



Ontology-Driven Conceptual Modeling

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Supported by the European Union in the frame of Unified Program Document 3
under the European Social Fund together with the Czech Republic and the City of Prague.





Schedule

- **09:00 – 10:30 (First Part)**
- **10:30 – 10:50 (Coffee Break)**
- **10:50 – 12:00 (Second Part)**
- **12:00 – 13:00 (Lunch Part)**
- **13:00 – 14:30 (Third Part)**



Part I – Types and Properties



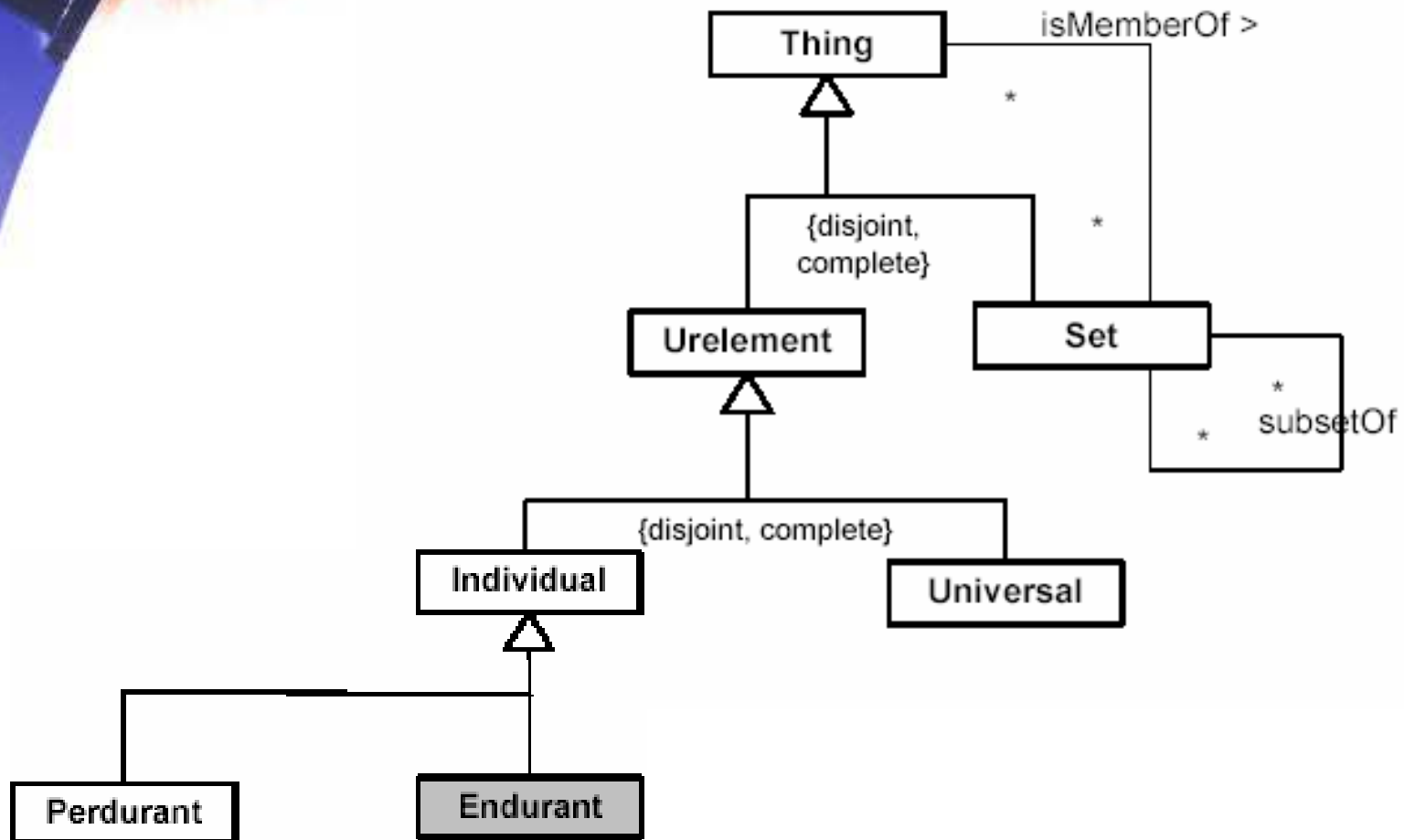
Types and Properties

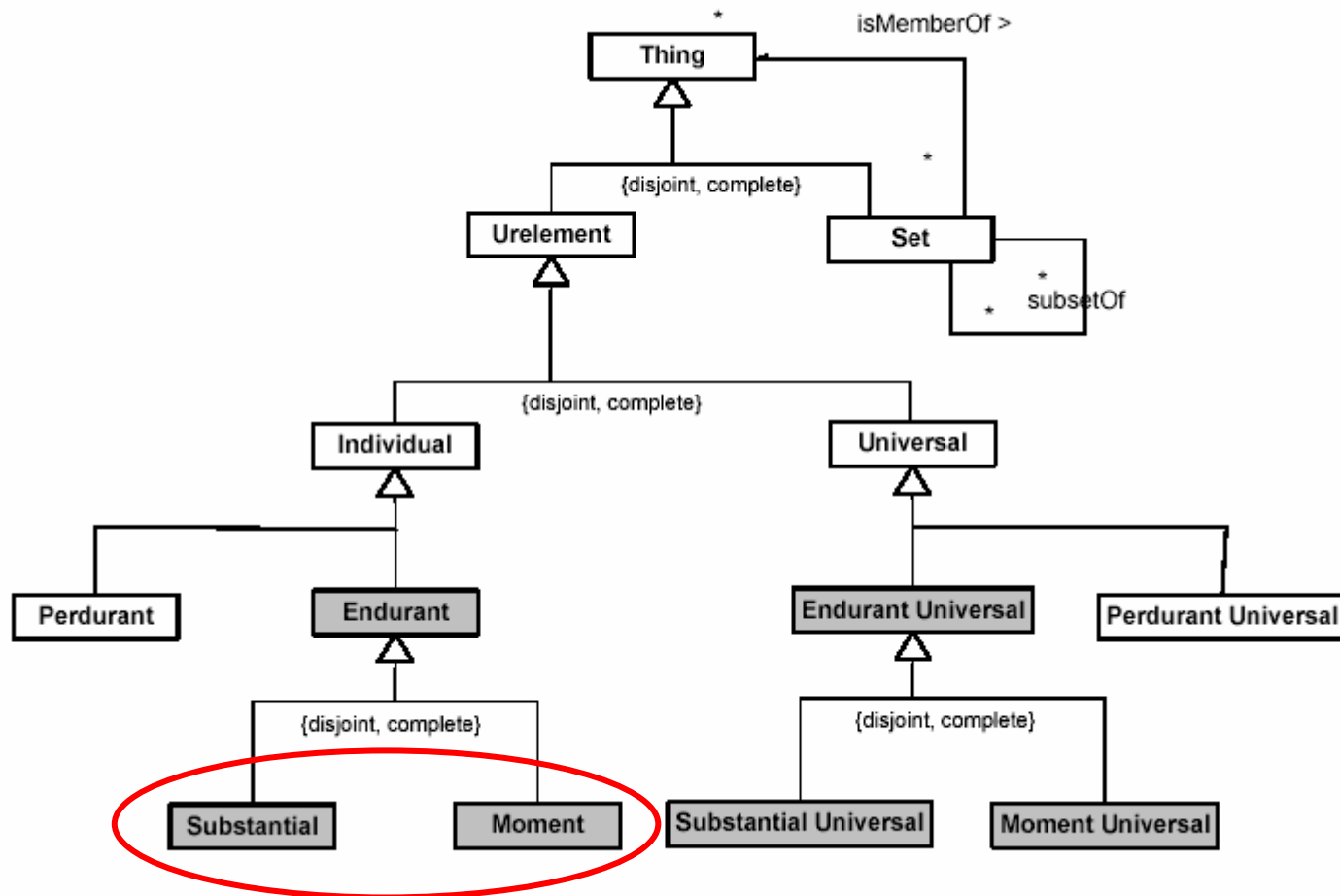
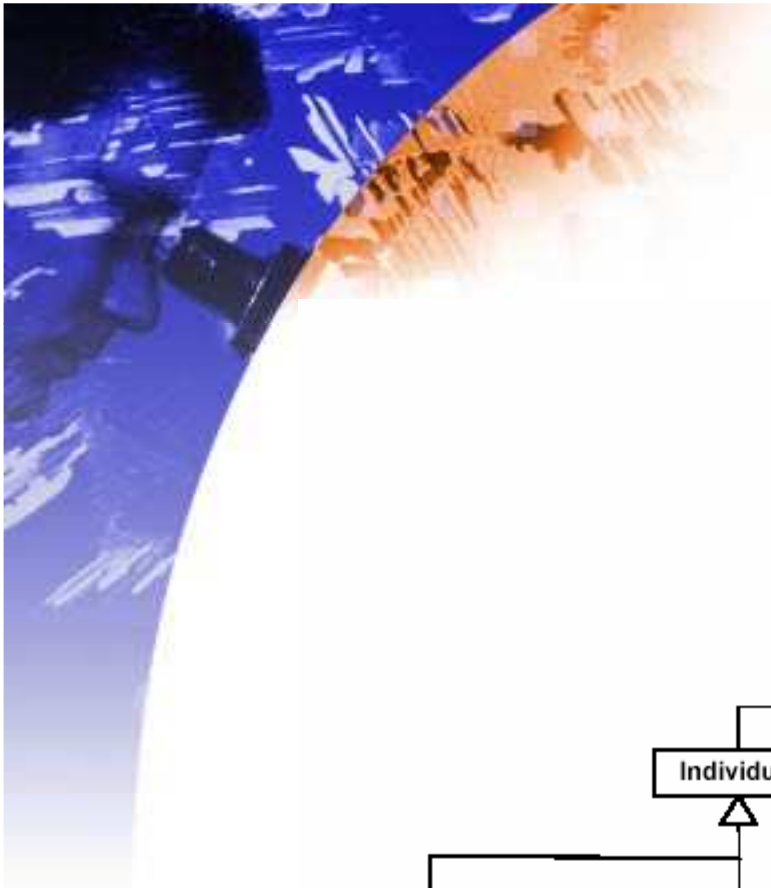
- **Types (e.g., Person or Car), attributes (e.g., being colored, or being happy), and associations (e.g., being married to, being enrolled at) are all considered sorts of universals, i.e., predicative terms that can possibly be applied to a multitude of individuals.**
- **But what exactly is a universal?**



Problems with Set Theory

- **Identity of co-extensional classes**
- **Types change when sets change**
- **Problem with the subtype relation as the subset relation and the empty set**
- **The *direction of explanation***
- **The problem with disjunctive and negated classes**







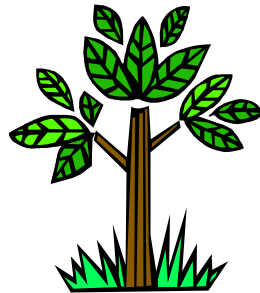
Ontological Distinctions

- The ontological categories are distinguished by possessing different meta-properties.
- For instance, the **Substance x Moment (Property Instance)** distinction based on the meta-property of existential dependence (Husserl):
- *An individual x is **existentially dependent** on another individual y iff, as a matter of necessity, at any time that x exists, y must also exist*

$$\text{ed}(x,y) =_{\text{def}} \Box(\varepsilon(x) \rightarrow \varepsilon(y))$$

