

Objects, events, qualities

An introduction to formal ontological distinctions (in DOLCE)

Lecture 4 – Roles, measurement and constitution

Claudio Masolo

Laboratory for Applied Ontology, ISTC-CNR

`masolo@loa-cnr.it`

Essli 2010 – Copenhagen, August 16-20

Outline

- Concepts, roles, and qua-entities.
- Different way of representing properties in DOLCE-CORE.
- Founding properties on measurement.
- Constitution and ontological levels.

CONCEPTS AND ROLES

1 Concepts

- ****recuperare qualche cosa sul solito triangolo che usa molto nicola****

2 Roles

- ****METTERE QUI UN PAIO DI SLIDES SUI RUOLI****

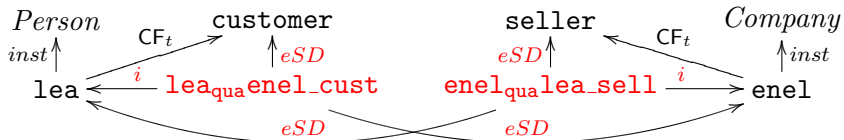
3 Qua-entities

- ****METTERE QUI UN PAIO DI SLIDES SULle qua-entities****

4 Qua-individuals: Entity stacking again

- Different properties for Lea and *Lea as customer of Enel*
- Different properties for simultaneous roles played by Lea:
Lea as customer of Telecom, Lea as customer of Enel
 - ▶ customer code, amount of money spent, ...
Not attributes of the property customer
- The counting problem: counting customers (passengers, representatives...) is not counting people (nor events, nor slices)
- What we count are “qua-entities”:
Lea-qua-Enel-customer, Lea-qua-AF1234-passenger
- Qua-entities *inhere* in the role players
Inherence is an *existential specific constant* dependence

5 Roles and qua-entities



6 Riassunto rappr. proprieta' dolce

- ****METTERE QUI LA SLIDE che fa vedere quali sono le diverse modalita in cui si possono trattare le proprieta in DOLCE e DOLCE-CORE****

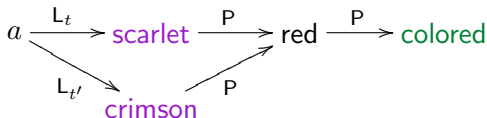
7 Properties in DOLCE-CORE

- **Predicates.** Adequate to model the *basic elements* of the user's conceptualization and the categories/primitive relations of DOLCE. The formalization of properties as extensional predicates is straightforward and requires no special formalism.
- **Concepts** (in DOLCE 3.0). Concepts are properties *reified* in the domain of quantification to consider the intensional, contextual, or dynamic aspects (roles). A sort of instantiation relation (classification) needs to be introduced in the theory.
- **Qualities and quality spaces.** In addition to the intensional, contextual, and dynamic aspects of concepts, properties are *structured* (possibility of talking of the relations btw properties) in spaces according to specific points of view, instruments, etc.

FOUNDING PROPERTIES ON MEASUREMENT

8 Towards an empirical approach: measurement

- I will start from a framework very similar to DOLCE but without individual qualities:



- Later, it will be clear why, by providing a central role to measurement, individual qualities are no more necessary.
- *Aim*: provide an empirical basis to this general framework.
 - ▶ No strong commitment to the nature of objects.
 - ▶ **Communicability** and **inter-subjectivity** (instead than objectivity) of properties without making powerful assumptions about their conformity with 'ontological properties'.

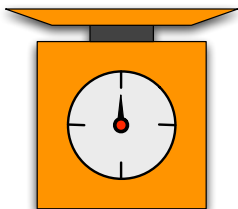
9 Giving a central role to measurement

- **Basic idea:** an object has the property of 'being 1m long' if and only if the result of its length measurement is 1m.

