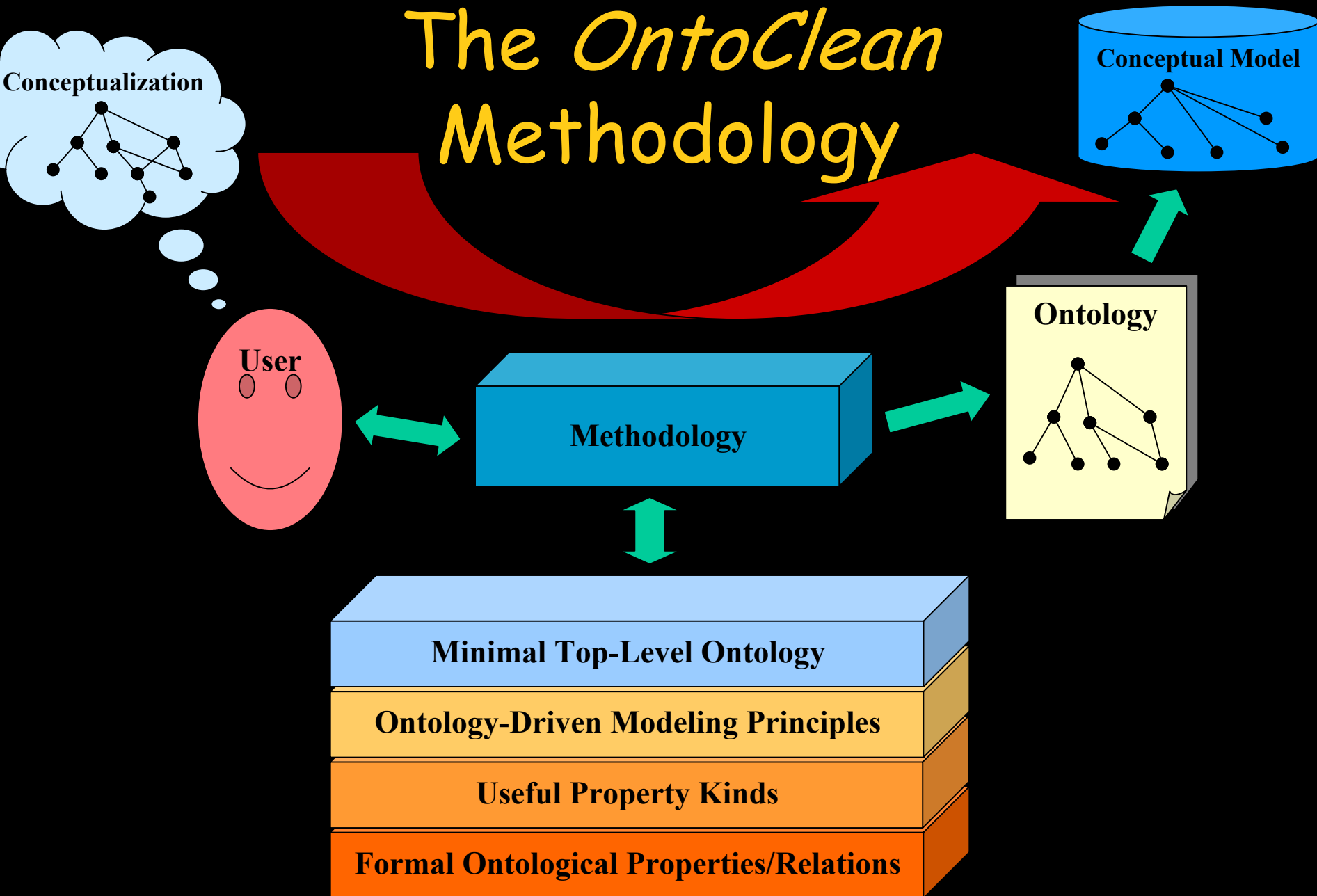


The *OntoClean* Methodology



Summary

- Re-visiting common conceptual modelling constructs
- Some basic ontological distinctions: the DOLCE ontology

Re-visiting conceptual modelling constructs

- Instantiation
- Generalization
- Association
- Aggregation

The Instance-of Relation

How to decide whether something is an instance?

- Properties can be instances of meta-properties
- Hence, "being an instance" may be a subjective property
- But "being a particular" **IS NOT!**

- Particulars are always "ultimate" instances.
- Concrete entities are *always* particulars.
- So-called "temporal instances" are either temporal *parts* of a particular or instances of an abstract *class*.

Particulars and Universals

- Universals
 - Have multiple exemplifications
 - All abstract
- Particulars:
 - Have no exemplifications
 - Can be either concrete or abstract

Concrete entities are all particulars

Instance-of vs. membership (1)

- The problems of logical predication
 - x is an apple \rightarrow Apple(x)
 - x is red \rightarrow Red(x)
- Instance-of vs. class membership
 - John is a member of "Person" \rightarrow Person(John)
 - Tree1 is a member of "BlackForest" \rightarrow BlackForest(Tree1) ??

(violates usual intended interpretation of unary predicates: property shared by all instances of the corresponding class. Doesn't pass the "is-a" test)

Instance-of vs membership (2)

- Instance-of:
 - Particular-universal
 - Universal-universal
- Membership:
 - Particular-particular

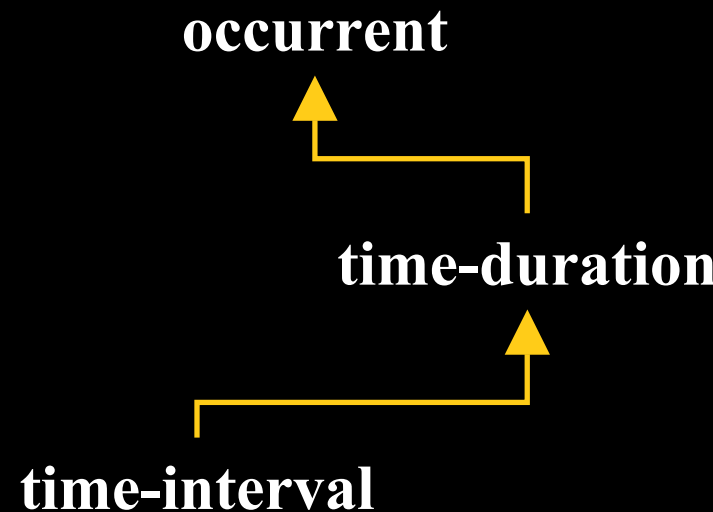
Overloading Subsumption

Common modeling pitfalls

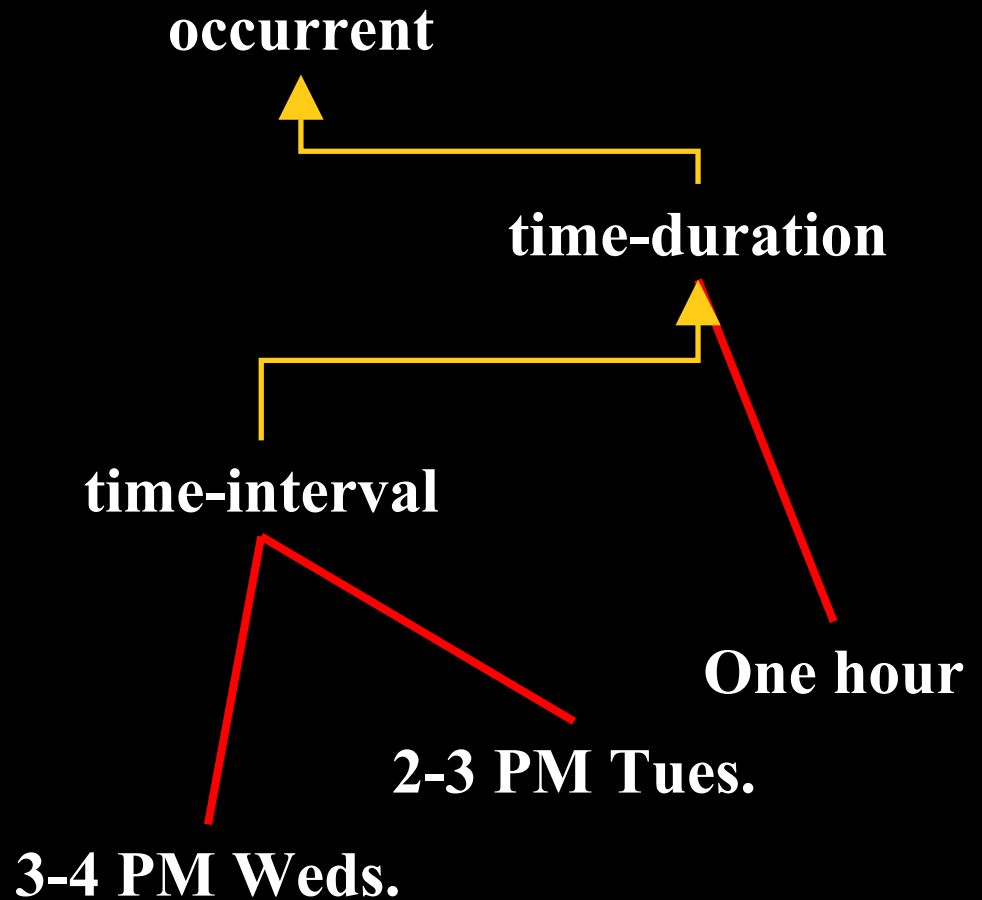
- Instantiation
- Composition
- Disjunction
- Polysemy
- Constitution

Example - Identity

- Is *time-interval* a subclass of *time-duration*?
 - Initial answer: yes
- IC for *time-duration*
 - Same-length
- IC for *time-interval*
 - Same start & end