Substantial

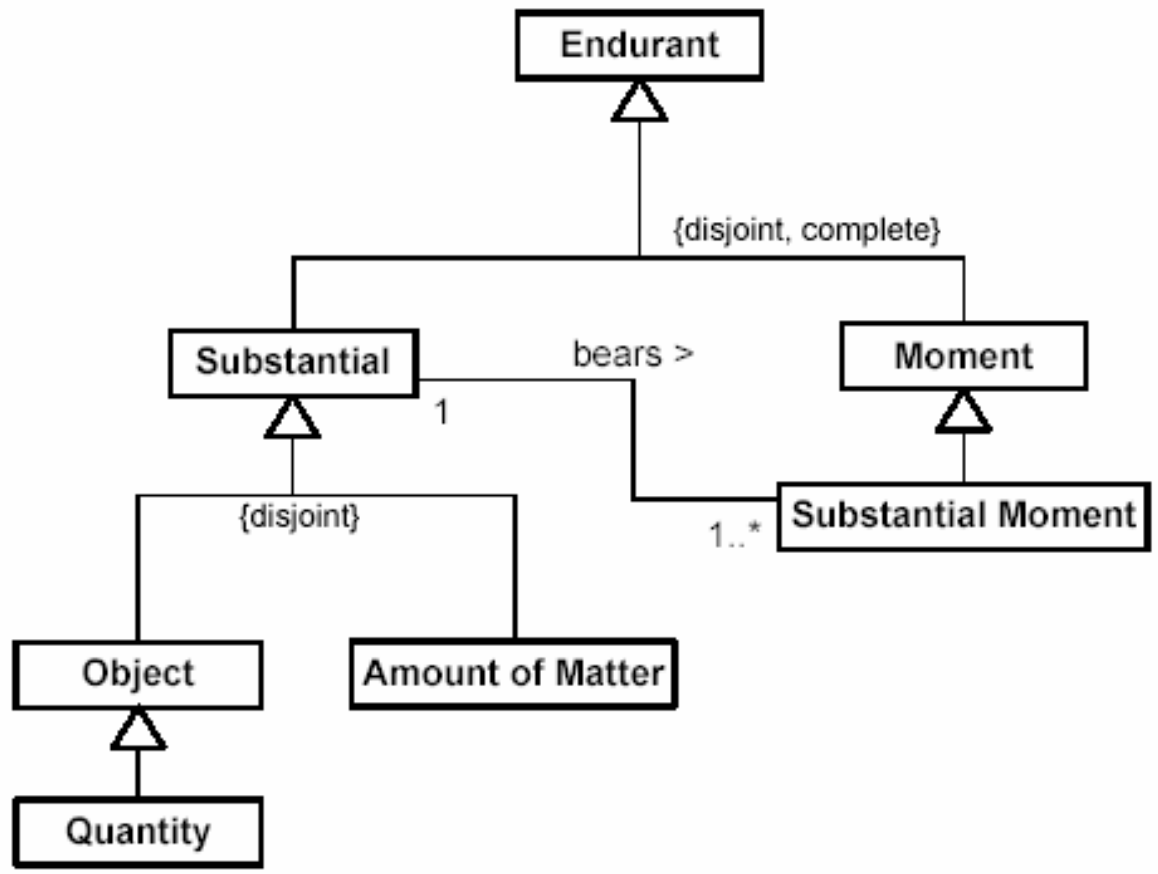
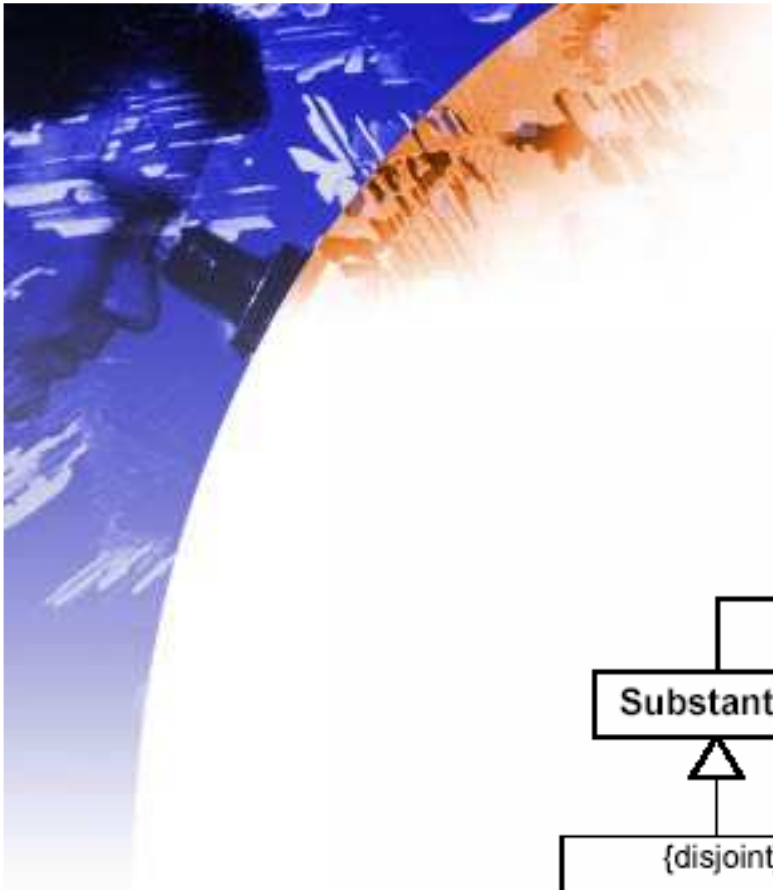
- A **substance individual** is that of which can exist by itself, i.e., they are not *existentially dependent* on any other entity.





Substantial

- **The category of substantial includes all independent objects of everyday experience (including the so-called *Fiat Objects* and *Negative Objects*)**





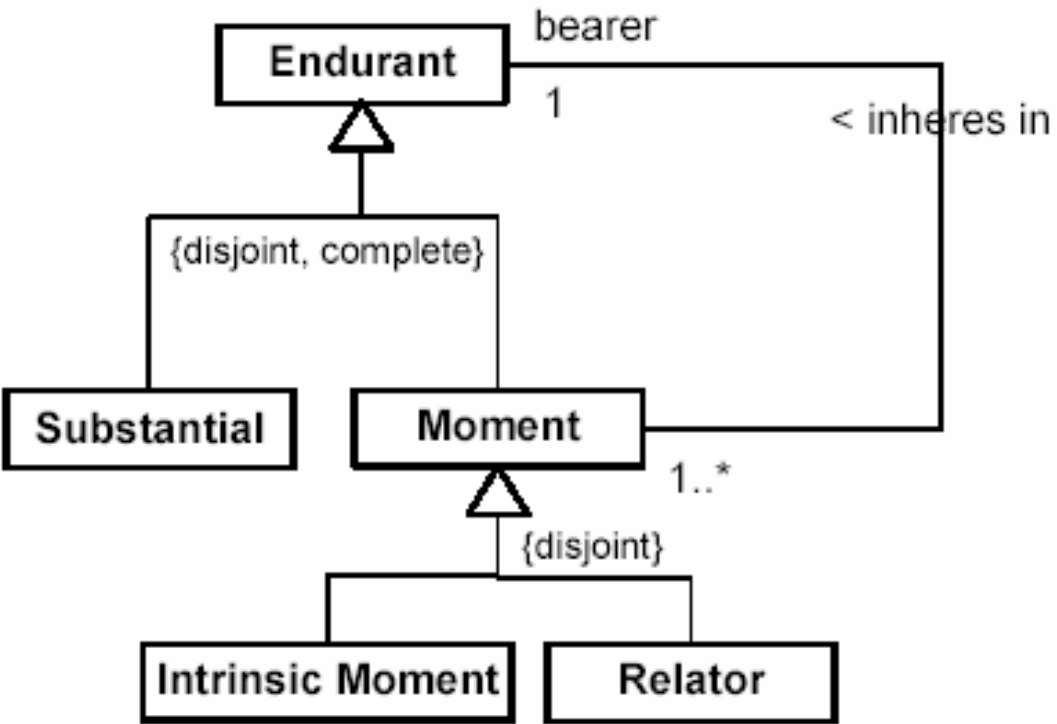
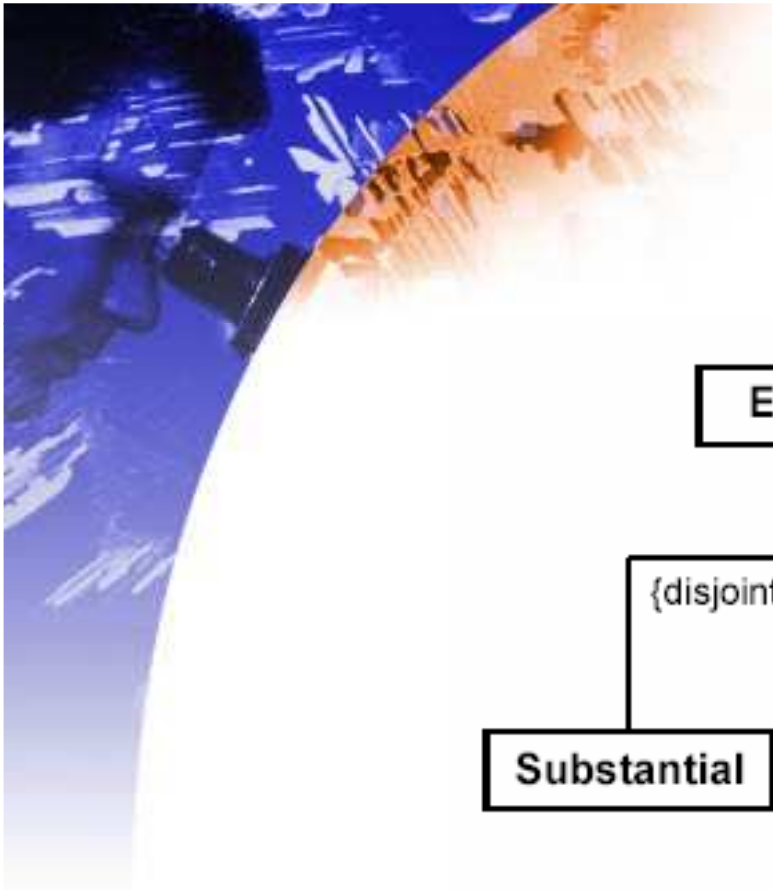
Moments (Property Instances)