10 Which measurement theory?

- **Representational Measurement Theory (RMT)**
(Suppes, Krantz, Luce, and Tversky)
is one of the best known measurement theories.
- ▶ **Empirical Measurement Theory (EMT)**
(Frigerio, Giordani, and Mari)
explicitly considers the epistemic/empirical aspect of measurement.

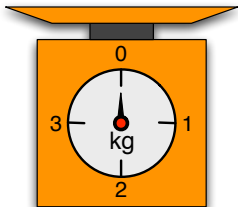
11 Measurement system: physical description



- m is the physical **support**
 - ▶ m is the scale in this case;
- $\mathcal{E} = \langle U, R_1, \dots, R_n \rangle$ is the **empirical structure**: the set of empirically discernible internal states of m and the relations between them
 - ▶ U is the set of 4 states $\{s_0, s_1, s_2, s_3\}$ that correspond to any alignment between the indicator and one notch (discrete scale);
 - ▶ R is the order established (in U) by the clockwise order of notches:

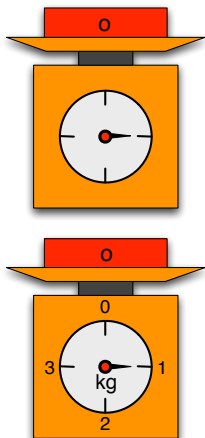
$$s_0 \prec s_1 \prec s_2 \prec s_3$$

12 Measurement system: symbolization



- $\mathcal{S} = \langle V, S_1, \dots, S_n \rangle$ is the **symbolic structure** necessary to abstract from and refer to the internal states of the support m
 - ▶ $V = \{0\text{kg}, 1\text{kg}, 2\text{kg}, 3\text{kg}\}$
 - ▶ $S: 0\text{kg} < 1\text{kg} < 2\text{kg} < 3\text{kg}$
- $\lambda: U \rightarrow V$ is the **symbolization function**
 - ▶ $\lambda(s_n) = n\text{kg}$
 - ▶ $n\text{kg} < m\text{kg}$ iff $s_n \prec s_m$

13 Measurement system: interaction



- $\kappa: O \rightarrow U$ is the **interaction function** that associates to an object $o \in O$ the internal state of the complex system $m \bullet o$
 - ▶ $\kappa(o) = s_1$, then
 - ▶ $\lambda(\kappa(o)) = 1\text{kg}$

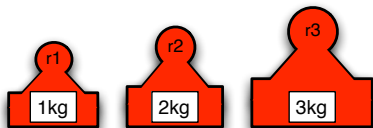
it describes as the support interacts with the environment.

14 RMT vs. EMT

- RMT conceives measurement as the building of a homomorphism from an *empirical structure* $\mathcal{O} = \langle O, R_1^O, \dots, R_n^O \rangle$ to a *numerical structure* $\mathcal{S} = \langle V, S_1, \dots, S_n \rangle$.
 - In EMT, it is the MS that *induces* (via an interaction process) a structure on objects:
 - ▶ U gives the *resolution* of the MS
$$o \approx o' \text{ iff } \kappa(o) = \kappa(o')$$
 - ▶ each R_i induces a relation on objects
$$R_i^O(o_1, \dots, o_n) \text{ iff } R_i(\kappa(o_1), \dots, \kappa(o_n))$$
- i.e. it is the MS (and the measurement procedures) that provides a specific ‘point of view’ on reality.

15 Measurement standard (mST)

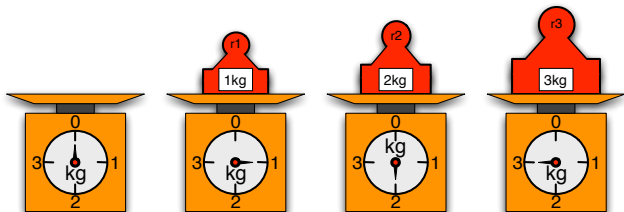
- a set R of *reference objects*: $\{r_0, r_1, r_2, r_3\}$;
(in the example we have the problem of the 'null object' r_0)
- a *symbolic structure* $\mathcal{R} = \langle M, S_1^M, \dots, S_n^M \rangle$;
 - ▶ $M = \{0\text{kg}, 1\text{kg}, 2\text{kg}, 3\text{kg}\}$;
 - ▶ $0\text{kg} < 1\text{kg} < 2\text{kg} < 3\text{kg}$;
- $\alpha: R \rightarrow M$ is a one-to-one function that conventionally assigns to each object in R a symbol in M : $\alpha(r_n) = n\text{kg}$