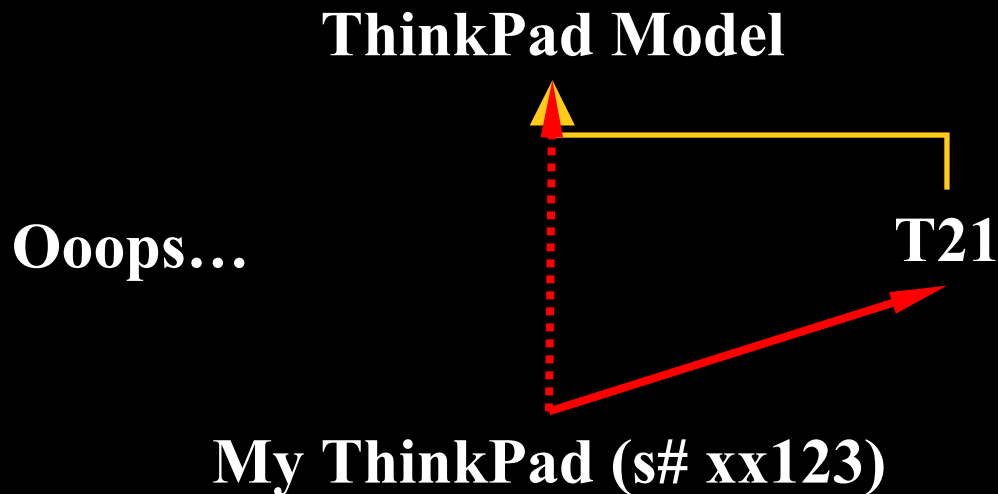


Example - Identity



Instantiation (1)

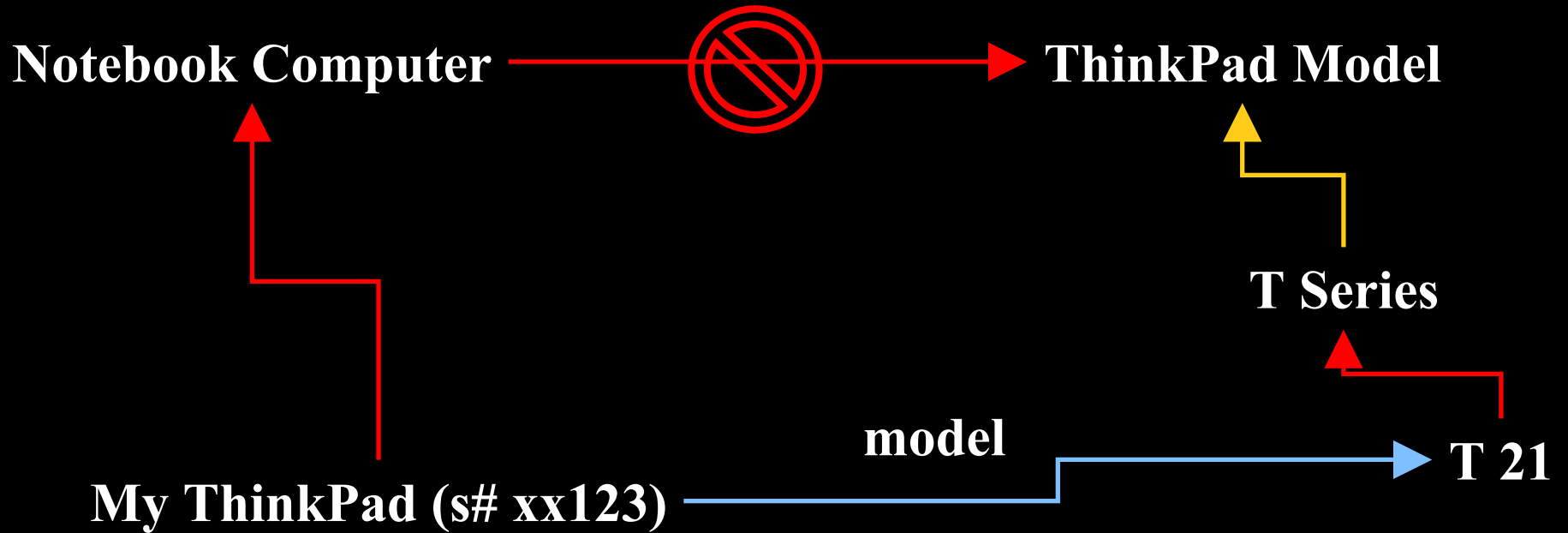
Does this ontology mean that **My ThinkPad** *is a* **ThinkPad Model**?



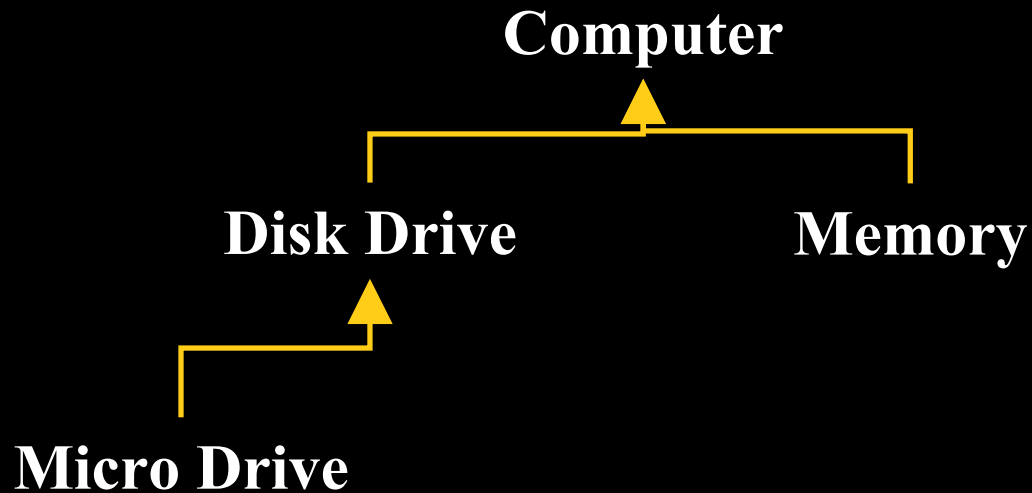
Question: What ThinkPad models do you sell?

Answer should NOT include My ThinkPad -- nor yours.

Instantiation (2)

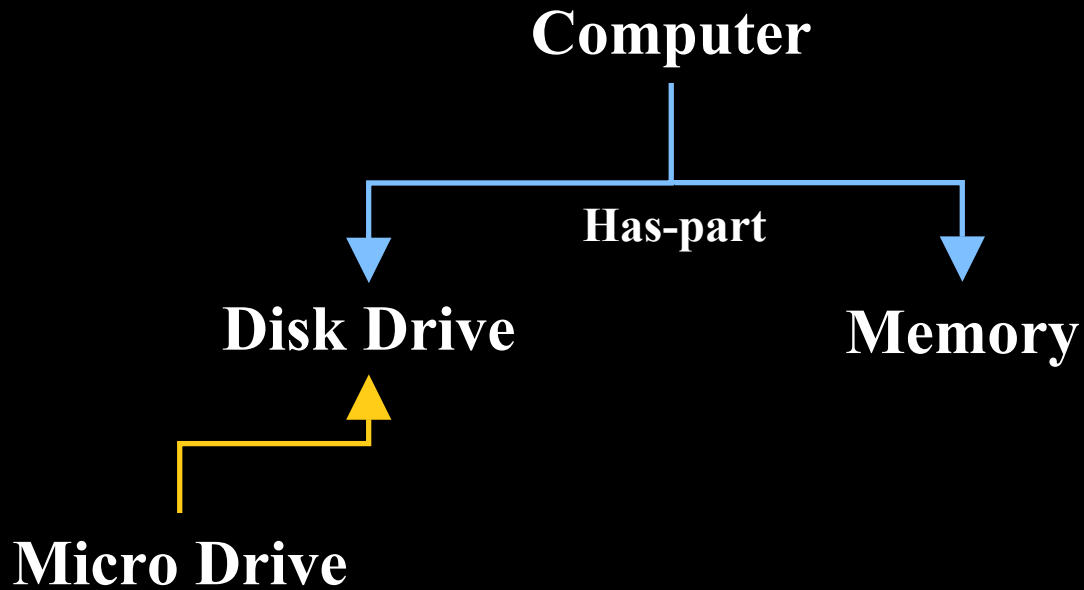


Composition (1)

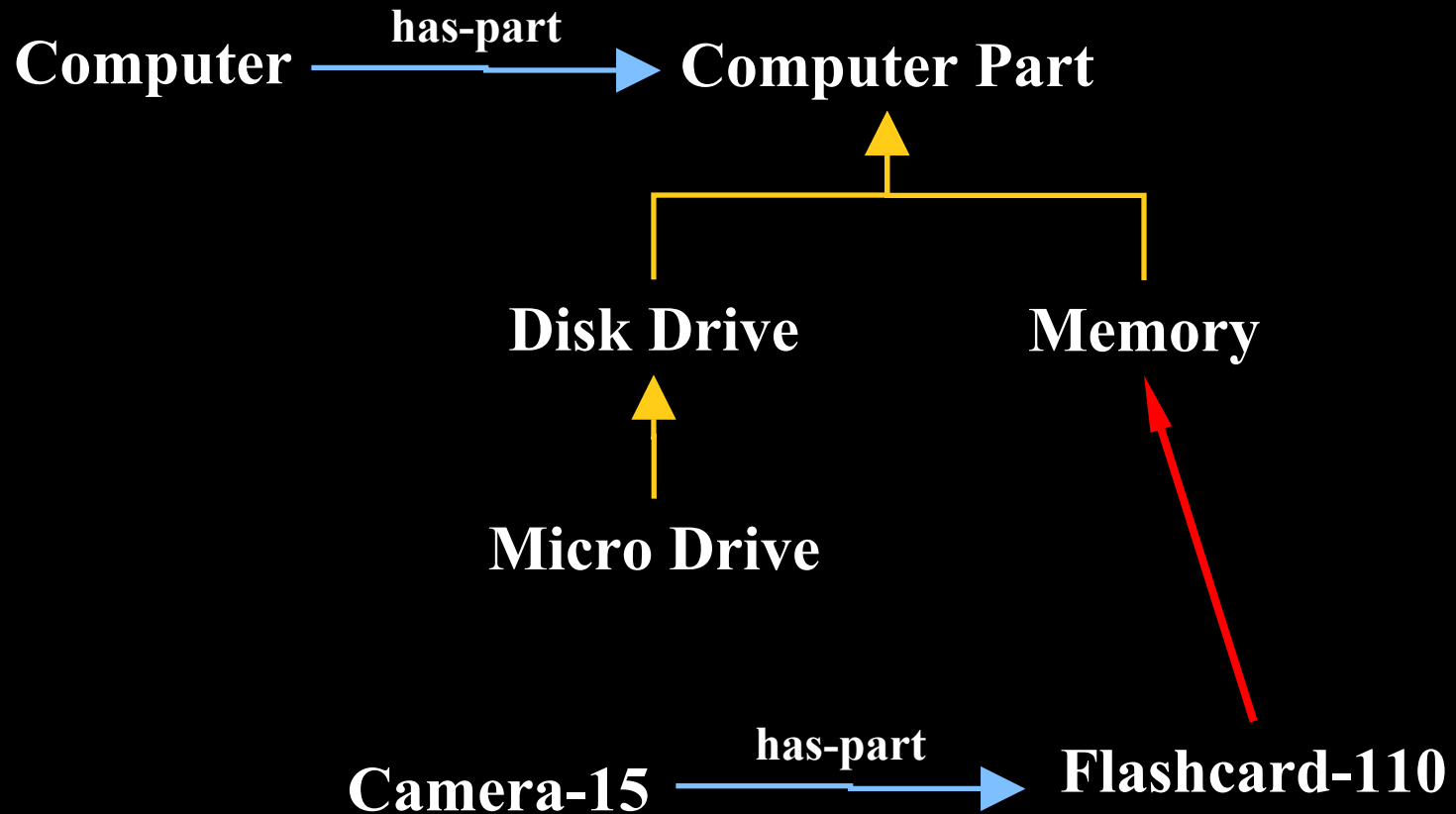


Question: What kinds of computer do you sell?
Answer should NOT include Disk Drives or Memory.