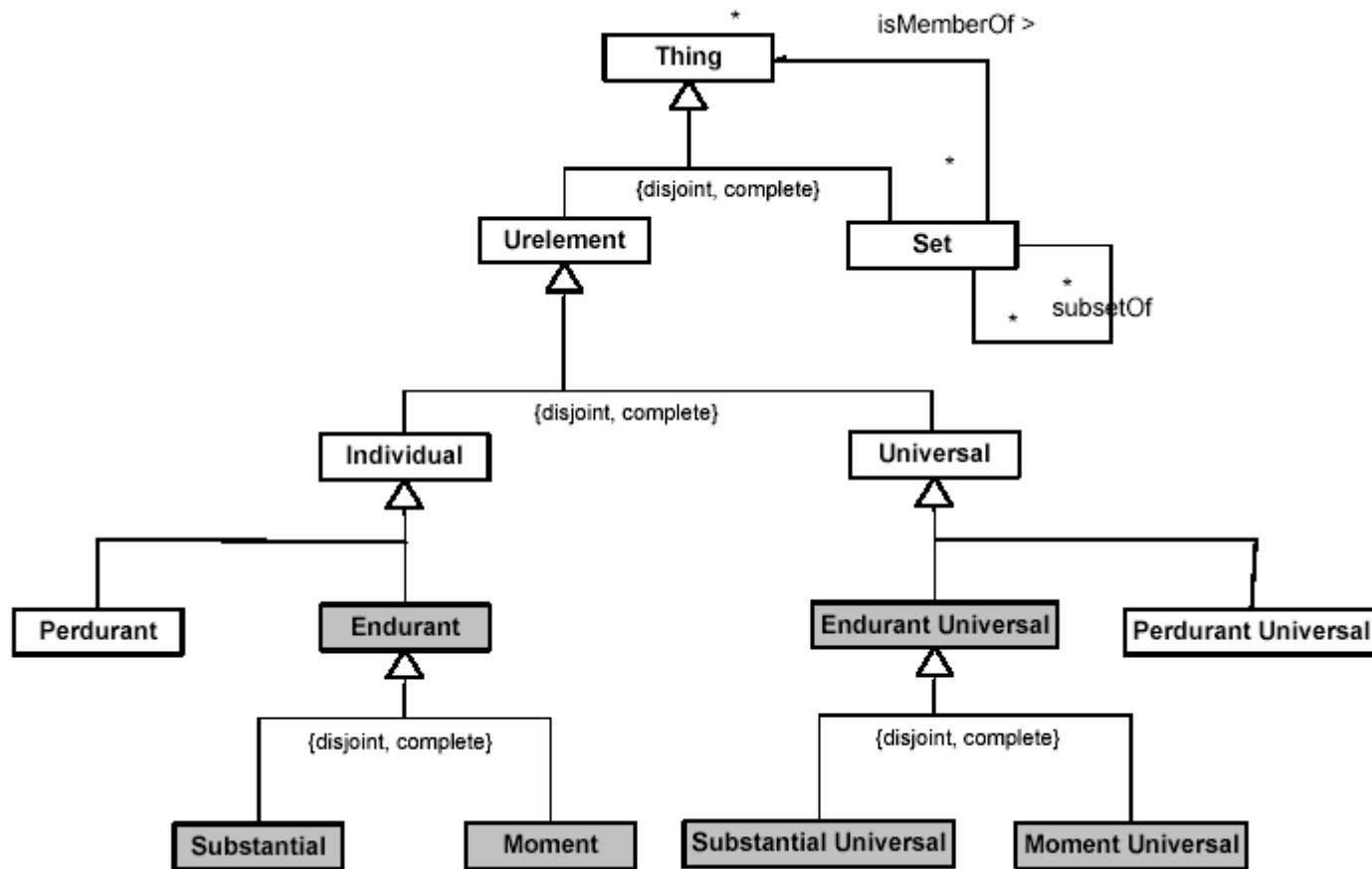
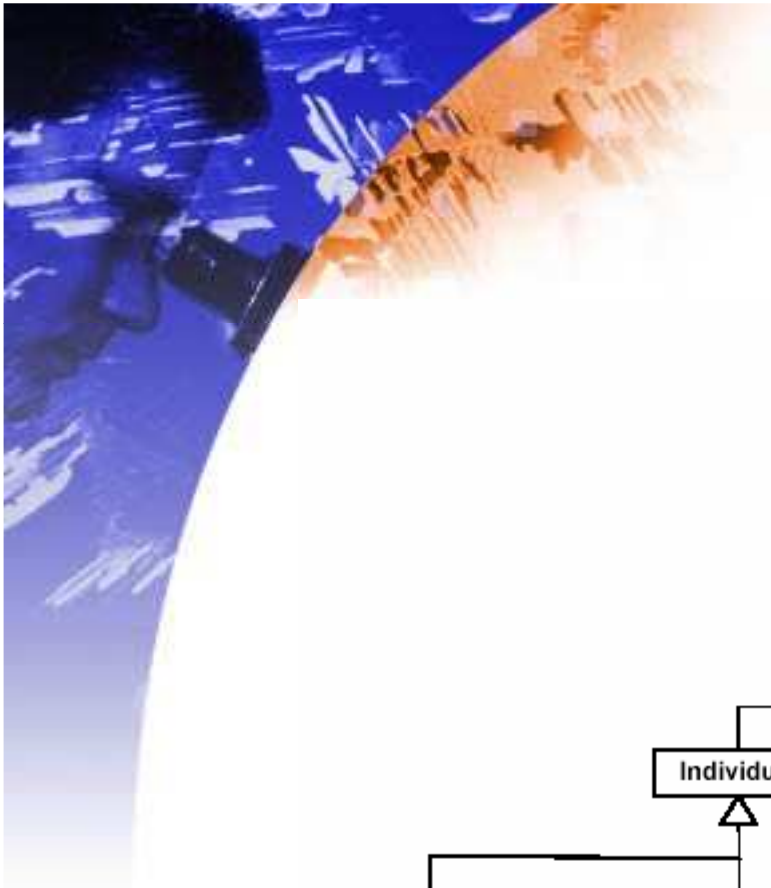
- It can only exist in another individual, i.e., every moment is *existentially dependent* on some other individual (e.g. a charge in a conductor, the color of a fruit, a flight connection, a kiss)

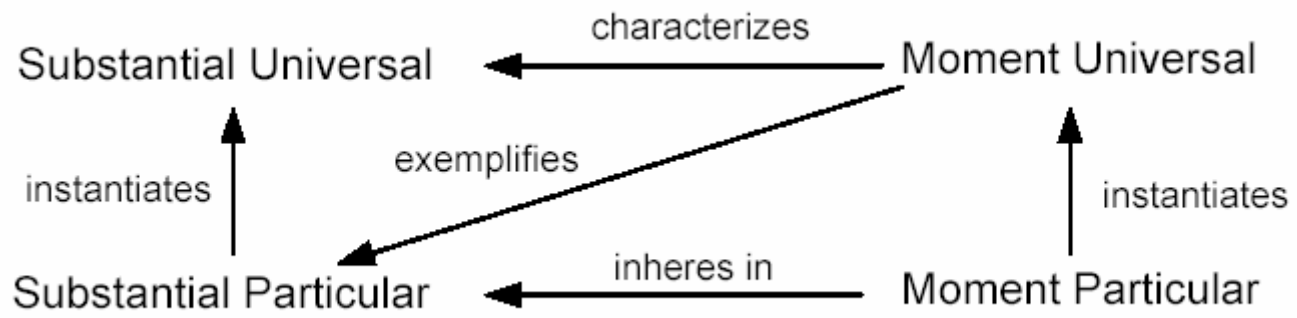
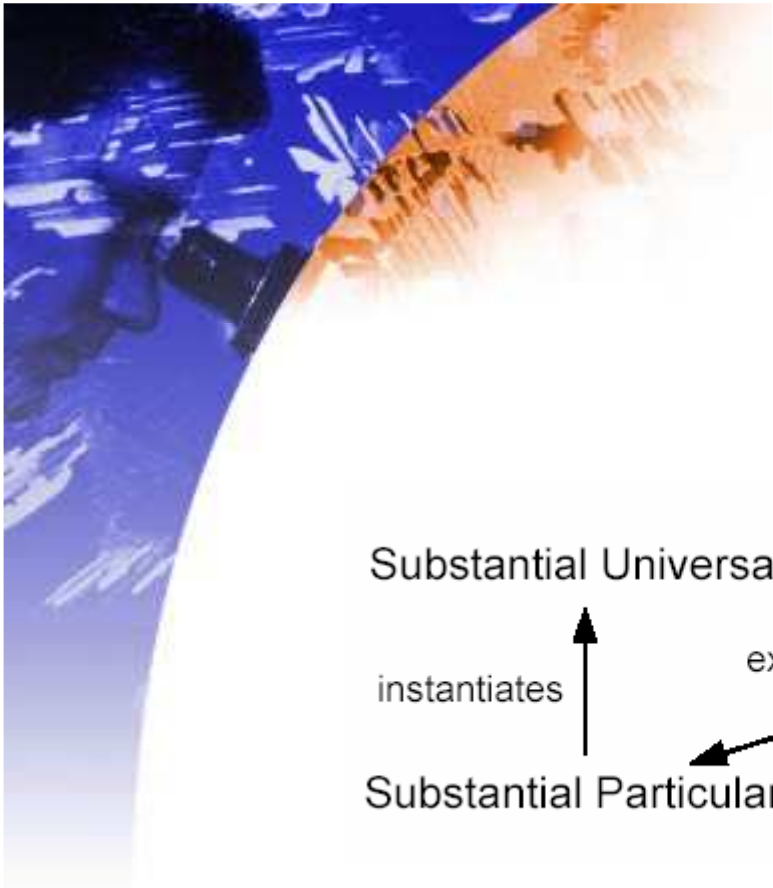