16 Calibration

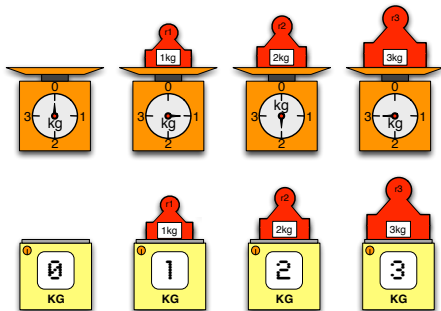
MS $\langle m, \mathcal{E}, \kappa, \mathcal{S}, \lambda \rangle$ is calibrated w.r.t mST $\langle R, \mathcal{R}, \alpha \rangle$ iff:

- ▶ $\mathcal{S} = \mathcal{R}$ (or more generally, there is a one-to-one relation between \mathcal{S} and \mathcal{R} , i.e. the MS resolves the reference objects of the mST);
- ▶ for each $r, r_1, \dots, r_n \in R$
 - ▶ $\lambda(\kappa(r)) = \alpha(r)$ and
 - ▶ $S_i(\lambda(\kappa(r_1)), \dots, \lambda(\kappa(r_n)))$ iff $S_i^M(\alpha(r_1), \dots, \alpha(r_n))$



17 Measurement framework

- A **measurement framework** is a couple $\langle s, M^* \rangle$ where s is an mST, and M^* is a set of MSs calibrated with respect to s .
- ▶ It abstracts from physical realizations of MSs and through symbolization and calibration assures *communicability* and *inter-subjectivity*.



18 Measurement and realism

- The objects that interact with an MS providing the same result ($\kappa(o) = \kappa(o')$) can, but do not necessarily have to, share an *ontological/physical* property.
 - ▶ In particular an MS with a coarse resolution is probably unable to distinguish some ontological properties.
 - On the other hand, the states induced in an MS depend on the ontological properties of the objects.
 - ▶ MSs are **builted** because the classifications and the comparisons they provide allow us for (environmentally useful) **predictions**.
- (!) However, no subjective evaluations but inter-subjective measures.

19 Measurement and Time

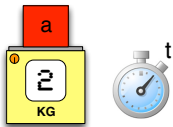
- At different times an object can interact with an MS in different ways because the object changed.

- $[t](\lambda(\kappa(a)) = s_p)$

represents the fact that m and a interacted at t with the result s_p ;

► considering λ as constant: $\kappa(a, t)$.

- At t , a has the property of 'being 2kg heavy' iff $[t](\lambda(\kappa(a)) = 2\text{kg})$, i.e. if a has been measured at t with the result 2kg.



20 The general framework in terms of MSs

Given the measurement structure $\langle O, T, S, F \rangle$:

Objects	$\mathbf{ob}^{\mathcal{I}} \subseteq O$
Times	$\mathbf{tm}^{\mathcal{I}} \subseteq T$
Regions of space i	$\mathbf{sp}_i^{\mathcal{I}} \subseteq M_i$ (the set of symbols of the mST \mathbf{s}_i in an MF of F)
Location	$\mathbf{L}^{\mathcal{I}} \subseteq S \times O \times T$ $\langle r, o, t \rangle \in \mathbf{L}^{\mathcal{I}}$ iff there exists an MS $\langle m, \mathcal{E}, \kappa, \mathcal{S}, \lambda \rangle \in M_i^*$ (i.e. in one measurement framework) s.t. $[t](\lambda(\kappa(o))) = r$

21 Change of mSTs and MSs

- **mSTs can change across time**

Just because reference objects can change.