Composition (2)



Disjunction (1)



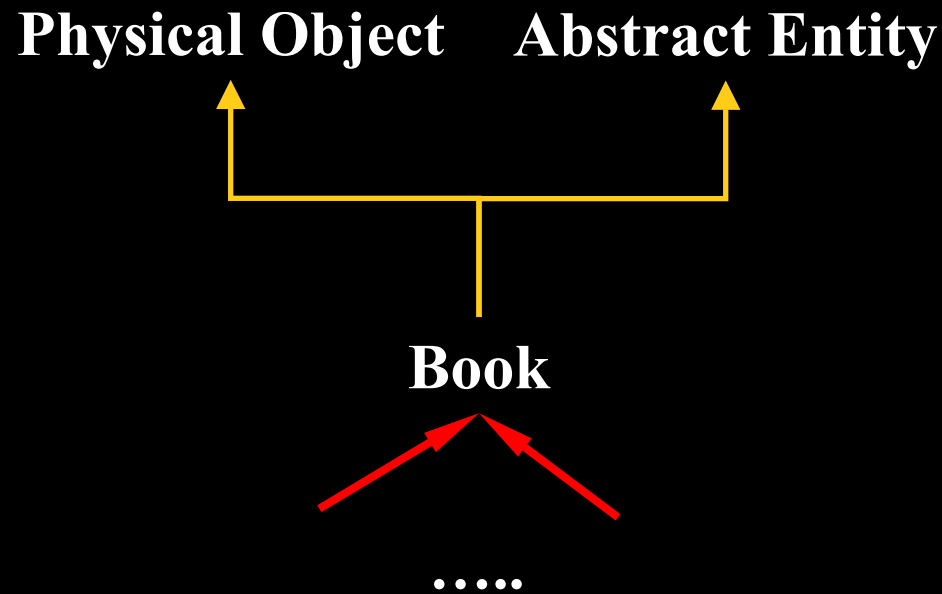
Unintended model: flashcard-110 is a computer-part

Disjunction (2)

Computer $\xrightarrow{\text{has-part}}$ **Disk Drive \vee Memory \vee ...**

Polysemy (1)

(Mikrokosmos)



Question: How many books do you have on Hemingway?
Answer: 5,000

Polysemy (2)

(WordNet)

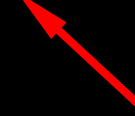
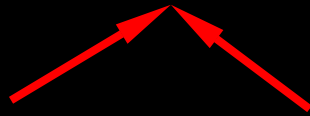
Physical Object

Abstract Entity



**Book
Sense 1**

**Book
Sense 2**

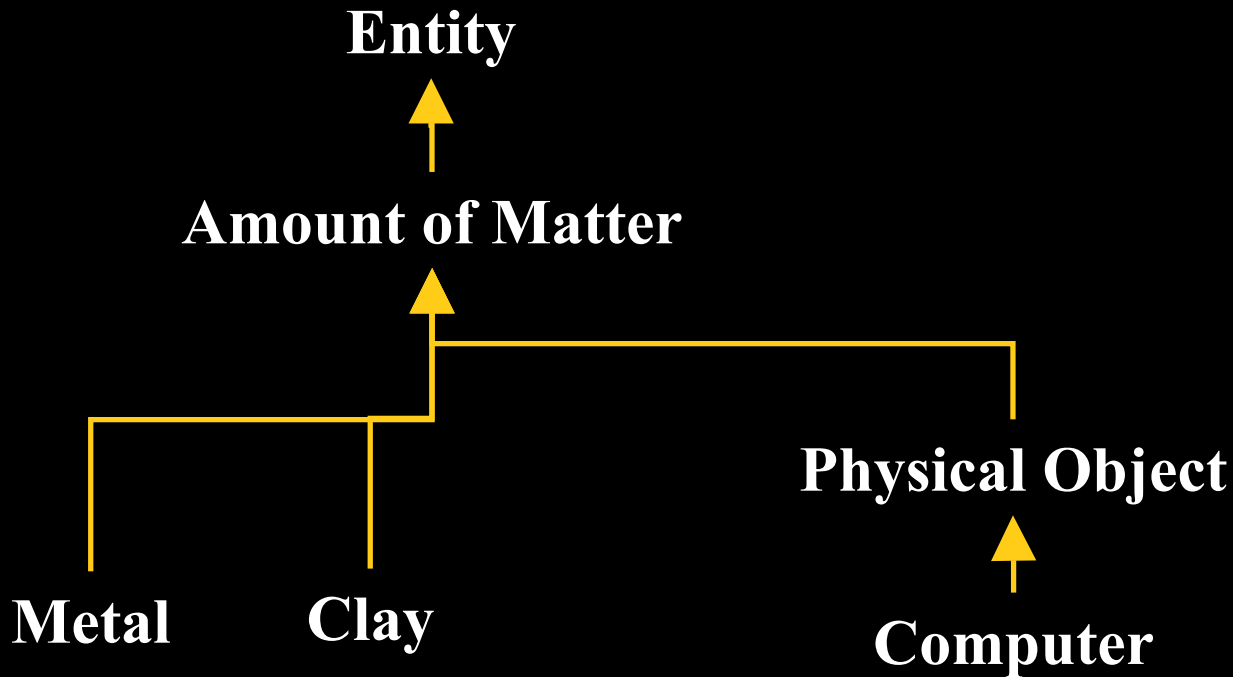


.....

Biography of Hemingway

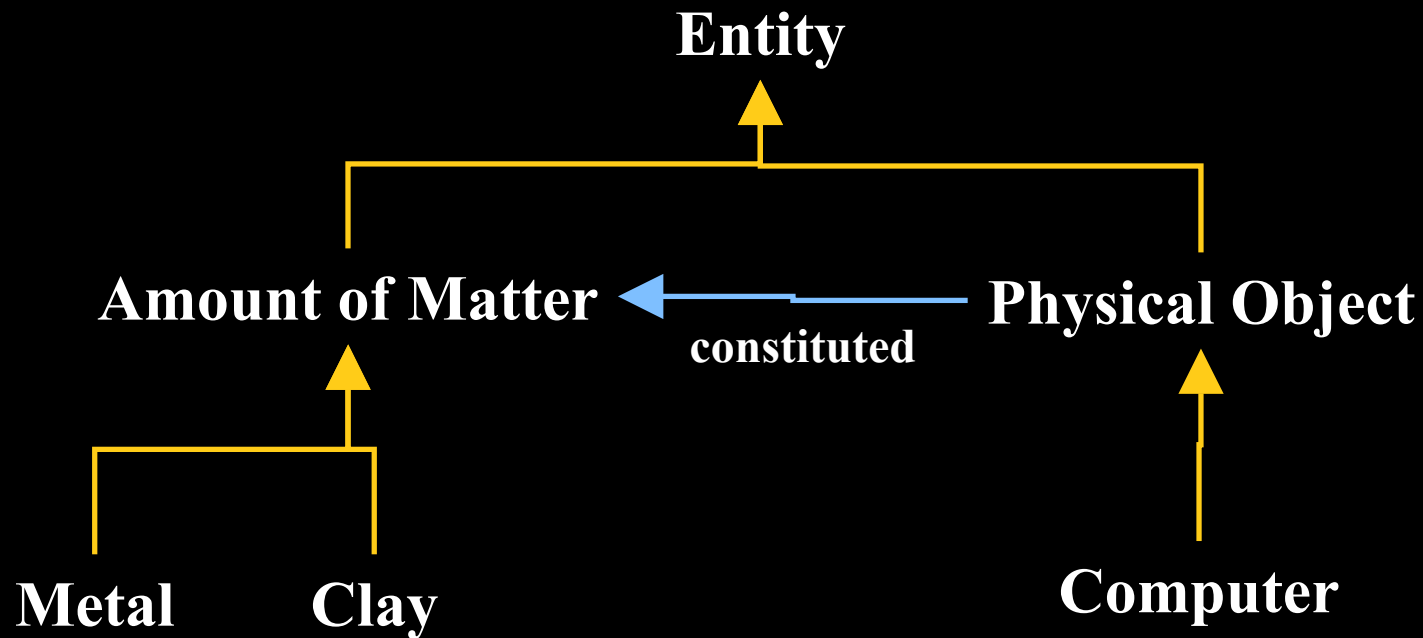
Constitution (1)

(WordNet)



**Question: What types of matter will conduct electricity?
Answer should NOT include computers.**

Constitution (2)