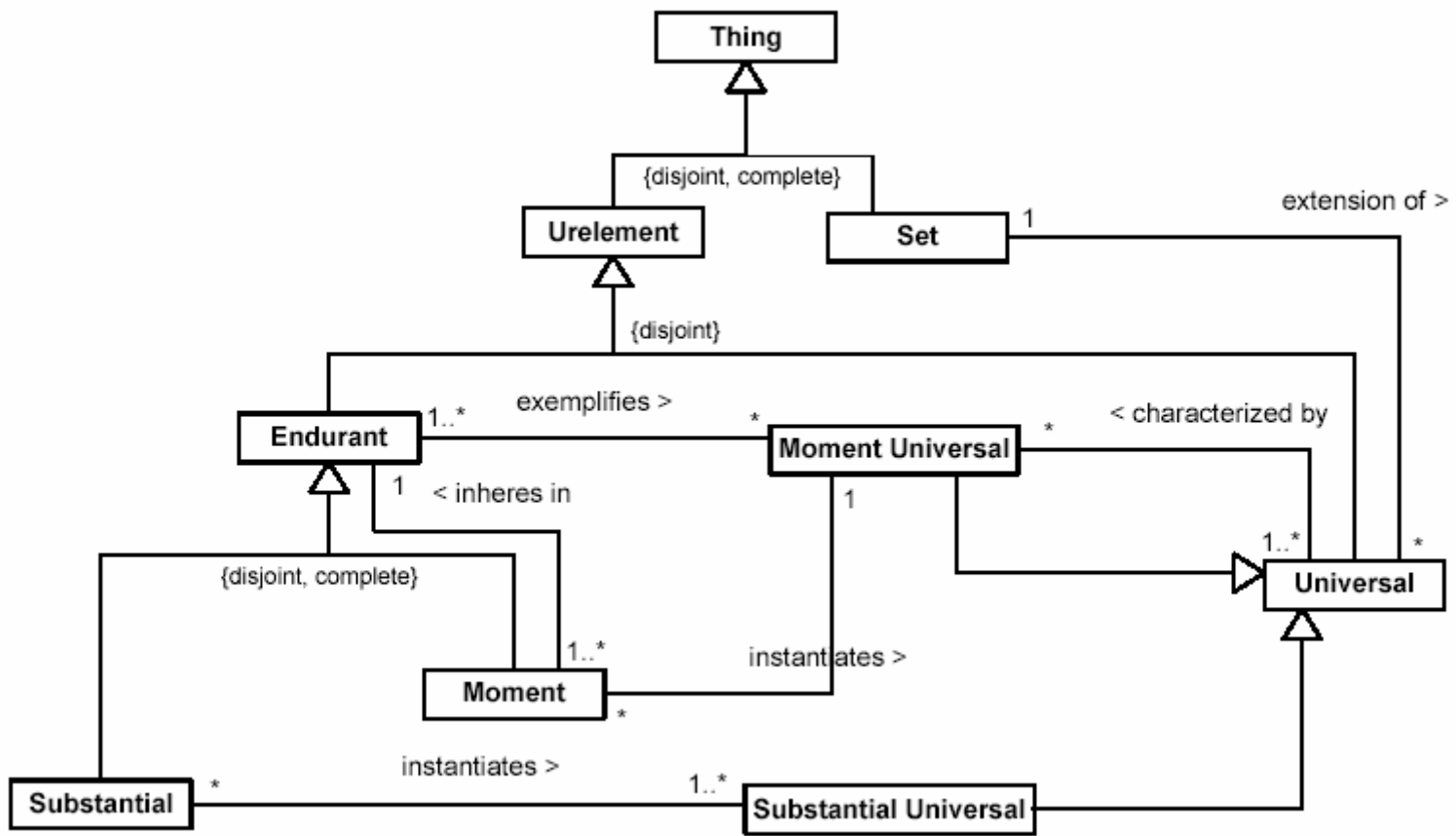
Ontological Distinctions

- This distinction based on existential dependence can also be employed to characterize a further distinction within the category of moments, namely, the one between **intrinsic** and **relation** moments
- There are one-place moments which depend on a single substance (**Intrinsic Moments**)
- and **relators** which depend on a multitude of substances











Ontological Distinctions

- **The relation of existential dependence between moments and substantials (property instances and Objects) requires a semantics which falls outside that of association in most languages**
- **Its analogous to the essential x mandatory parthood distinction**
- **It requires:**
 - **Minimum cardinality of one**
 - **Immutability**



Ontological Distinctions

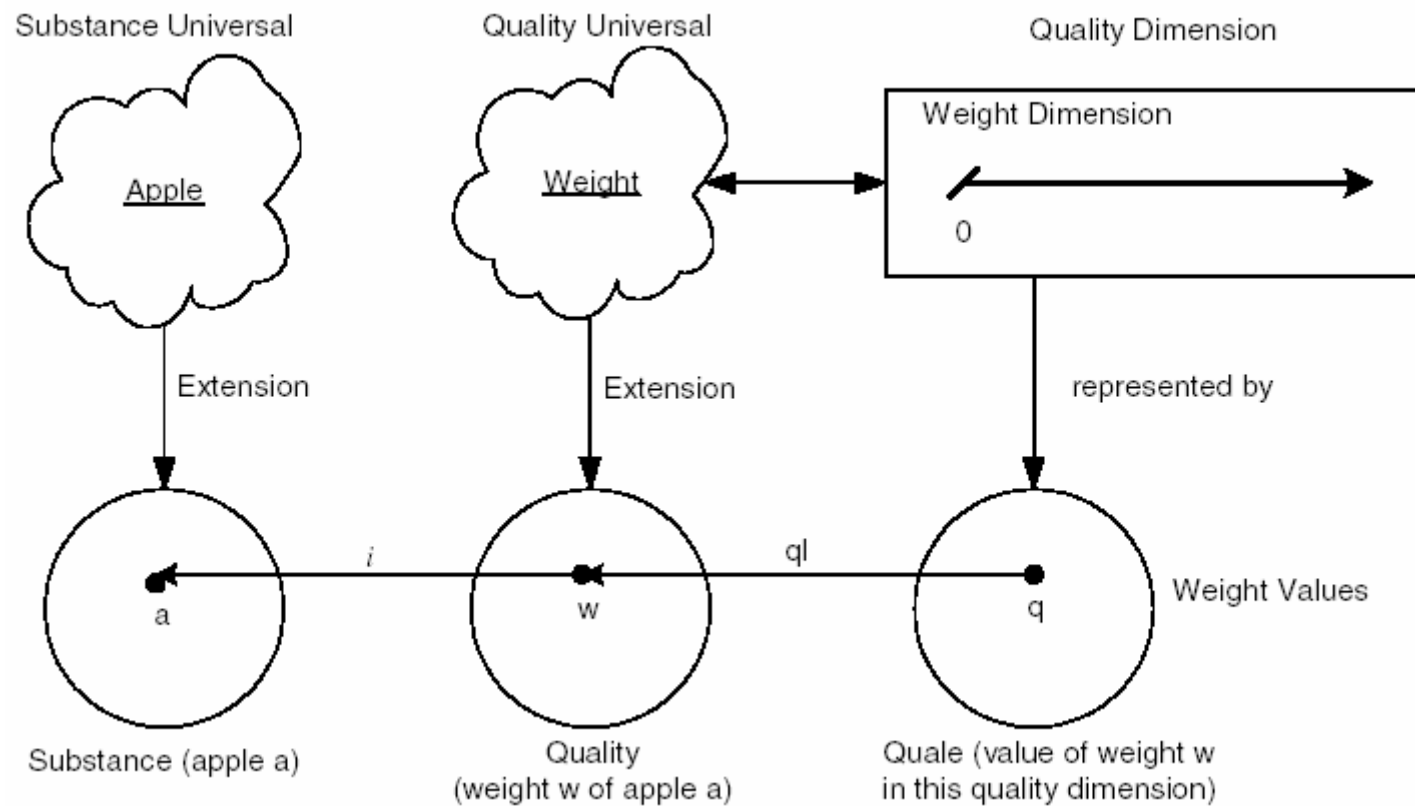
- **But if every property instance such as a color exists in one single object, what does it mean to say that objects o_1 and o_2 have the same color?**



Qualia and Quality Dimensions

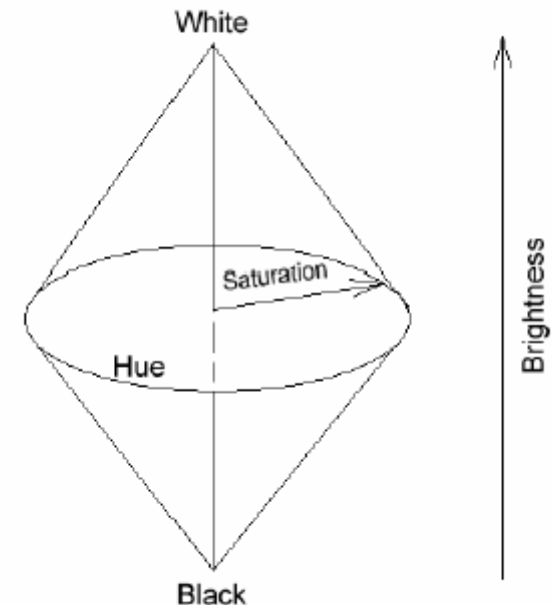
- We distinguish between the color of a particular apple (its moment) and its 'value' (e.g., a particular shade of red). The latter is named *quale*, and describes the position of an individual moment within a certain *quality dimension*.
- For each *perceivable* or *conceivable* quality type there is an associated quality dimension in human cognition. For example, to the quality universal *Weight* there is associated a one-dimensional structure with a zero point isomorphic to the half-line of nonnegative numbers.

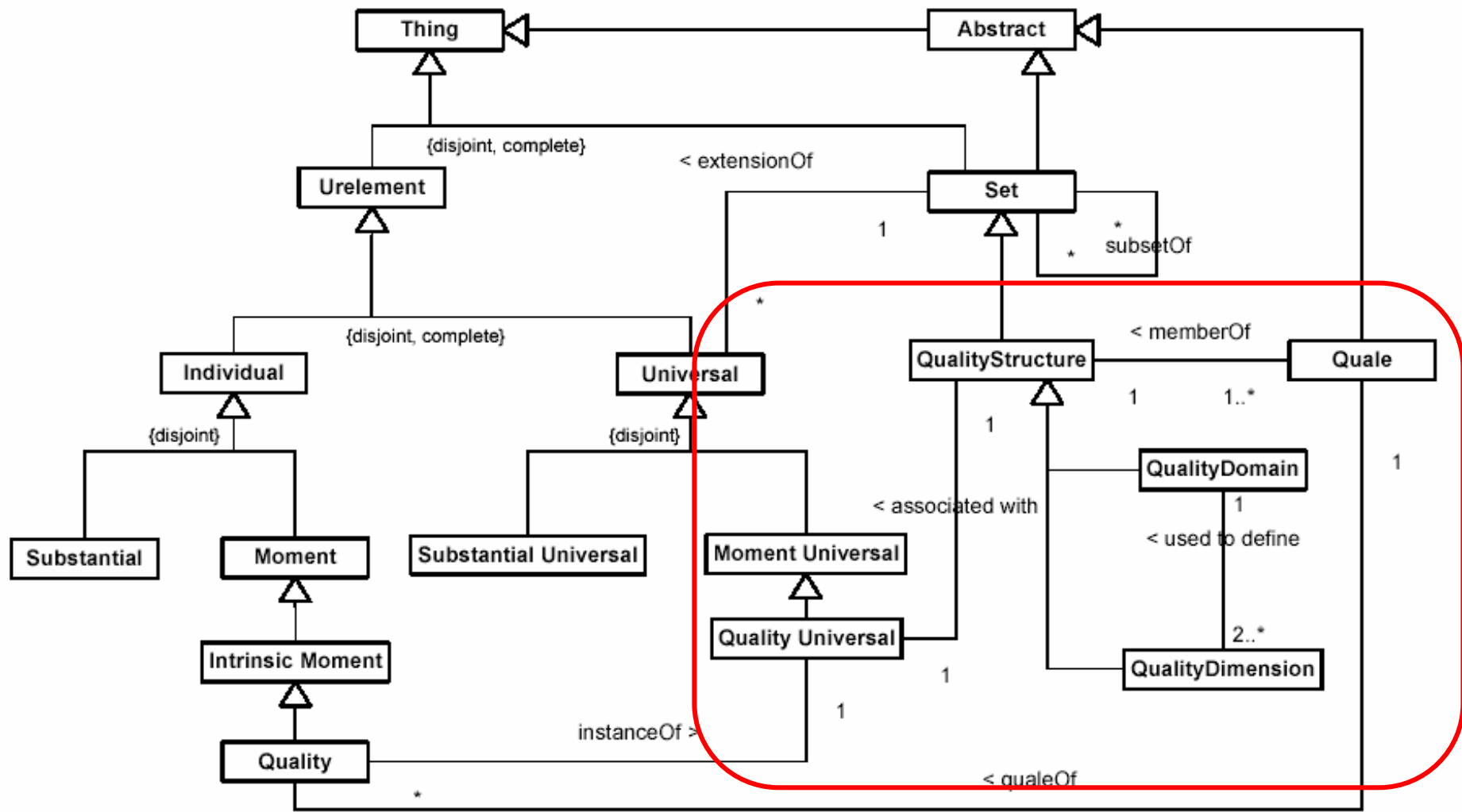
Qualia and Quality Dimensions



Quality Domains

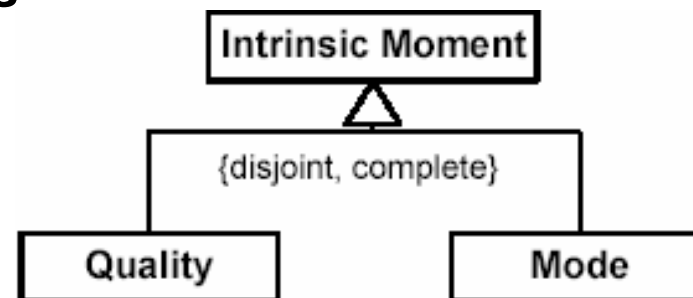
- Certain quality dimensions are **integral** in the sense that one cannot assign an object a value on one dimension without giving it a value on the other (e.g., hue, saturation and brightness)
- Dimensions that are not integral are said to be **separable** (e.g. size and hue)
- A quality domain is a set of integral dimensions that are separable from all other dimensions. Example, the **color quality domain**