- **MSs can change across time**

Just because the supports can change

(and calibration and measurement cannot be synchronous).

22 Stable frameworks of objects

- Only by **assuming** the stability of mSTs and MSs (at least from the calibration to the measurement) the comparison between the states of $m \bullet a$ and $m \bullet b$ becomes a comparison between a and b .
- Only by **assuming** the stability of mSTs and MSs the inter-subjectivity becomes possible.
- ▶ In some sense, instead of re-identifying objects on the basis of a stable framework of properties, here we are 're-identifying properties' on the basis of a stable framework of objects.

23 Tuning systems

QUESTA E' DA ADATTARE MA FORSE E' INTERESSANTE PRENDERE QUALCHE COSA

Tuning systems: aligning, finding correspondences between, **qualities** (i.e. equivalence classes of objects) in different worlds.

- Following Forbes, one should assume the existence of objects that, with respect to the quality kind considered, are invariant across (branching) worlds (the shared segment).
By means of these invariant objects, correspondences between equivalence classes can be established.
- Our goal is to extend (and weaken) this notion of 'shared segment' to general worlds (that is, to worlds where a branching relationship is not defined) to make it applicable to objects and qualities.

24 Infinite regression

- **But** to empirically justify the stability of mSTs and MSs one needs to diachronically compare the supports and reference objects.
- To do that other mSTs and MSs, the stability of which, in turn, needs to be justified.

Infinite regression! (or circularity)

- One can consider the *global framework* of all mSTs and MSs, the stability of which is determined on the basis of the **mutual relationships** between the components.
- This does not detect absolute change that maintain the mutual relationships.

CONSTITUTION AND ONTOLOGICAL LEVELS

25 ????

- *Spatial coincidence*: amount of clay vs. statue.
 - ▶ Squeezing, loss/destruction of some parts, continuous and complete renovation, temporal extension, causal powers.
- *Counting problem* and *Conflict properties paradox*: passenger vs. person.
 - ▶ A person can fly different airlines or several times the same airline with different destinations or simply in different days.
 - ▶ Luc as passenger of Air France has the right of checking in online, while, as passenger of Alitalia, has the obligation of checking in at the airport.

26 Abstraction hierarchies

- *Abstraction hierarchies* can be used to represent a complex systems at different levels of detail.
- High-level objects can be seen as the result of an abstraction process that starts from basic (often physical) objects.
 - ▶ Cells can be aggregated to compose organs with specific functions, i.e. cells are the 'physical implementations' of organs. (the same for the components of a complex system)
 - ▶ Relation between an one object and a *plurality* of objects.
- To plan a trip a road can be seen as a 2D object that abstracts from its 3D aspects.
 - ▶ Relation between two objects without spatial coincidence.

27 Multiplicativism

- Lump1 *constitutes*, but it is different from, Goliath.
 - ▶ Constitution is a factive (asymmetric) relation that does not reduce to parthood or co-location; it just allows the *inheritance* of some properties, i.e. it provides a sort of *unity*.
- Luc-qua-passenger *inheres in*, but he is different from, Luc.
 - ▶ During its whole existence, a qua-entity inheres in the same *host* (the player of the role passenger in the example).
- My heart is an *aggregation* of, but it is different from, a plurality of cells.

28 Ontological levels

- In DOLCE constitution is an asymmetric and transitive *primitive* relation $K(x, y, t)$ stands for “ x constitutes y at t ” that implies the spatial coincidence of x and y at t (if x and y are spatially extended).
- The additional constraint

$$K(x, y, t) \wedge tP(y', y, t) \rightarrow \exists x'(tP(x', x, t) \wedge K(x', y', t))$$

introduces a notion of ontological level without however developing this idea further.