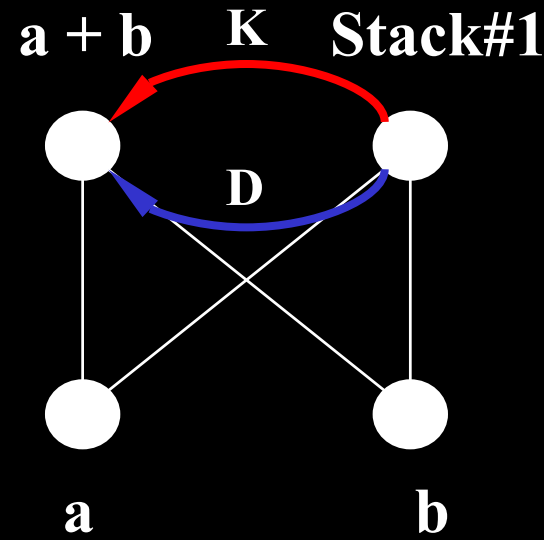
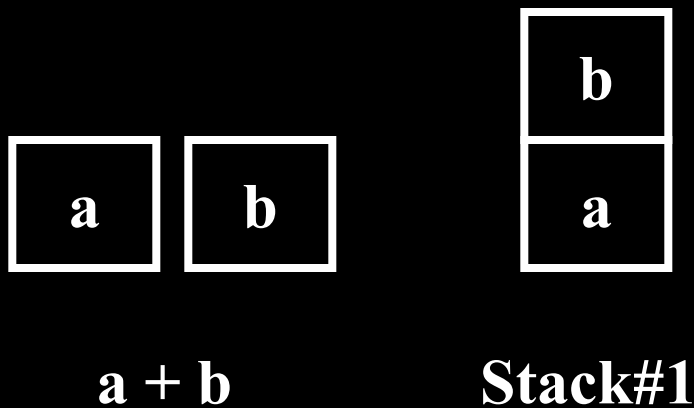
Part-of vs. part-*whole* relations

- portion/mass
- component/integral object
- member/collection
- **Member/social organization**

- stuff/object
- place/area
- feature/activity

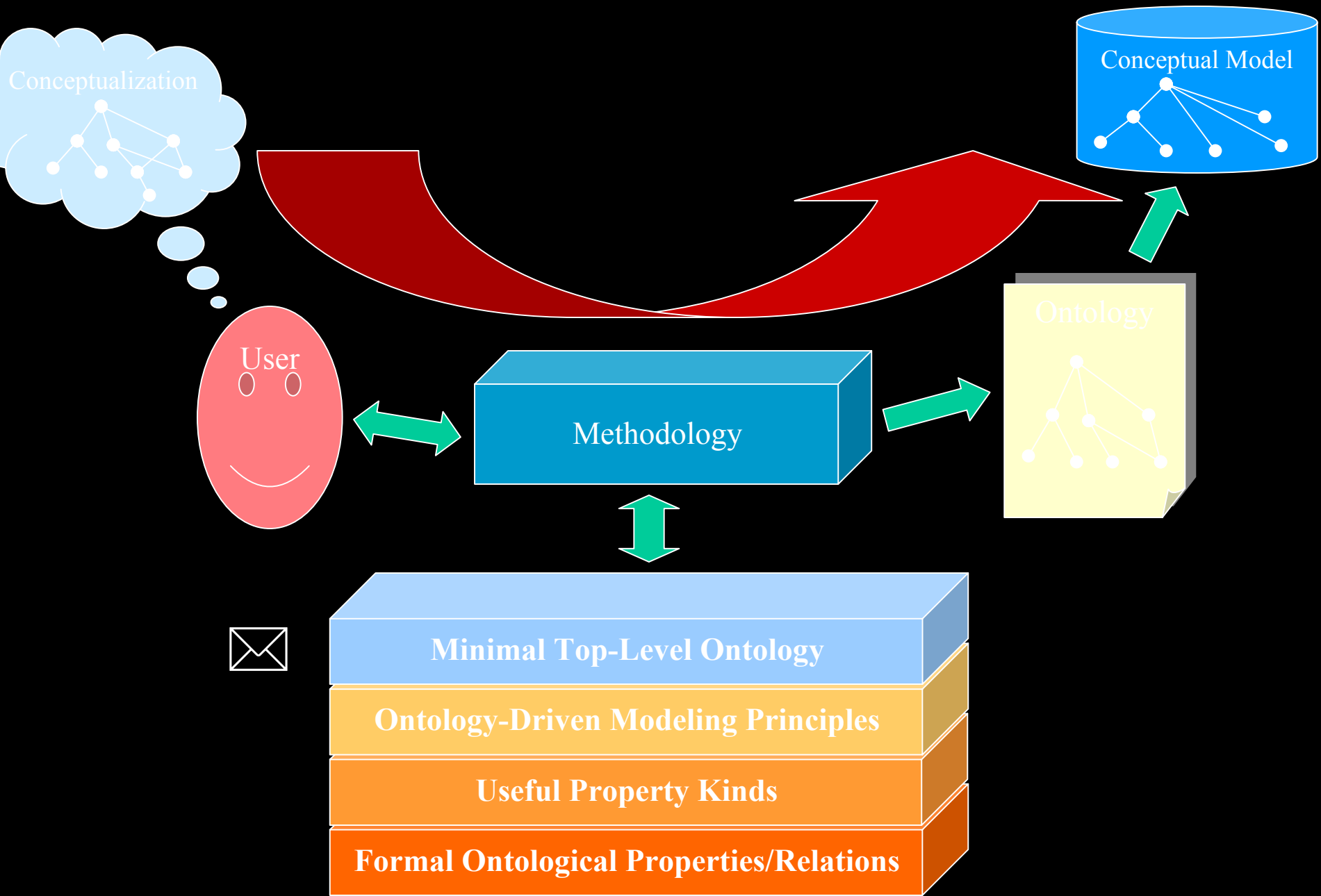
Part, Constitution, and Identity

- *Structure* may change identity
- *Mereological extensionality* is lost
- *Constitution* links the two entities
- Constitution is asymmetric (implies *dependence*)



Attributes vs. Arbitrary Relations

- Woods' example
 - John
 - age: 32
 - hits: Mary
- Internal vs. external relations
- Woods' linguistic test
- The Attribute Consistency Principle:
 - Any X of Y is a X



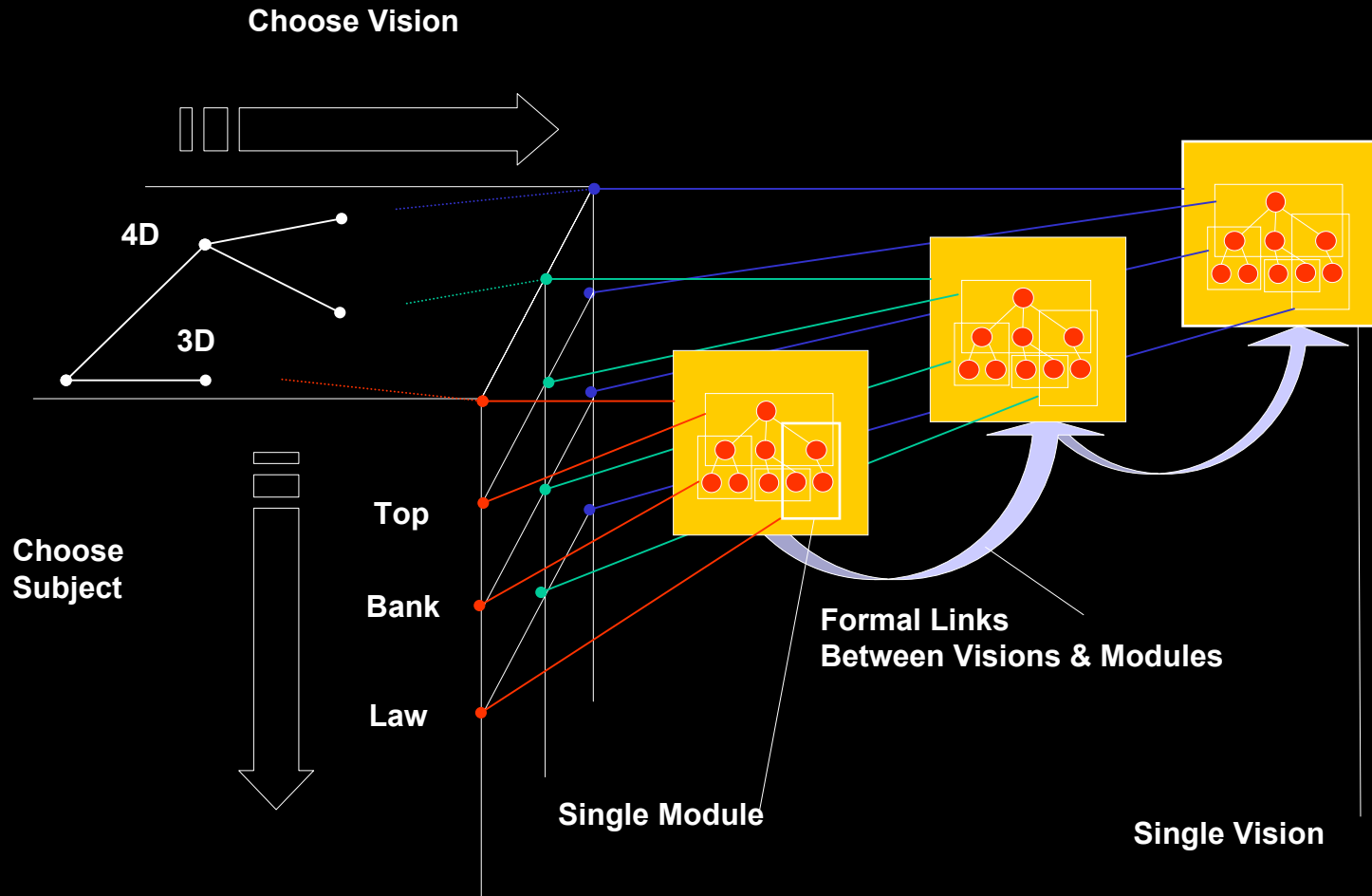
Developing foundational ontologies

- List the *basic options*
- Explore most relevant mutual *dependencies*
- Propose one preliminary upper level which is carefully *justified* and *positioned* with respect to the space of possible choices
- Add some *minimal ontologies* specifically relevant for selected domains
- Explore *alternative* upper levels

The WonderWeb Library of Foundational Ontologies

- No single upper level
- Rather, a (small) set of *foundational ontologies* carefully *justified* and *positioned* with respect to the space of possible choices
- *Basic options* clearly documented
- Clear *branching points* to allow for easy comparison of ontological options)

The WFO architecture



DOLCE: *a Descriptive Ontology for Linguistic and Cognitive Engineering*

- A first reference module for the Foundational Ontology Library
- Strong *cognitive bias* influenced by
 - Perception
 - Culture
 - Social conventions
- Rich axiomatization
- Categories as *conceptual containers*: no "deep" metaphysical implications

DOLCE's basic taxonomy

Endurant

Physical

Amount of matter
Physical object
Feature

Non-Physical

Mental object
Social object

...