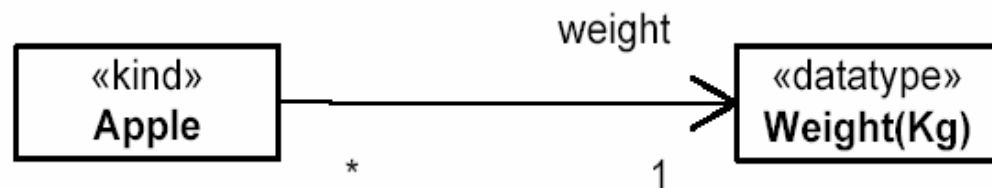


Qualities and Modes

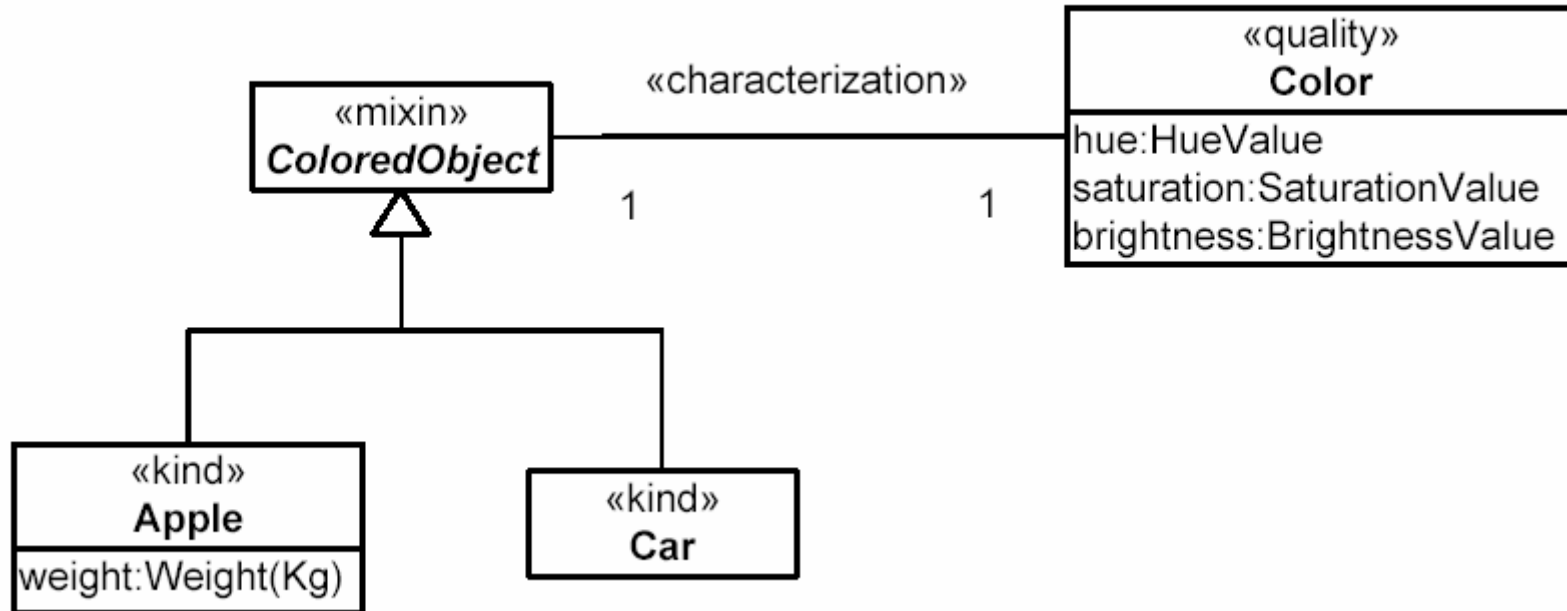
- An intrinsic Moment associated with a single quality domain is named here a **quality**. In contrast, intrinsic moments associated with several quality domains are named here **Modes**
- The distinction is important because qualities and modes will be typically represented in different ways in conceptual modeling
- **Modes** are the ontological counterpart of the notion of **weak entities** in ER diagrams



Representation of Qualities



Representation of Qualities





Representation of Qualities

- It allows for a representation of indirect qualities
- The «quality» stereotype indicates that every instance of a Hue, Saturation and Brightness (**indirect qualities**) is existentially dependent on an instance of Color (**quality individual**) which is, in turn, existentially depends on a Colored Object (**substance individual**)

Representation of Qualities

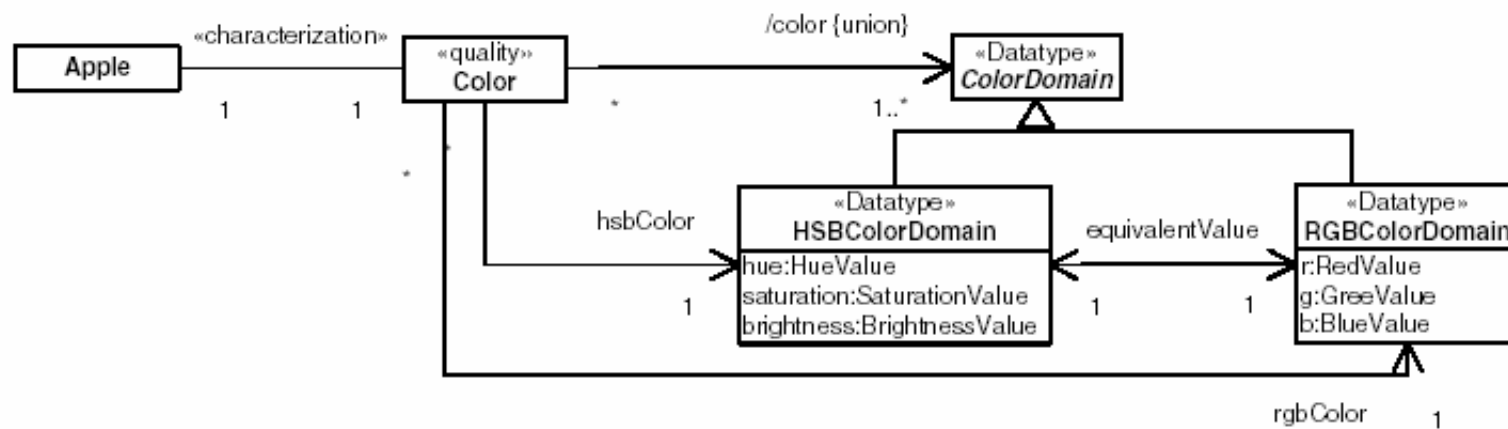




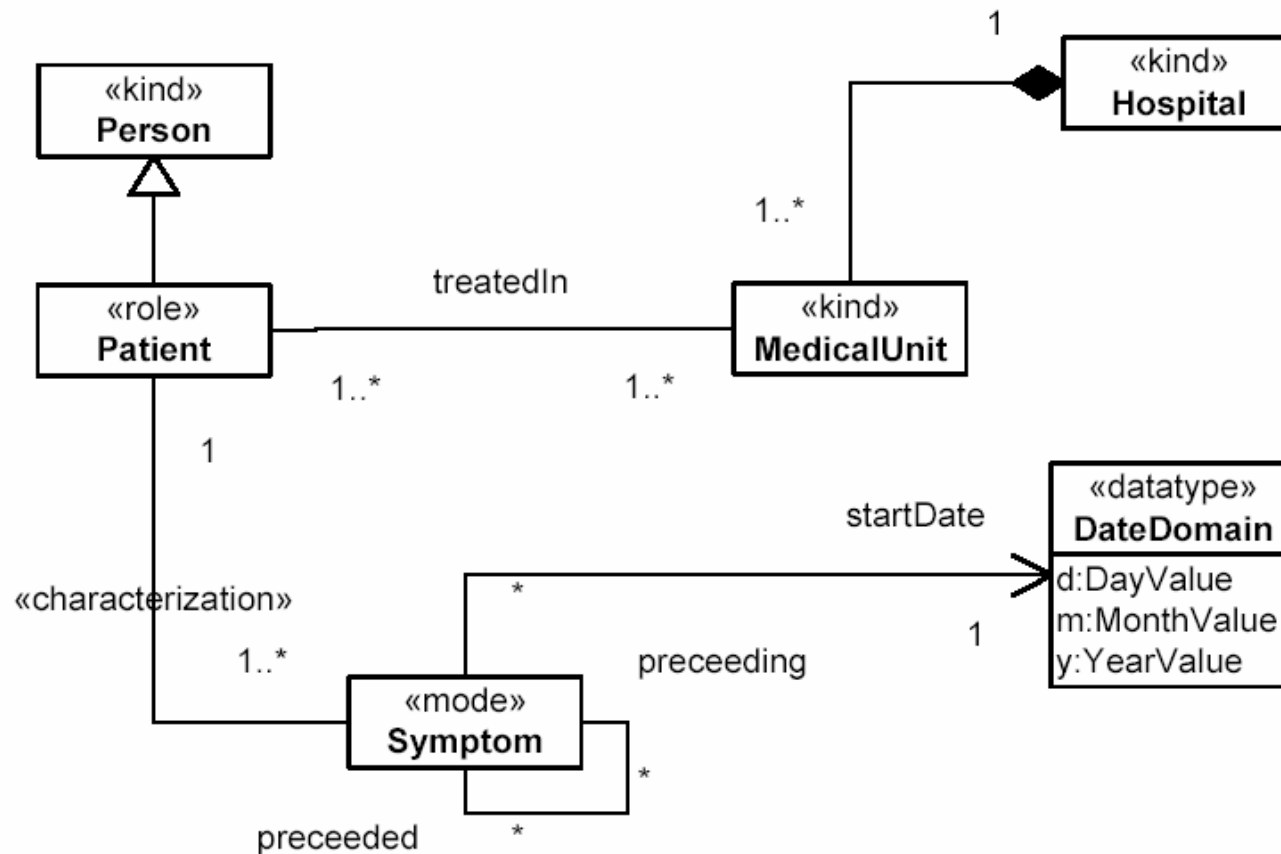
An alternative Representation for Qualities