29 Ontological levels

- A more deep analysis of the notion of ontological level ha been provided in [KR 2010].
- Framework that allows to manage *constitution*, *inherence*, and *abstraction (aggregation)* in a *uniform* way and to introduce a layering of entities in *ontological levels*.
- As usual, this framework does not have to be intended as a definite one, *alternative* frameworks are possible and their comparison would improve our understanding of levels.

30 Entity stacking

- I will refine a multiplicative approach called *entity stacking* that is based on the notion of *existential dependence*:
 - ▶ Goliath depends on Lump1,
 - ▶ Luc-qua-passenger depends on Luc,
 - ▶ my heart depends on the on cells,but the opposite holds for none of the previous examples.
- This dependence can be generalized to kinds.
 - ▶ E.g. statues, to exist, require amounts of matter but amounts of matter can exist without any statue.

31 Grounding

- Existential dependence is often defined as $\Box(Ex \rightarrow Ey)$.
(very close to the *specific constant dependence* in DOLCE)
- Existential dependence of x on y “amounts to the necessary truth of a material conditional whose antecedent is about x only and whose consequent is about y only; and given that any such material conditional fails to express any ‘real’ relation between the two objects, it is hard to see how prefixing it with a necessary operator could change anything in this connection” (Correia 2002, p58).
- Grounding: an object x is grounded on a (different) object y at t if the existence of y at t makes possible the existence of x at t , i.e., x owes its existence at t to y ’s existence at t .
- Grounding introduces a *factual relation* among objects.

32 The notion of level

- Grounding can stack more than one object:
 - ▶ a pebble can be grounded on an amount of matter and it can ground a paperweight;
 - ▶ cells ground organs that ground bodies that ground persons that ground organizations, etc.
- Grounding is a 'vertical' relation between objects. To group objects in levels an 'horizontal' relation is necessary.
- General relation compatible with different views on levels:
 - ▶ levels depend only on laws of nature;
 - ▶ levels are the result of a conceptualization;
 - ▶ levels correspond to (natural) kinds of objects.

33 Being at the same level as

- I consider 'being at the same level as' as an additional primitive.
- Why not assuming a recursive definition in terms of grounding?
 - ▶ Not first-order axiomatizable.
 - ▶ Requires bottom-level objects to stop the recursion.
 - ▶ Given a bottom level, hierarchies of levels build on it are linear.
- Level hierarchies are assumed as non-linear by some authors.
 - ▶ Some comparisons do not make sense: are robots on a higher level than sea slugs? (Baker 2007))
 - ▶ Levels account for conceptual points of view on reality, the same object can be seen in different ways.

34 Parthood

- A *whole*, e.g. a table, can have persistence criteria and causal powers different from the ones of its *parts*, e.g. a top and four legs. To exist, the table requires the existence of the top and the legs. Is therefore parthood just a kind of constitution or aggregation?
- The relation between parthood and constitution/aggregation is a highly debated issue complicated by the fact that there is no consensus about the core properties of parthood.
- I differentiate *grounding* from *parthood* by assuming a purely *formal* parthood: mereology just aims at referring to ‘pluralities’ (‘multitudes’) of entities without committing to sets: *mereological sums* are ‘nothing more’ than their summands.

35 Formal primitives

- A logic with two sorts, *time* and *object*, distinguished by a notational convention: variables on times are noted by t, t', t_i , etc.
 - $\text{EX}_t x$ “ x exists at time t ”
 - $x \prec_t y$ “ x grounds y at t ”, “ y owes its existence at t to x ”
 - $x \text{tP}_t y$ “ x is part of y at t ”
 - $x \equiv y$ “ x is at the same level as y ”
- I will discuss here only some axioms that I consider important (the complete axiomatization can be founded in the paper).

36 Static notion of level

- ▶ $x \equiv y$ “ x is at the same level as y ”
- Objects cannot change level through time, e.g. no object can survive a change in natural kind because no object can lose essential properties.
- *Dynamic* theories are interesting, require two temporal arguments, and are more complex from the formal point of view.