Perdurant

Static

State
Process

Dynamic

Achievement
Accomplishment

Quality

Physical

Spatial location

...

Temporal

Temporal location

...

Abstract

Abstract

Quality region

Time region
Space region
Color region

...

...

Abstract vs. Concrete Entities

- Concrete: located in space-time (regions of space-time are located in themselves)
- Abstract - two meanings:
 - Result of an abstraction process (something common to multiple exemplifications)
 - ✉ *Not located in space-time*
- Mereological sums (of concrete entities) are concrete, the corresponding sets are abstract...

Endurance vs. Perdurance

- **Endurants:**
 - All proper parts are present whenever they are present (*wholly presence*, no temporal parts)
 - Exist in time
 - Can genuinely change in time
 - Need a time-indexed parthood relation
- **Perdurants:**
 - Only some proper parts are present whenever they are present (*partial presence*, temporal parts)
 - Happen in time
 - Do not change in time
 - Do not need a time-indexed parthood relation

Qualities and qualia

- Linguistic evidence
 - *This rose is red*
 - *Red is a color*
 - *This rose has a color*
 - *The color of this rose turned to brown in one week*
 - *The room's temperature is increasing*
 - *Red is opposite to green and close to brown*
- Every entity comes with certain qualities that permanently *inhere* to it and are *unique* of it
- Qualities are perceptually mapped into *qualia*, which are regions of *quality spaces*.
- Properties hold because qualities have certain locations in their quality spaces.
- Each *quality type* has its own quality space

Qualities

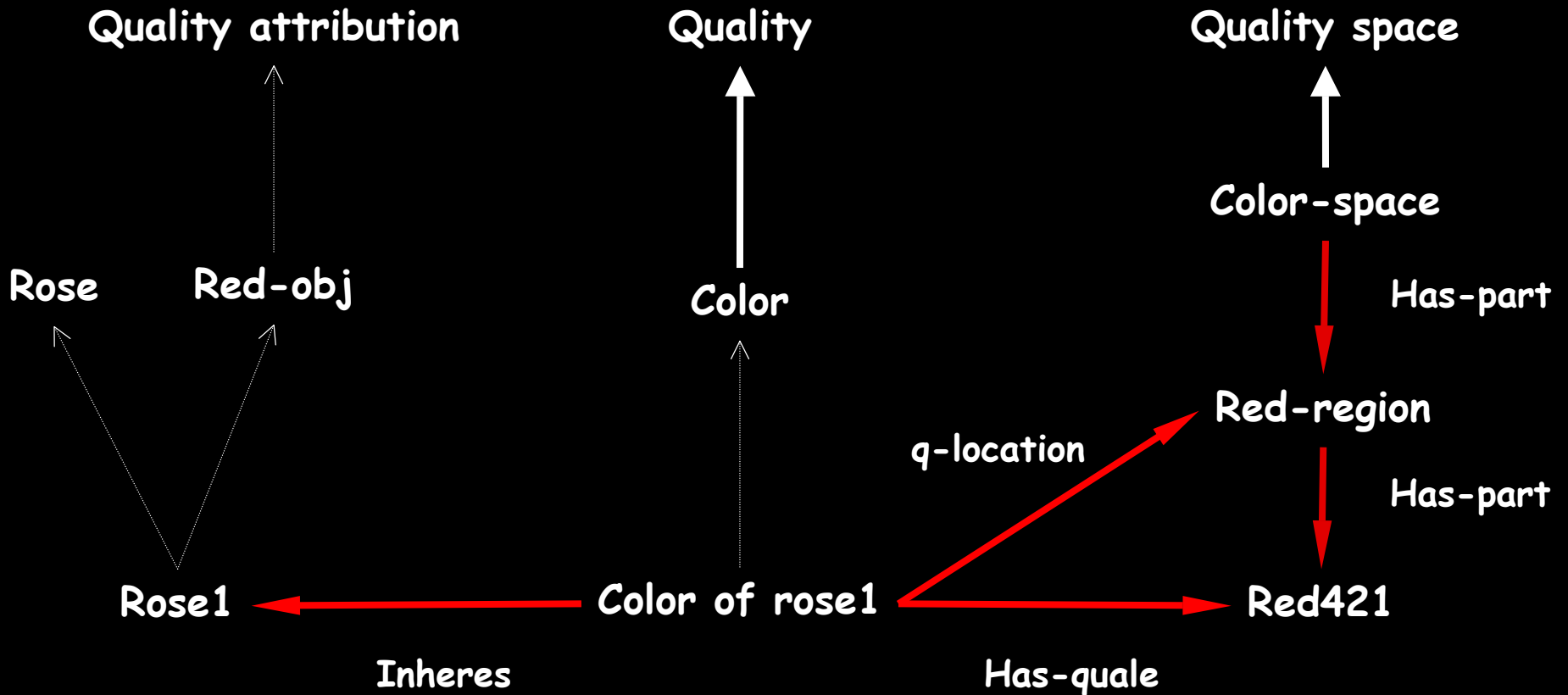


The rose and the chair have *the same color*:

- different color qualities inhere to the two objects
- they are located in the same quality region

Therefore, the same color attribute (red) is ascribed to the two objects

Qualities



Aggregate vs. Object



- Both are *enduring* entities
- An object has a **unity criterion**, while an aggregate does not.

Physical vs. Non-physical Object



FIAT SpA

- Physical objects:
 - *inherent spatial localization*
 - *not dependent* on other objects (physical objects, like cars) or no inherent localization and be dependent on *agents* (non-physical objects, like laws and institutions).
- Non-physical objects can also be divided into *mental* (depending on *singular* agents) and *social* (depending on *communities* of agents).

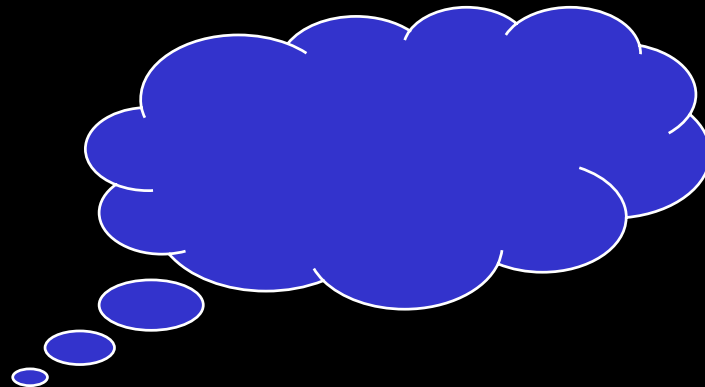
Features

- Features are “parasitic” entities, that exist insofar their host exists.
- Features may be relevant parts of their host, or places (which are not parts of their hosts).
- All features are essential wholes, but no common unity criterion may exist for all of them (*U).



Abstracts

- **Abstracts** are entities that have no inherent spatial or temporal localization. Examples of **Abstract** are *propositions, sets, symbols, regions, etc.*
- *Quality regions* and *quality spaces* are relevant examples of abstract entities



