Levels for Conceptual Modeling

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1 Isa and inheritance

- **Abstraction (specification):** starting from a given domain, objects are grouped in classes (types) according to the properties (attributes) they have in common:
  - more *general* a class is, less properties its instances share;
  - more *specific* a class is, more properties its instances share.

- Inheritance has no problems if we consider this basic intuition.
2 Difficulties with isa and inheritance

- **Hiding/blocking.** Student $\Rightarrow$ Person but Student has no weight. Employee $\Rightarrow$ Person but Employee has no home phone number.

- **Overriding.** Statue $\Rightarrow$ AmountOfMatter but the price of statues could be different from the price of mere amounts of matter. Employee $\Rightarrow$ Person but the phone number of an employee could be different from his/her personal one.

- **Ambiguous inheritance and conflicting attributes.** WorkingStudent $\Rightarrow$ Employee and WorkingStudent $\Rightarrow$ Student but room of John when employee $\neq$ room of John when student. Quacker $\Rightarrow$ Person and Republican $\Rightarrow$ Person but Nixon as quacker is pacifist while as republican is not.
3 Difficulties with isa and inheritance

- **Counting.** Suppose Customer $\Rightarrow$ Person and Customer has the additional (w.r.t. Person) attribute CustomerCode.
  - The same person can be a customer of different persons, therefore we cannot count persons to count customers.
  - Can we count customers, i.e. entities identified by codes?
4 General questions

- Are the previous difficulties symptomatic of isa overloading/misusing?
- Is it possible to find an alternative mechanism to *structure* types that
  - is general as Isa is,
  - it is compatible with Isa,
  - allows for a controlled inheritance mechanism,
  - does not suffer of the previous difficulties?
5 Parthood (aggregation)

- Each human necessarily has exactly one brain, exactly one heart, and at most two hands (hands are not necessary for humans).
- Some proposals consider a further distinction: humans have necessarily *specific* brains but not *specific* hearts (heart transplantation).
- Some proposals manage attribute inheritance through parthood.
- Less addressed question: is it enough to have a brain and an heart (and maybe two hands, one trunk, etc.) to have an human?
6 Constitution

- Statues are *constituted* by amounts of matter.

  - Statue $\Rightarrow$ AmountOfMatter, i.e. are statues amounts of matter?
    - Problem. Statues can *change* their material support across time.

  - AmoutOfMatter $\overset{1}{\rightarrow} \overset{1}{\Diamond}$ Statue, i.e. are amounts of matter necessary parts of statues?
    - Problem. *Extensionality* of parthood
      \[
      PP_{xy} \rightarrow \exists z (P_{zy} \land \neg O_{zx})
      \]
      what makes the difference btw amounts of matter and statues?
      [what makes the difference between four legs plus a top and a table?]
7 Individual roles

- Are these objects?
  1. ‘The president of Italy’
  2. ‘The director of the Berlin Philharmonic’
     ['The Berlin Philharmonic']
  3. ‘The Amazon customer #125678’

- General vs. specific dependence: presidents and directors can change their ‘substratum’ while customers relate to one single person.
8 Individual roles /2

- Customer ⇒ Person and President ⇒ Person?
  - Migration problems + presidents can be represented by different persons at different times.
  - Is Person an abstraction from Customer, Person, etc., i.e. its instances are customers, students, etc.?

- Person \( ^1 \star \Diamond \) Customer and Person \( ^1 \star \Diamond \) President?
  - What makes the difference between persons and customers?
    1. Properties, tropes, relators, etc. to be added to the domain.
      ~ do tables require some structural constraint btw legs and tops?
    2. New objects to represent the “many faceted nature” of some kinds of entities.
9 General idea

- Follow a multiplicative approach that puts change at the core of the analysis and generalizes parthood to account for:
  - hearts are *aggregations* of, but different from, pluralities of cells;
  - the Amazon customer #125678 is different from John;
  - today, the president of Italy is only *represented* by Napolitano;
  - statues are *constituted* by, but different from, amounts of matt., paperweights are *constituted* by, but different from, pebbles.

- No properties, roles, relators, or new objects are necessary.
- Persons are not parts customers or presidents.
10 Grounding

- Intuitively, $x$ grounds $y$ at $t$ if, at $t$, to exist, $y$ requires $x$ but, vice versa (at $t$) $x$ does not require $y$.

- Is asymmetric, transitive, down linear and it does not satisfy neither the strong nor the weak supplementation principles.

  [For a FOL characterization see the paper or KR2010]

- It does not necessarily require reduction.

- In between pure existential dependence and constitution.
11 Grounding /2

- To exist, customers require both companies and persons.
- Grounding aims at capturing only the specific existential dependence between customers and persons.

Intuitions:
- the customer is spatially co-located with John not with Alitalia;
- relations are “directed”:
  - there is a difference between “John is a customer of Amazon” and “Amazon is a supplier for John”;
  - there is a change in perspective from John seen as a customer of Alitalia to Alitalia seen as a supplier for John.
12 Specific vs. generic grounding between classes

- $T_1$ is specifically grounded on $T_2$ ($T_1 \triangleright T_2$), if every $T_1$-object is grounded on a single $T_2$-object during its whole life; e.g. Customer $\triangleright$ Person.
  - Often motivated by emergent properties;
    - [note: Customer is now a rigid type]
- $T_1$ is generically grounded on $T_2$ ($T_1 \triangleright\triangleright T_2$), if every $T_1$-object is grounded on on some, but not necessarily the same, $T_2$-object; e.g. Statue $\triangleright\triangleright$ AmountOfMatter.
  - Often motivated by different persistence conditions.

- These definitions can be extended to take into account cardinality constraints.
13 Inheritance through grounding

- Often it is taken for granted that:
  1. the intension of a type reduces to the set of its properties;
  2. if the \textit{intension} of $T_1$ includes the \textit{intension} of $T_2$ then the \textit{extension} of $T_1$ is included in the \textit{extension} of $T_2$.

- But grounded types are \textit{disjoint} therefore, from (1)-(2), grounding, in general, does not allow for inheritance of (all) attributes.

By relaxing (2), seeing inheritance as a mechanism that helps in “factoring out shared specifications”, then
- inheritance not only through \textit{isa} but also through grounding;
- the inheritance through grounding can be completely controlled.
14 An example of levels
Grounding allows also for a new perspective on “abstraction” that I did not explore in this work.

- Are parts abstracted from (and therefore dependent on) wholes, i.e. *whole to parts* vs. *parts to whole*?
  
  E.g., *brains depend on humans* vs. *humans depend on brains*, brains are *carved out* from humans by an abstraction process.

- More generally, what about *perspectives on a given object*?