37 Down-linearity of grounding

$$\mathbf{a20} \quad y \prec_t x \wedge z \prec_t x \rightarrow y \prec_t z \vee y = z \vee z \prec_t y$$

- To account for the following intuitions:
 - ▶ Goliath is intimately connected to Lumpl, it cannot be grounded on something else at the same level;
 - ▶ two objects with different grounding are different, i.e. the difference in grounding is enough to distinguish them.
- (a20) is too strong if grounding is a simple existential dependence:
 - ▶ one objects can depend on all its parts (all at the same level);
 - ▶ relational tropes can, in principle, depend on objects belonging to different levels (that do not depend one on the other).

38 Generic dependence between levels

$$\mathbf{a22} \quad x \equiv y \wedge u \prec_t x \wedge \mathbf{EX}_{t'} y \rightarrow \exists v (v \equiv u \wedge v \prec_{t'} y)$$

- Entities belonging to higher levels depend on lower level entities.
- (a22) partially characterizes the notion of level.

39 One-level objects

$$\mathbf{d14} \quad 1\mathbf{L}x \triangleq \forall yt(y\mathbf{tP}_tx \rightarrow y \equiv x)$$

$$\mathbf{a30} \quad x \equiv y \rightarrow 1\mathbf{L}x \wedge 1\mathbf{L}y$$

$$\mathbf{a31} \quad x \prec_t y \rightarrow 1\mathbf{L}x \wedge 1\mathbf{L}y$$

- (a30) and (a31) assure that \equiv and \prec apply to objects with parts belonging to different levels.
- Is it not clear to me what \equiv and \prec mean for multi-level objects, some options exist.
- (a30) and (a31) do not exclude the existence of multi-level objects (in particular parthood is not defined only on one-level objects).

40 Partial grounding

d15 $x \prec_t y \triangleq \exists z(x \mathbf{tP}_t z \wedge z \prec_t y)$ (partial grounding)

t15 $z \prec_t y \wedge y \prec_t x \rightarrow z \prec_t x$

t20 $\neg x \prec_t x$

t24 $\exists a(x \mathbf{tPP}_{ta} \wedge a \prec_t y) \rightarrow \exists z(z \equiv x \wedge z \prec_t y \wedge \neg z \mathbf{tO}_t x)$

- (t24) is similar to weak supplementation of parthood.
- Partial grounding satisfies properties very similar to the ones assumed for *minimal mereology* (Casati&Varzi 1999).
- In my understanding, this explains why some authors use parthood to represent constitution or partial grounding. However some links between \prec and \mathbf{tP} or \equiv are not considered in any mereology.

41 Constitution

- At a given level and time, the grounding of an object is unique, therefore *constitution* can be directly represented by grounding.
- Constitution implies spatial co-location. Here I have not addressed this aspect but I think it is not difficult to extend the theory to take into account space.
- Who prefers a notion of partial constitution can use partial grounding.
- Note however that in my theory partial grounding and parthood are two different relations:

$$\mathbf{t14} \quad x \triangleleft_t y \rightarrow \neg y \mathbf{t} P_t x$$

42 Inherence

- While constituted objects can change their constituents across time, qua entities inhere in the same object during their whole existence.
- In addition inherence is generally assumed to satisfy the *non-migration principle*: a qua-entity inheres in a unique object (t^{**}).

$$\mathbf{d19} \quad x \odot_t y \triangleq x \prec_t y \wedge \neg \exists z (x \prec_t z \wedge z \prec_t y) \quad (\text{direct grounding})$$

$$\mathbf{d20} \quad x \text{IN} y \triangleq \forall t (\text{EX}_t x \rightarrow y \odot_t x) \quad (\text{inherence})$$

$$\mathbf{t^{**}} \quad x \text{IN} y \wedge x \text{IN} z \rightarrow y = z$$

43 Granularity

- The distinction between parthood and grounding allows to address *granularity* by considering *atoms* (objects without proper parts) that are grounded on non-atomic objects.
- I considered just a very trivial theory of granularity.
- The following assumptions can quite easily be characterized in terms of the presented theory:
 - ▶ objects are ultimately (mereologically) composed by atoms;
 - ▶ higher levels are coarser than lower ones (i.e. atoms are grounded on non-atoms;
 - ▶ higher atoms *partition* lower ones (i.e. any lower level atom partially grounds one and only one high level atom).