Physical and non-physical objects

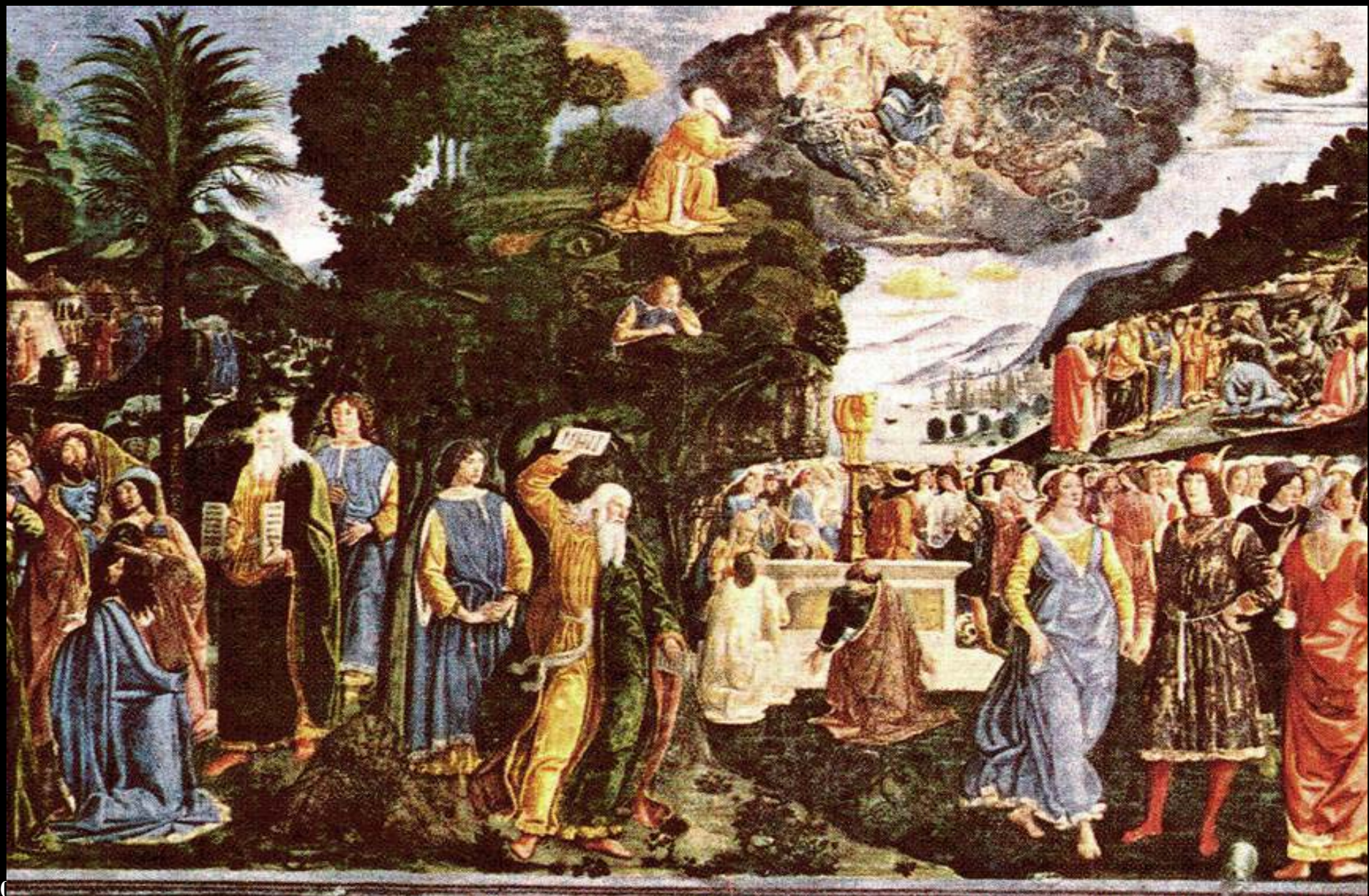
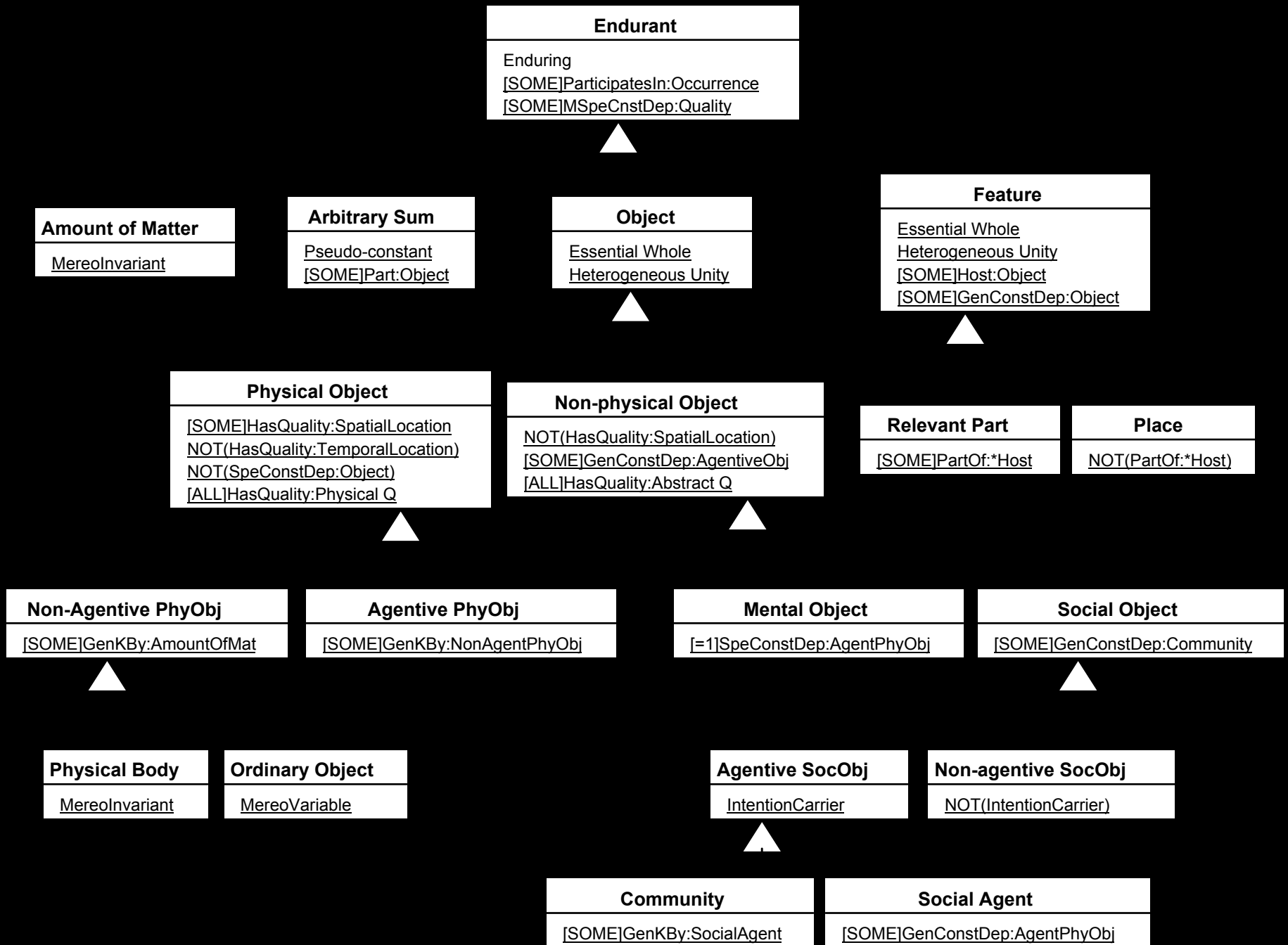


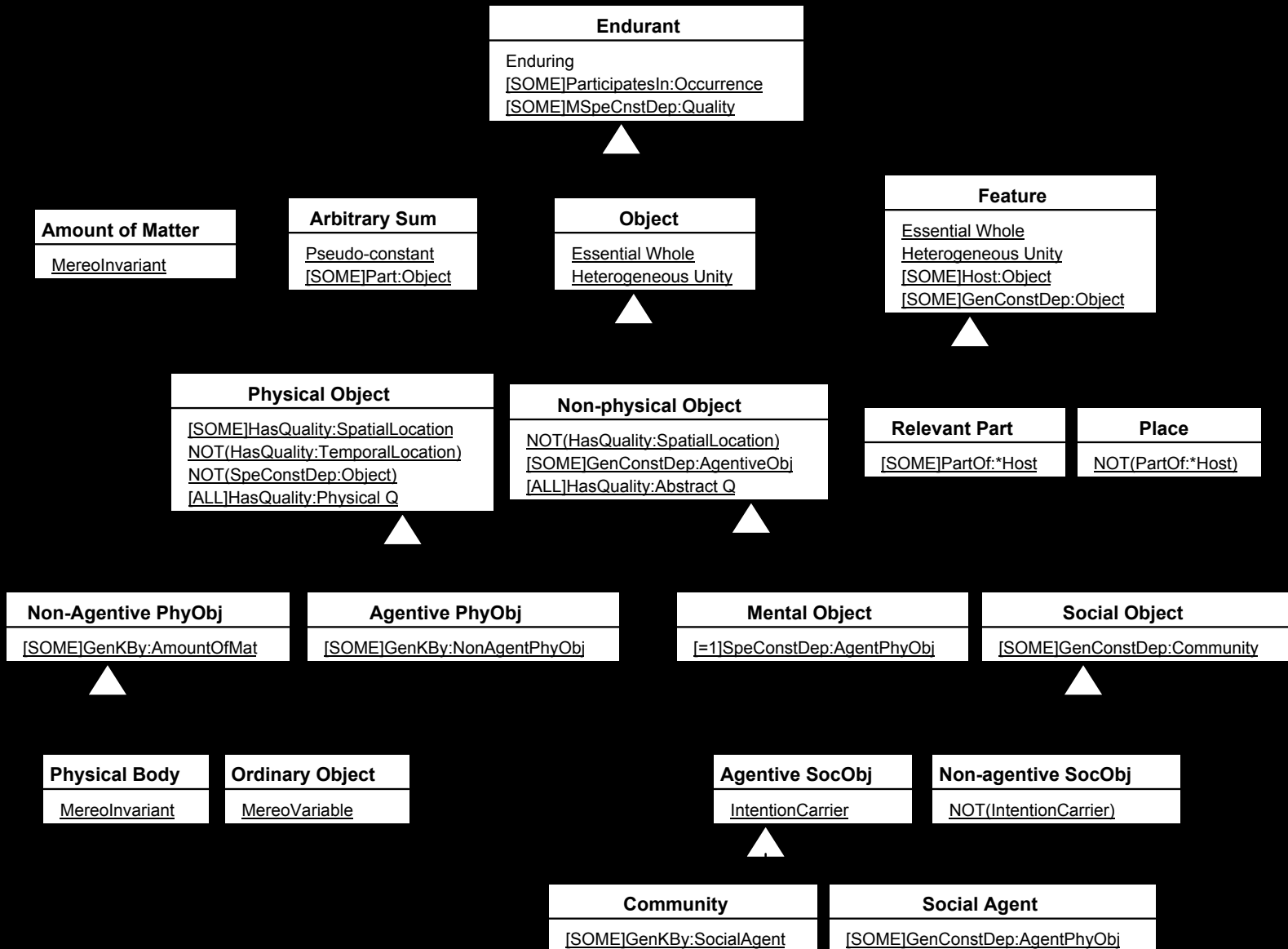
Figure Conventions

Given an entity x to be characterised as $D(x)$, its properties are written with the following compact syntax (in the 'attribute' slot of the next UML class diagrams):