- The **attribute functions** hue, saturation and brightness map each quality individual Color to **qualia** in the **quality dimensions** that compose the **Color quality domain**
- Constraints are added to the UML-class color so that the geometry of the color domain is respected, i.e., only triples that belong to that domain can be instantiated

Quality Spaces

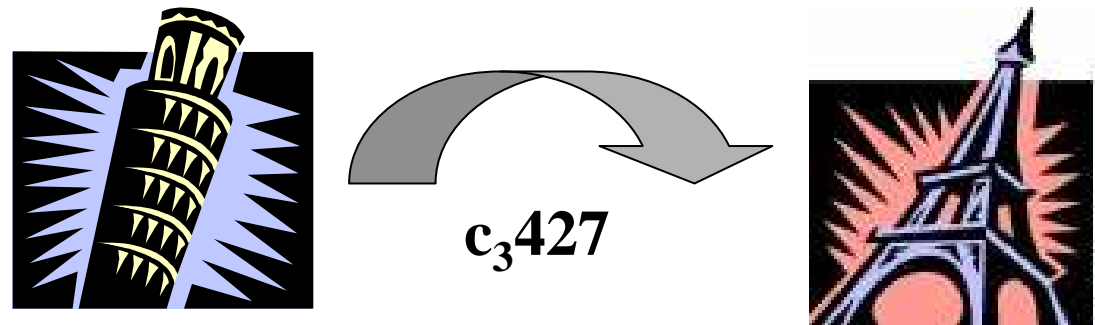


Representation of Modes

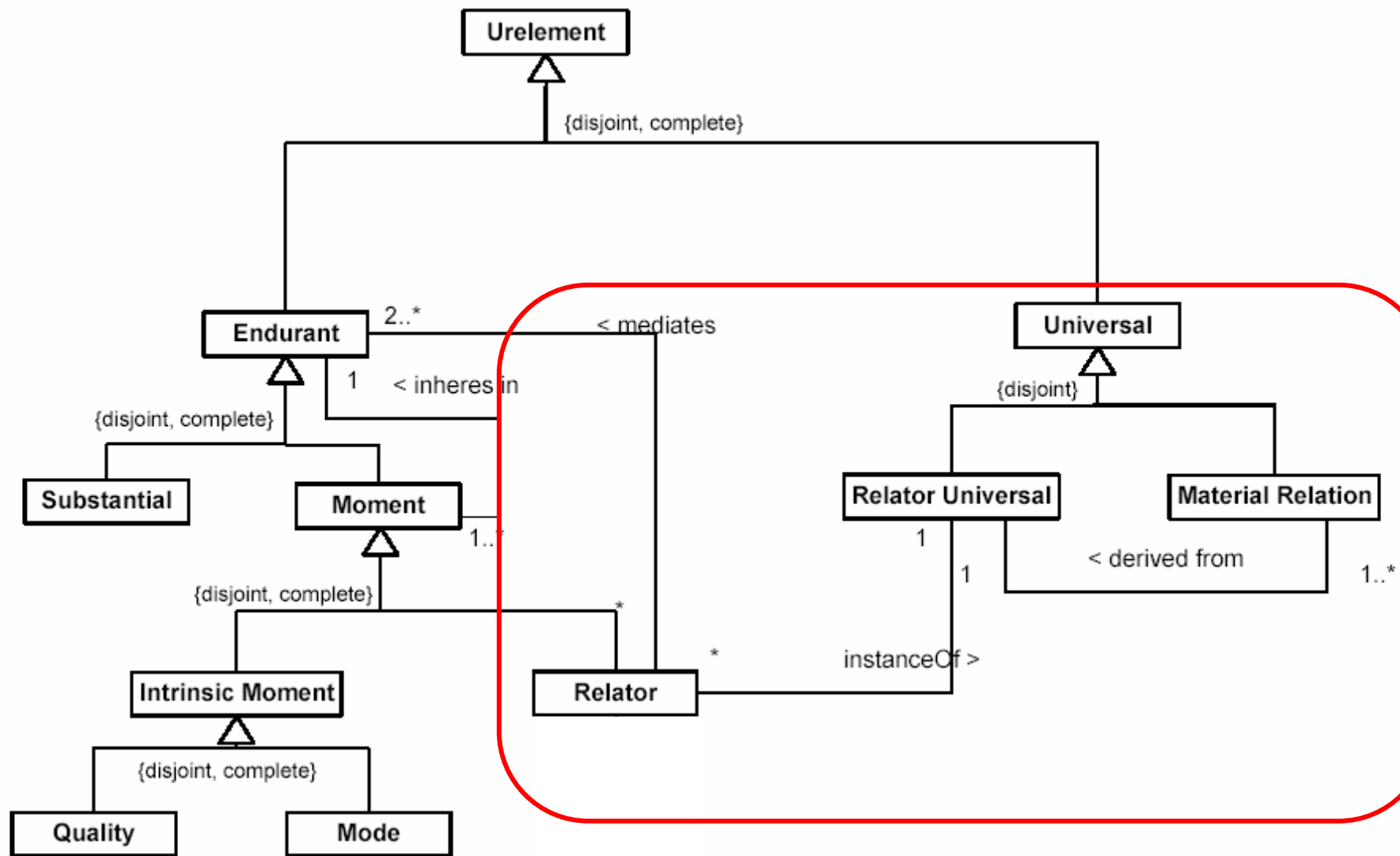


Formal and Material Relations

- Distinction between **formal** and **Material** relations
- The relata of Material relations are mediated by individuals called **relators**. Ex: a *flightconnection* is a relator connecting airports

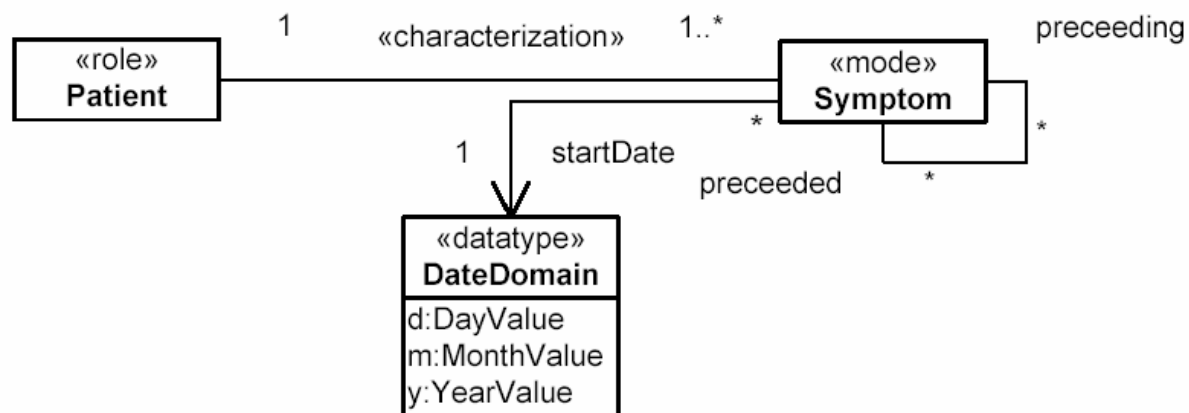


- “The airport of Pisa is connected to the airport of Paris”
- For every material relation, there is a **relator universal** whose instances “connect” individuals that share a relator (relational moment)



Relationships (Associations)

- In CM languages the concept of an association overloads: (a) a classifier whose instances are tuples of related objects; (b) a classifier whose instances are objects themselves
- We propose to use the former to model **formal relations**



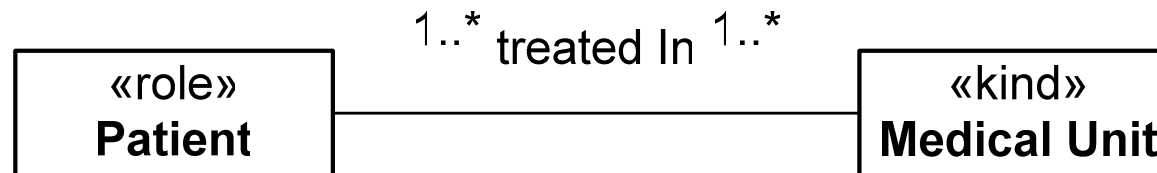


Domain Formal Relations

- **Two important remarks:**
 - **They are always derived relations in UML**
 - **Their meta-properties are also derived from the properties of their underlying conceptual spaces**

Relationships (Associations)

- Ordinary associations can be used to model formal relations. However, in the case of **Material Relations** there is always an ambiguity w.r.t. two different types of **cardinality constraints**



- For this relation to hold there must exist another entity, namely, a treatment process that relates Patients and Medical Units.

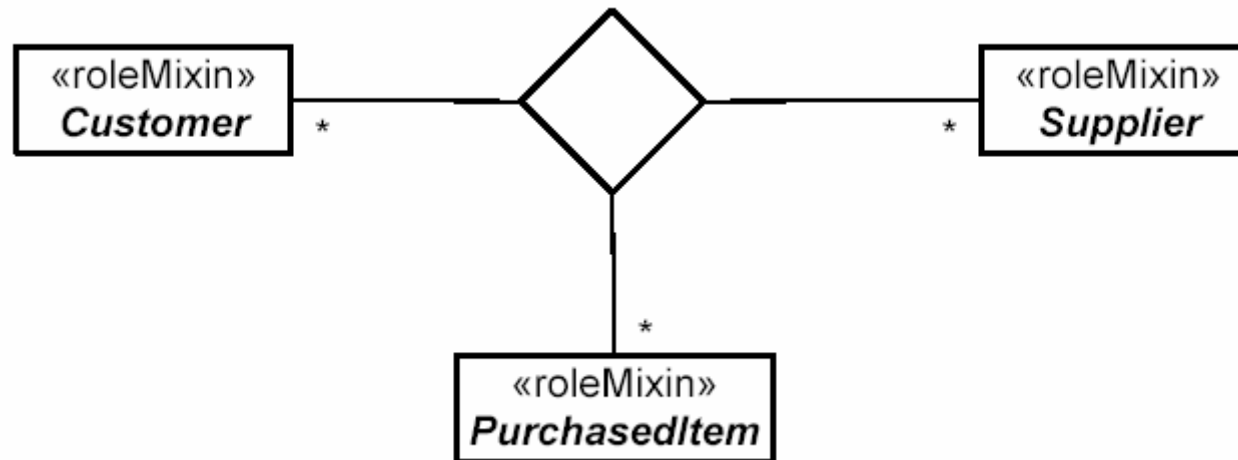


Relationships (Associations)

- **How the cardinalities can to be interpreted ?**
 - **In a treatment, a patient is treated by several medical units, and a patient can participate in many treatments**
 - **In a treatment, a patient is treated by several medical units, but a patient can only participate in one treatment**
 - **In a treatment, several patients can be treated by one medical unit, and a medical unit can participate in many treatments**
 - **In a treatment, a patient is treated by one medical unit, and a patient can participate in many treatments**
 - **...**

Relationships (Associations)