44 Examples

- ****QUI bisognerebbe introdurre degli esempi: (1) sulla costituzione e su come si tratta il cambiamento, ad es. prendendo in considerazione Tib and Tibbles o la nave di teseo, poi un esempio sulle qua entities, ed un esemprio sull'astrazione, anche queste sempre in una situazione dinamica**

45 Parthood vs. constitution

- ****ANTICIPARE qualche cosa su quest'aspetto, ma modifica parecchio****
- A *whole*, e.g. a table, can have persistence criteria and causal powers different from the ones of its *parts*, e.g. a top and four legs. To exist, the table requires the existence of the top and the legs. Is therefore parthood just a kind of constitution or aggregation?
- The relation between parthood and constitution/aggregation is a highly debated issue complicated by the fact that there is no consensus about the core properties of parthood.
- I differentiate *grounding* from *parthood* by assuming a purely *formal* parthood: mereology just aims at referring to 'pluralities' ('multitudes') of entities without committing to sets: *mereological sums*

are 'nothing more' than their summands.

46 The 3D / 4D debate

- Three- vs. four-dimensionalism.
 - ▶ Do all entities have temporal parts?
 - ▶ Objects / events, endurants / perdurants, continuants / occurrents.
- Co-localization, multiplicationism and identity criteria.
 - ▶ Mereology: things that have the same parts are identical.
 - ▶ Does a given spatio-temporal worm identify a single entity? (strong four-dimensionism)
- Identity across time.
 - ▶ Is Tibbles the cat identical to Tib?

- **QUESTA E LA PROSSIMA FORSE SERVONO PER IL TEMPO**
- In the previous example, the function time can be seen as an attribute of tropes that yields temporal qualia.
- Consequently, we admit tropes that inhere in tropes.
- Very useful in the case of complex tropes like *symptoms*, e.g. John's headache and influenza are tropes inhering in John and they are different from the ones inhering in another patients.
- Different *symptoms* can:
 - ▶ occur at different times;
 - ▶ have specific temporal/causation relations;

48 Attributes of Attributes

(2/2)

Another interesting representational problem regards roles, e.g.:

- if the instances of **Customer** are persons (or organizations) and **code** is an attribute of **Customer**, therefore to each person it is possible to associate only one customer code.

But, at the same time, the same person can be customer of different stores, therefore he can have a multitude of different codes, one for each store.

- A possible solution consists in introducing **code** as an attribute of a class of (relational) tropes that inhere in persons and stores.

49 Tropes: determinable vs. determinate properties

- let us suppose to have a scarlet rose r : both 'the scarlet of r ', 'the red of r ', and 'the color of r ' exist and are distinct or only one of them exists?
- how change is represented by means of tropes?
 - ▶ individual qualities are more general than tropes, similar to the idea that objects is more general, is compatible, both with a 3d and a 4d approach
 - ▶ Cleland assumes that concrete phases are tropes relative to determinable properties P that survive the change of tropes that are relative to determinate properties that are specializations of P .

50 Tropes: examples and individuation

- the same basic determinate property can be instantiated by different objects at different times
- the same object at the same time can instantiate different basic determinate properties
- the same if we assume the spatiotemporal regions instead of tropes
- **visto che quest'argomento e' importante per le teorie degli eventi di Bennett, Lombard, Cleland ed in fondo anche per Kim, forse si puo' parlarne direttamente qui**