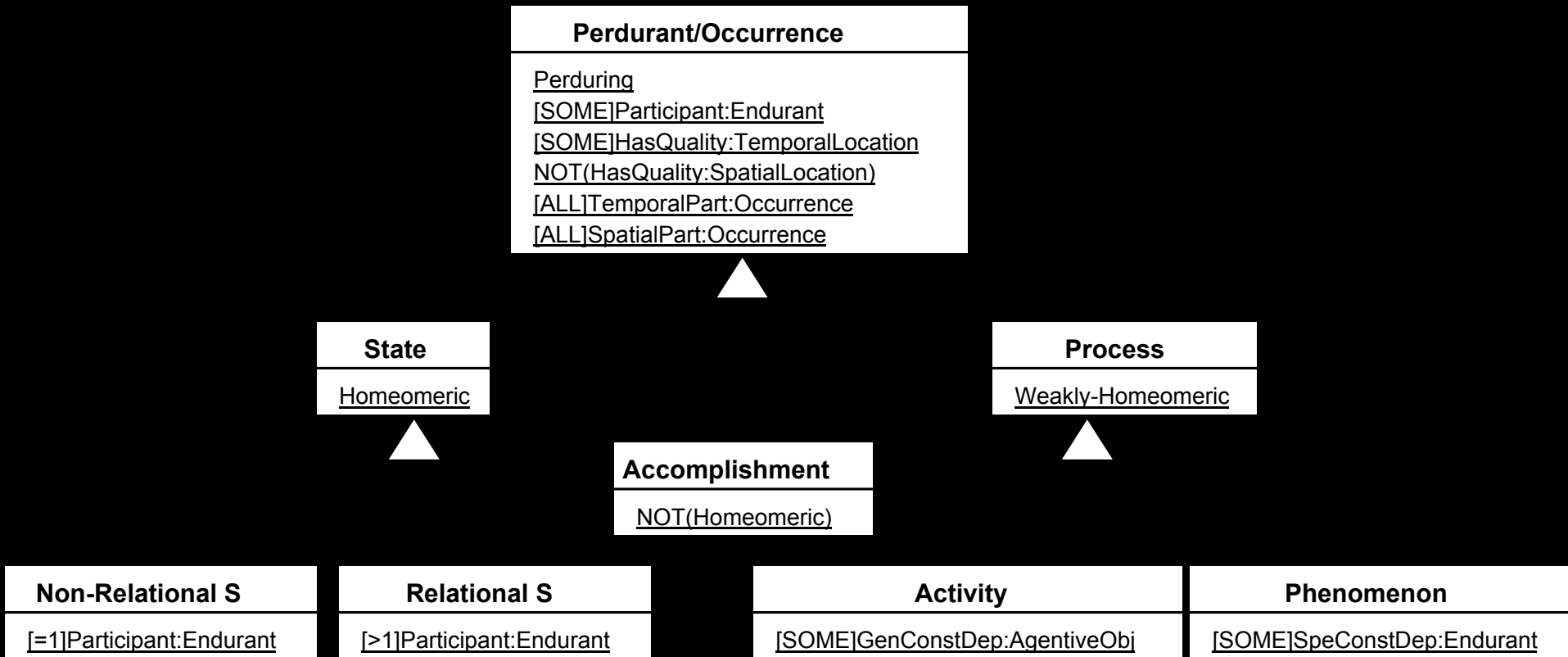
- C $\quad \quad \quad \forall x D(x) \rightarrow C(x)$
- $\text{NOT}(C)$ $\quad \quad \quad \forall x D(x) \rightarrow \neg C(x)$
- $R:C$ $\quad \quad \quad \forall x D(x) \rightarrow \exists y R(x,y) \wedge C(y)$
- $[\text{SOME}|=|>|<]$ $\quad \quad \quad \forall x D(x) \rightarrow \exists_{(n|>n|<n)}(y) R(x,y) \wedge C(y)$
- $[\text{ALL}]R:C$ $\quad \quad \quad \forall x,y D(x) \rightarrow R(x,y) \rightarrow C(y)$
- $\text{NOT}(R:C)$ $\quad \quad \quad \forall x D(x) \rightarrow \neg \exists y R(x,y) \wedge C(y)$