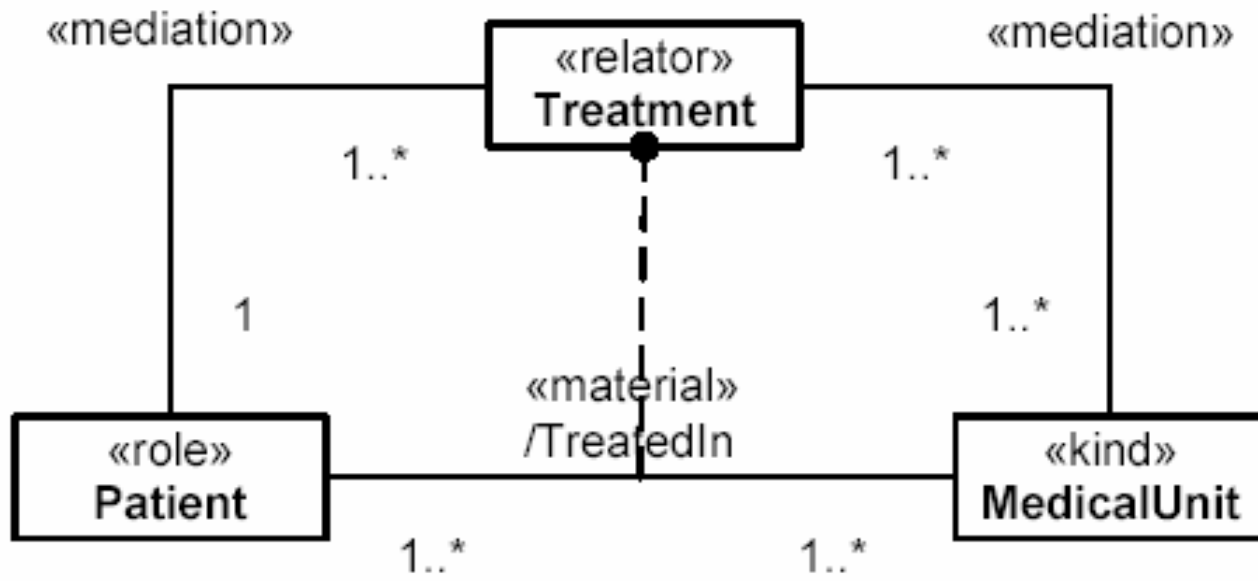
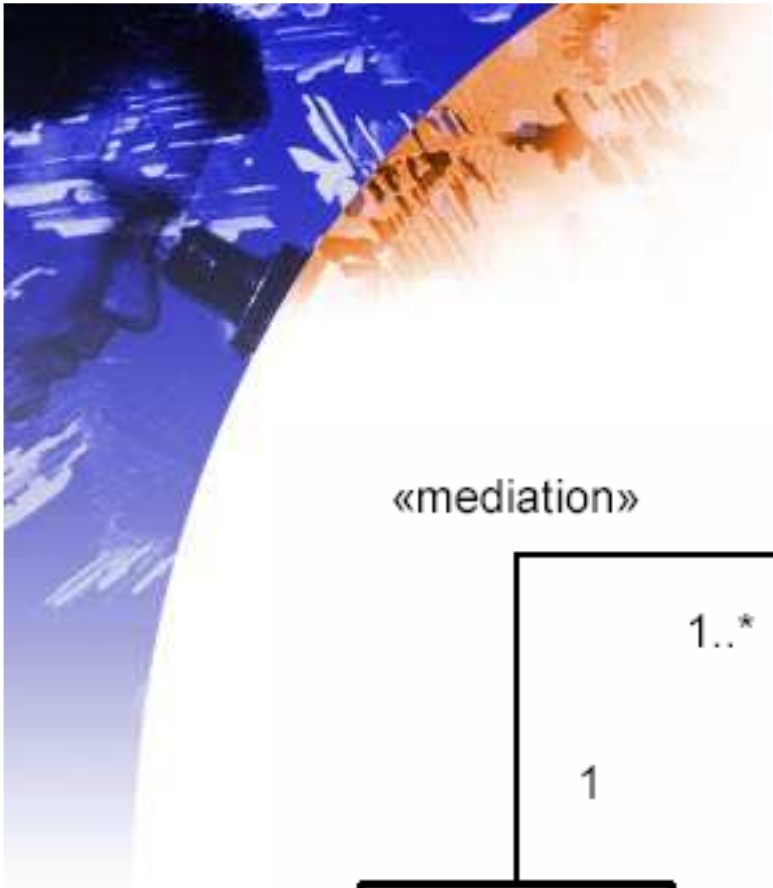
- The problem is even worse in n-ary associations (with $n > 2$)

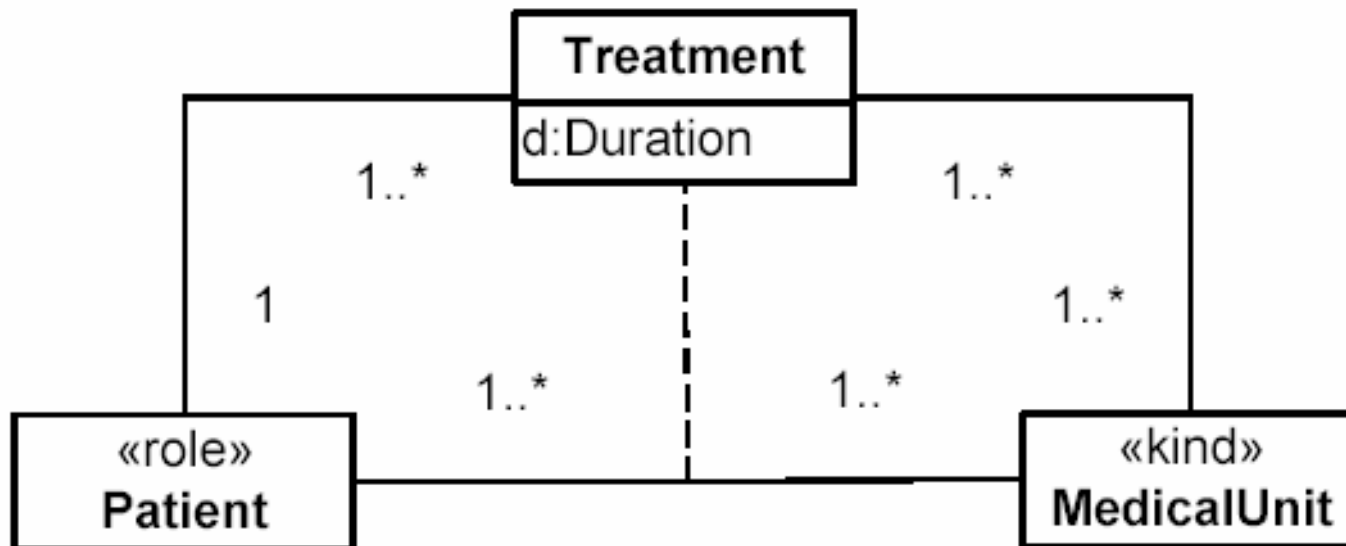
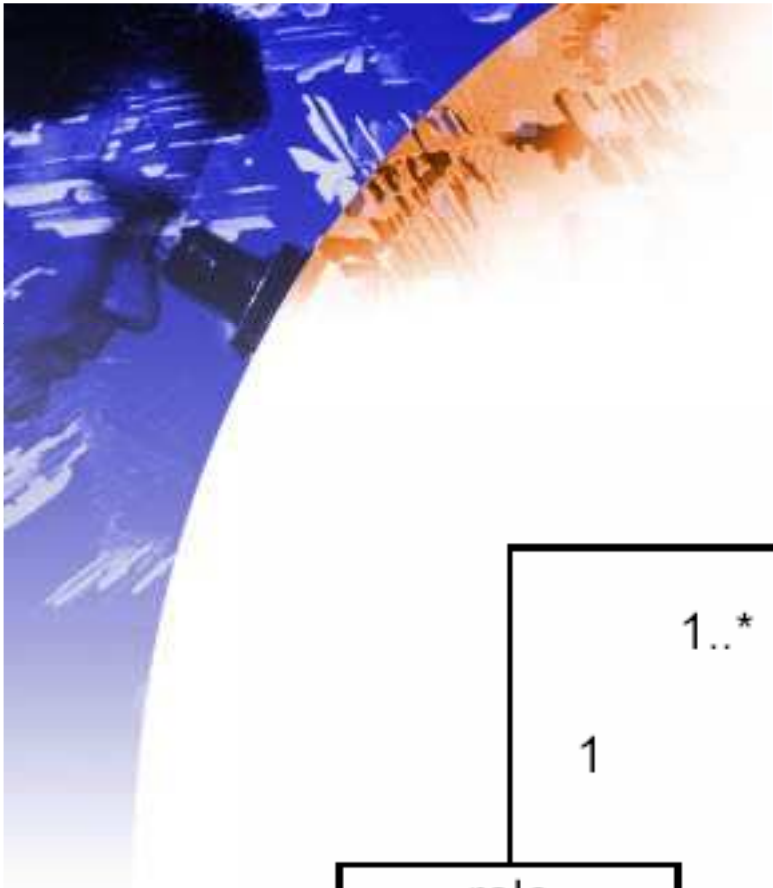




Relationships (Associations)

- In a given purchase, a Customer participates by buying many items from many Suppliers and a customer can participate in several purchases;
- In a given purchase, many Customers participate by buying many items from many Suppliers, and a customer can participate in only one purchase;
- In given purchase, a Customer participates by buying many items from a Supplier, and a customer can participate in several purchases;
- In given purchase, many Customers participate by buying many items from a Supplier, and a customer can participate in several purchases;