Endurants



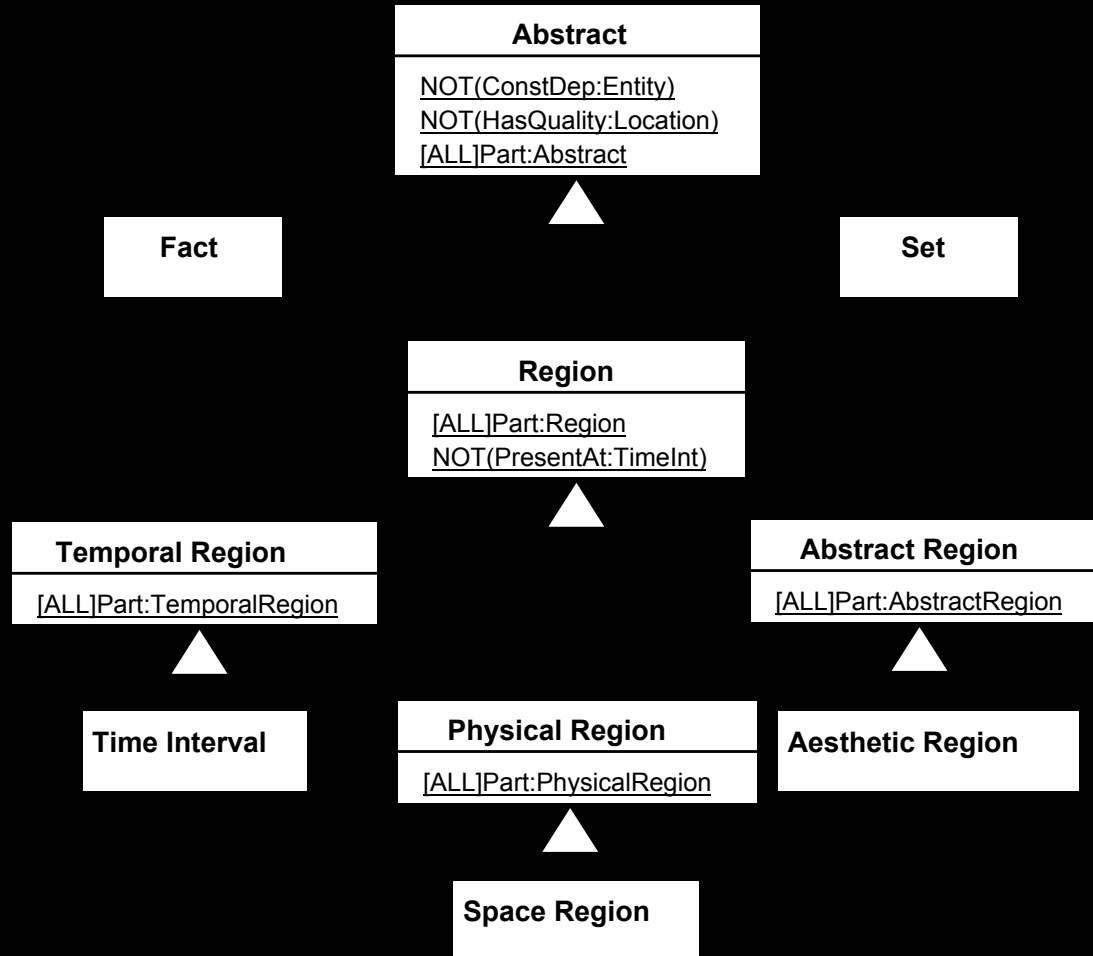
Perdurants



Qualities



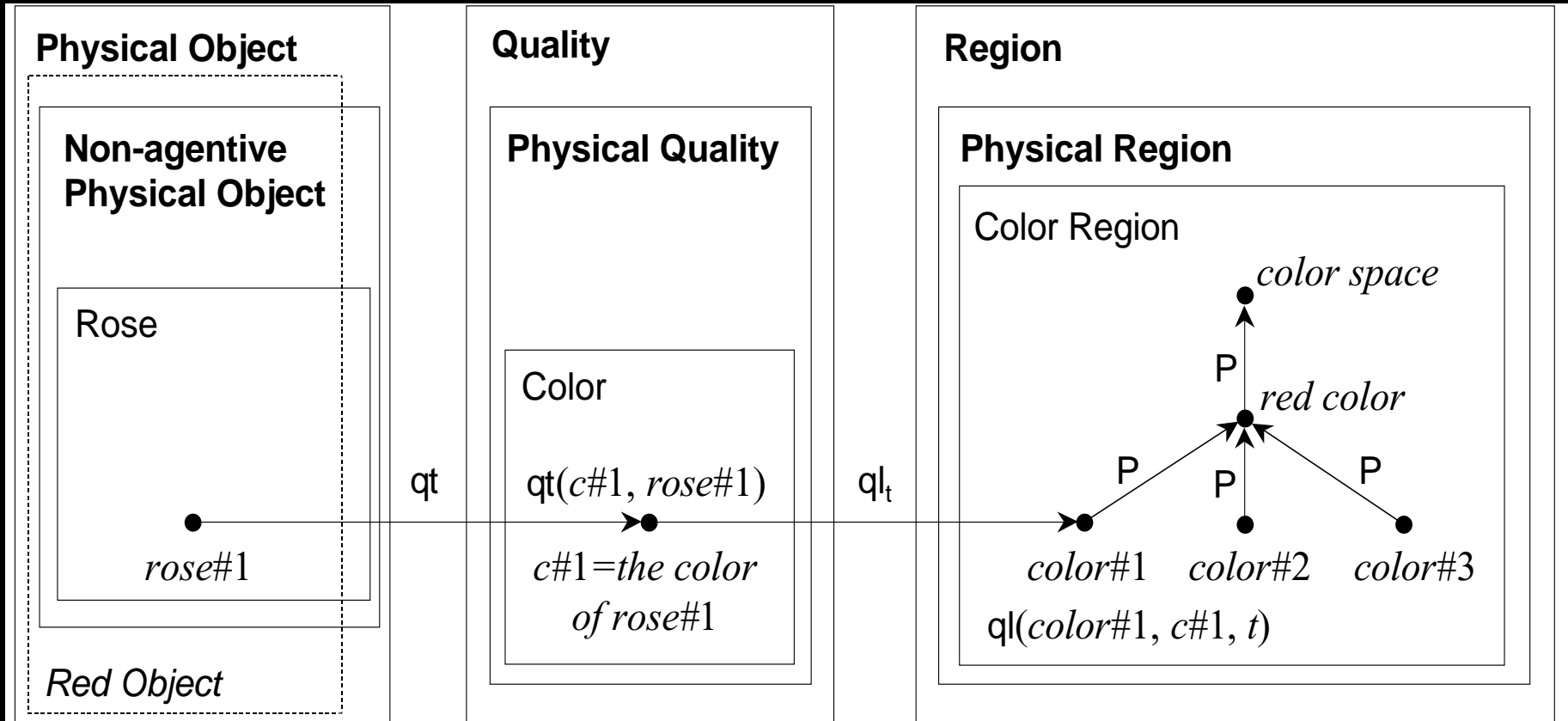
Abstracts



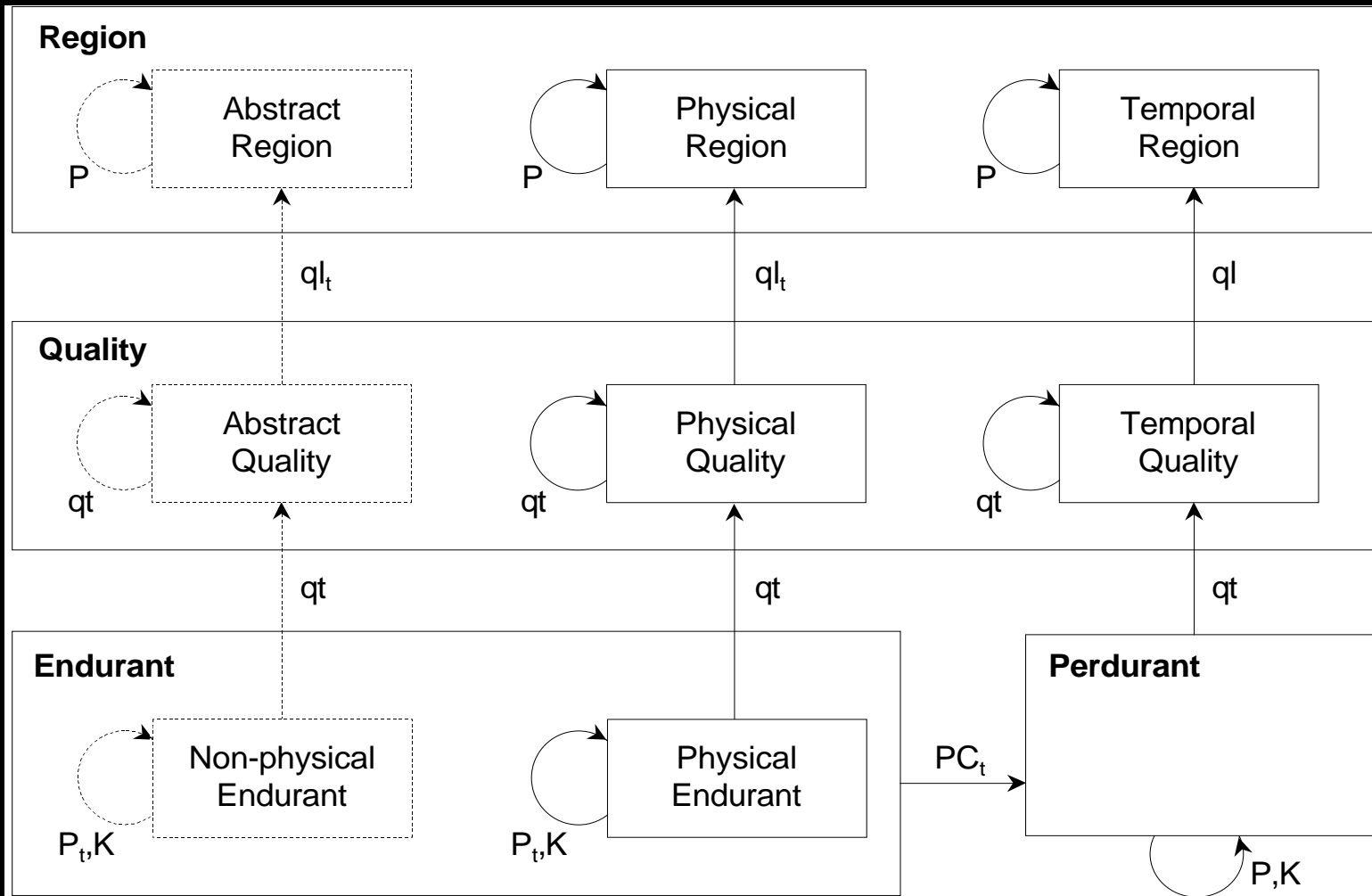
Basic Relations

- Parthood
 - Between quality regions (immediate)
 - Between arbitrary objects (temporary)
- Dependence
 - Specific/generic constant dependence
- Constitution
- Inherence (between a quality and its host)
- Quale
 - Between a quality and its region (immediate, for unchanging ent)
 - Between a quality and its region (temporary, for changing ent)
- Participation
- Representation

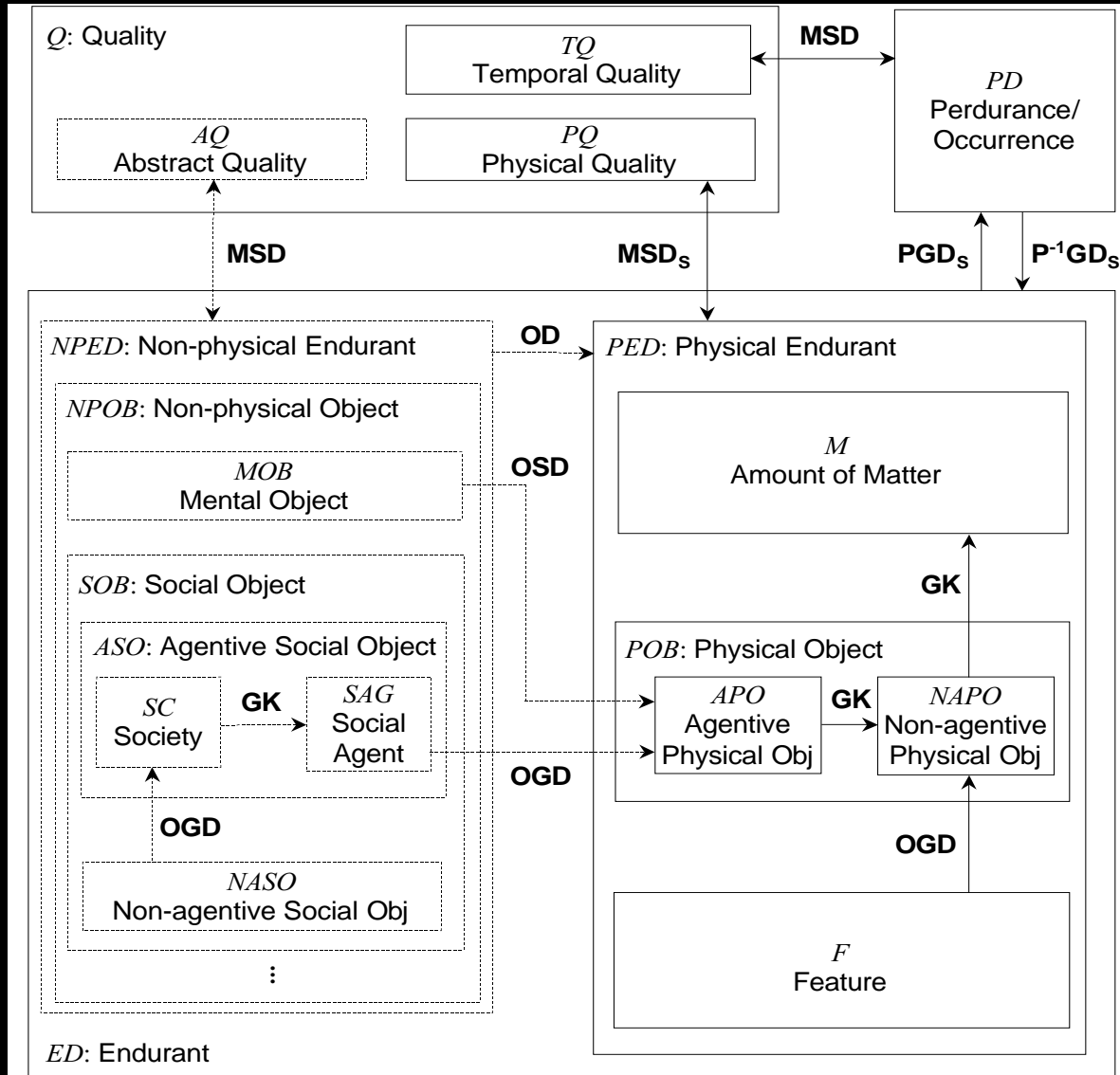
Quality relations



Primitive relations and basic categories



Dependence relations



Participation relations

- Hold between a perdurant and its involved endurants
- Extremely relevant for domain modelling
- Current axiomatization covers:
 - constant vs. temporary
 - complete vs. partial
- Further distinctions are currently primitive (thematic roles)
 - *Agent, Theme, Substrate, Instrument, Product*
 - More is needed on event structure, intentionality, and artifacts to produce analytic definitions

Representation relations

- Ongoing axiomatization (semiotics ontology)
- Extremely relevant for domain modelling
- Concepts
 - PhysicalRepresentation vs. Expression
 - Expression vs. Content
 - Content vs. Reference
- Relations
 - *Realization, Interpretant, Reference, Description*
- Non-trivial dependences between use and instantiation of expressions and contents

Axiomatizing basic relations

- Ground axioms (mainly algebraic)
- Links to other relations
- Dependence on time
- FO Modal Theory (S5+Barcan)
- **WonderWeb** D17 v.2 for details

KIF example with PW

- $P(w, x, y)$ = "x is part of y in the possible world w"
- $P(w, x, y, t)$ = "x is part of y at time t in the possible world w"

; $O(x, y) =_{df} \exists z(P(z, x) \wedge P(z, y))$ (*Overlap*)

(defrelation O (?w0 ?x ?y) :=

(and (ENTITY ?x)

(ENTITY ?y)

(WORLD ?w0)

(exists (?z) (and (ENTITY ?z)

(P ?w0 ?z ?x)

(P ?w0 ?z ?y))))))

Q&A for drafting the concepts

- (are the parts of the entities you're talking about all present whenever such entities are present?)
 - Yes → *Endurant*
 - (can you count these entities?)
 - uncertain
 - (do they resemble a definite object rather than an indefinite amount of matter?)
 - Yes
 - (are these entities an undetachable part of something else?)
 - uncertain → *(Object ∨ Feature)*
 - (for example, are they more like a table or like its edge?)
 - a table
 - (can these entities exist independently of some agent that thinks, talks, or reason about them?)
 - uncertain
 - (are these entities constituted by matter?) → *Object*
 - Yes
 - (can these entities intend to do something, or believe, or desire something?)
 - (ok, put your class in the <NonAgentivePhysicalObject> branching) → *PhysicalObject*
 - No
- *NonAgentivePhysicalObject*

Some ongoing applications

- Ontology merging and building (e.g. fishery, bank norms)
- Catalogue creation/maintenance (e.g. portals)
- DB design and requirement analysis
- Behaviour description and detection
 - Quality/anomaly assessment from legacy DBs (money-laundering procedures)
 - Quality/anomaly assessment of runtime operations (service level agreement)