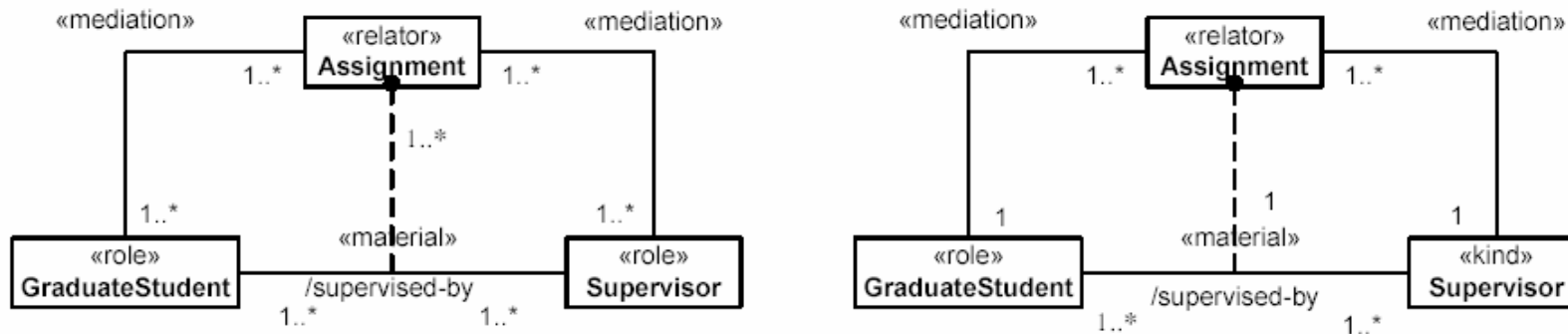


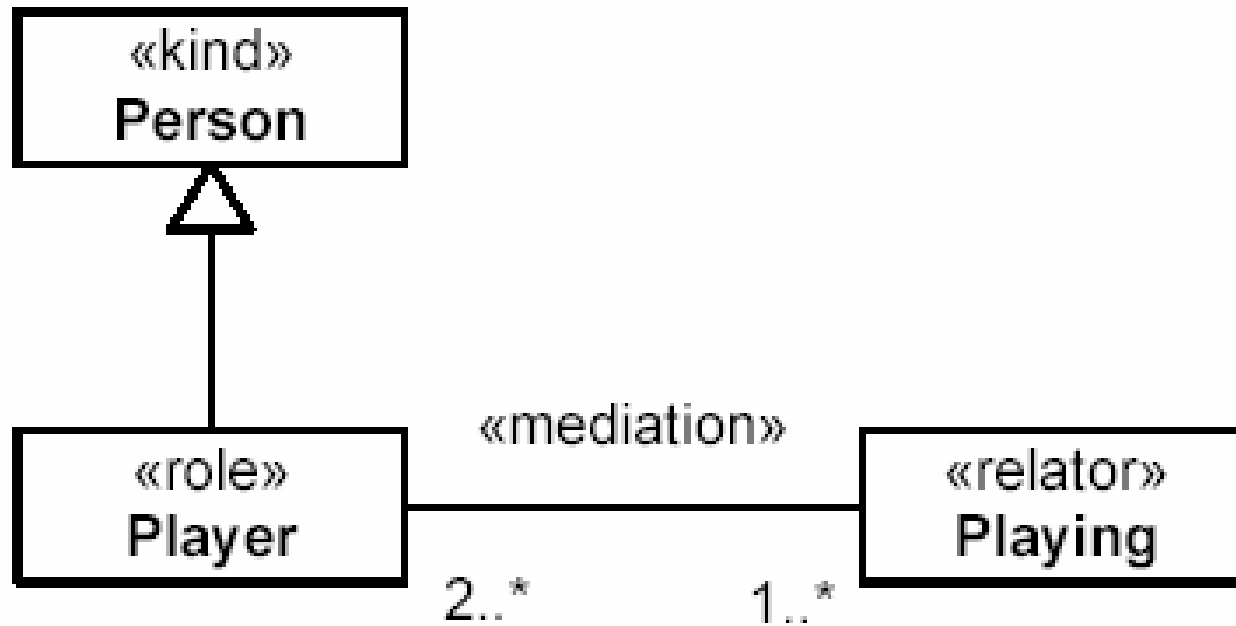
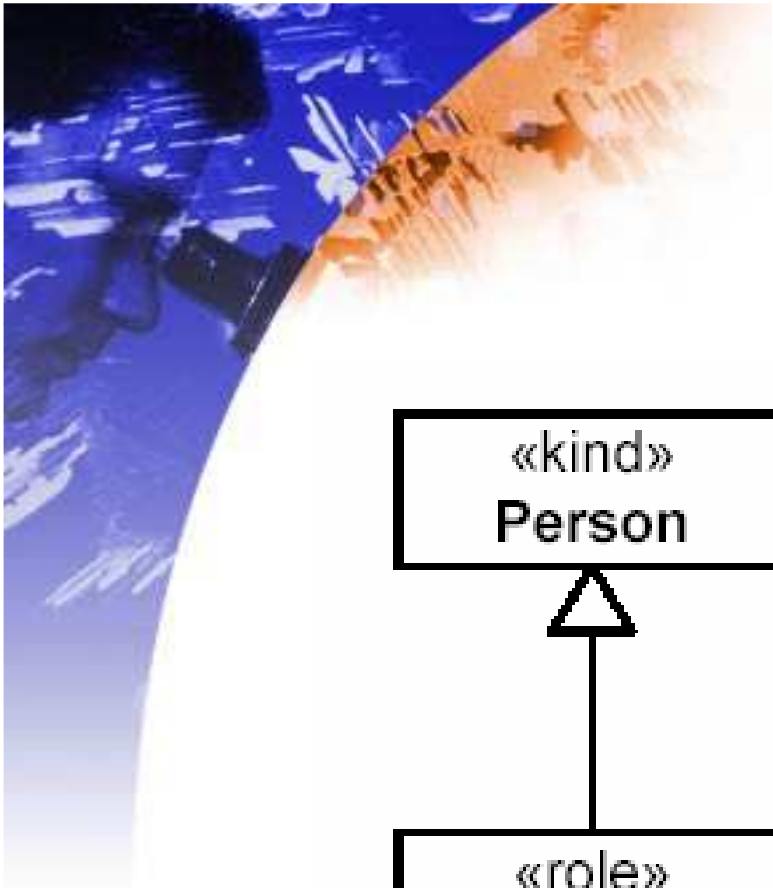
Relationships (Associations)

- **Yet another example:**
 - **Modeling that a graduate student have one or more supervisors and a supervisor can supervise one or more students**

Relationships (Associations)

- Yet another example:
 - Modeling that a graduate student have one or more supervisors and a supervisor can supervise one or more students







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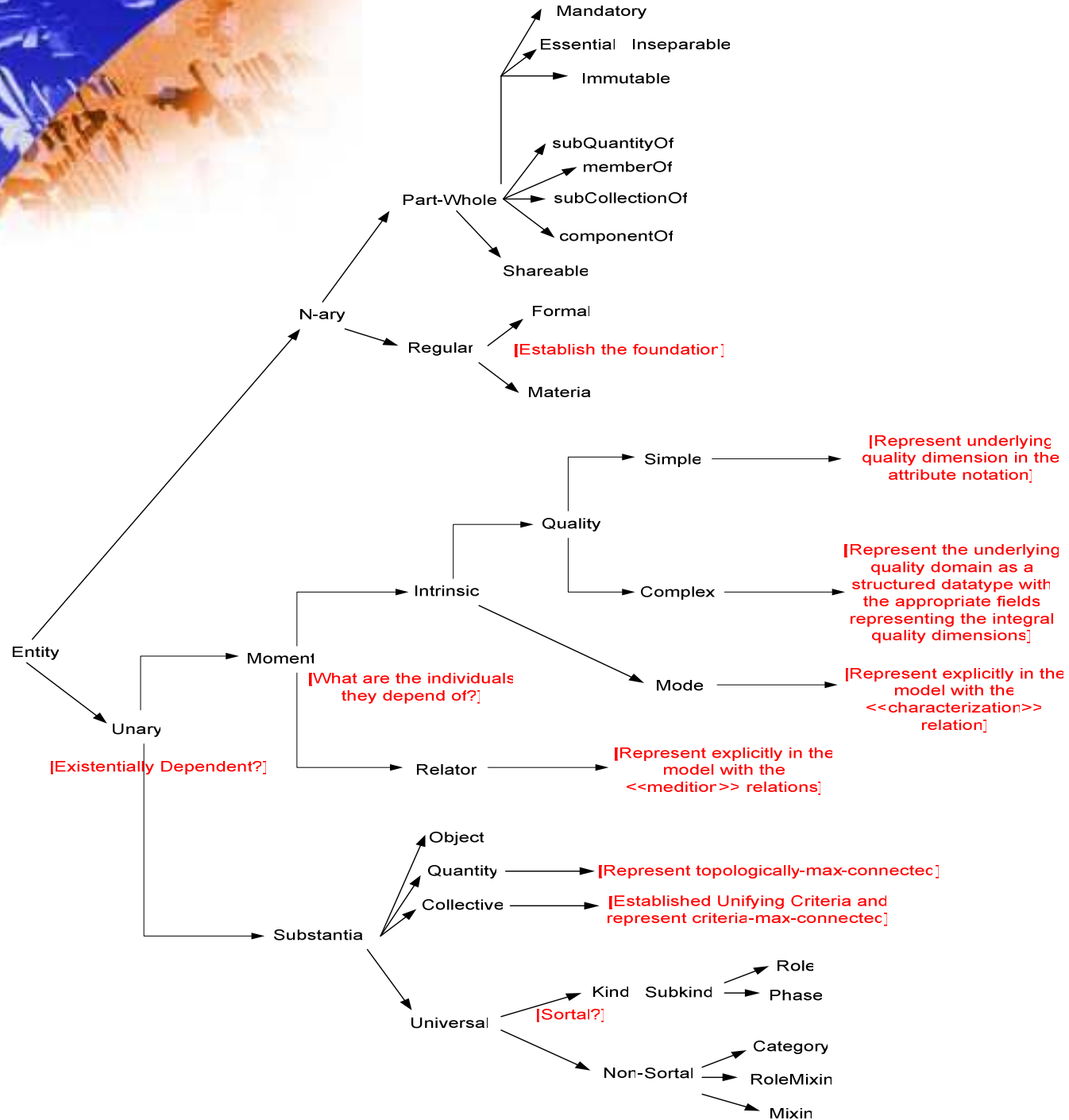
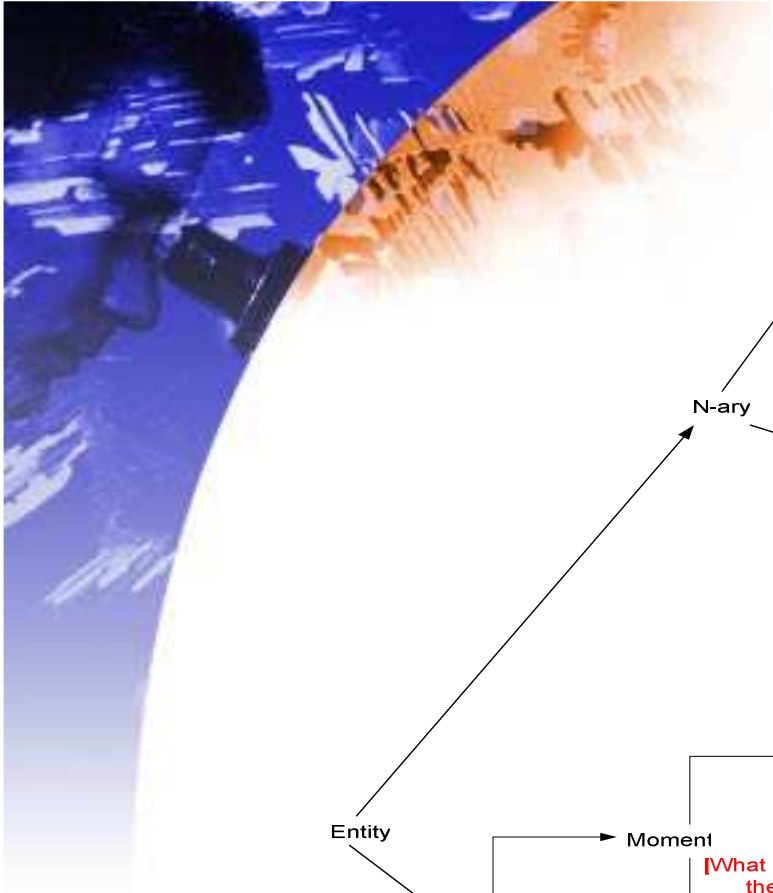


Material Relations

- **As seen before from a relator and mediation relation we can derive several material relations**
- **Asides from all the benefits previously mentioned, perhaps the most important contribution of explicitly considering relations is to force the modeler to answer the fundamental question of what is *truth-maker* of that relation**



Some Methodological Guidelines...





A possible integrated model...

