On the Need for Identity in Ontology-Based Conceptual Modelling

Brian Henderson-Sellers[1], Owen Eriksson[2] and Pär J. Ågerfalk[2]

[1]School of Software,
University of Technology, Sydney
P.O. Box 123, Broadway, NSW 2007, Australia

[2]Department of Informatics and Media
Uppsala University
P.O. Box 513, SE-751 20 Uppsala, Sweden

brian.henderson-sellers@uts.edu.au; {par.agerfalk, owen.eriksson}@im.uu.se

Abstract

Conceptual modelling is often argued to be a core technique in information systems development. An important aspect of conceptual modelling is the ontological and philosophical questions of how to conceive of object existence and identity. Despite significant interest in the topic, formal agreement on how object identity should be represented in modelling languages remains an open question. In the literature, the predominant view is that an object, or entity, is a modelling construct used to represent things. Contrary to this view, we draw on theories of language use and social ontology to understand object identity based on the notion that identity cannot be limited to the identity of physical things. The emphasis is on how language is used to create conceptual entities in a way that maintains fidelity to physical reality and ensures reliable identification of entities across domains. The theoretical implications of this work are primarily the new perspective of conceptual modelling that social ontology affords and the formal introduction and ontological grounding of institutional entities, which have so far been treated rather incidentally. Practical implications include a better foundation for designing and selecting identifiers and classes.

Keywords: Conceptual modelling, Identity, Ontology, Rigid designation, Social reality.

1 Introduction

Conceptual modelling has been a core technique in information systems development for about three decades and its wide use is often taken as evidence of its usefulness in the development community. However, the use of conceptual modelling is not without its problems. Part of the interest in the technique is that it employs relatively few constructs; however, such theoretical simplicity demands that the developer has to deal with a large degree of ambiguity. This ambiguity makes the approach difficult to apply in social contexts characterized by complex social relationships and roles and can be demonstrated with a simple example. Suppose the task of designing a conceptual model is to represent the concept of vehicle ownership. Ownership may be modelled, depending on context, as (1) an association between two classes: Person and Vehicle, each instance of the class being an 'object' representing a 'thing' in the real (material+social) world. However, if the ownership has properties of its own, it may itself be considered as (2) a class with its own identifiable objects, attributes and associations, i.e. as an objectified relationship (Halpin and Morgan 2010), or as (3) a part-whole relation (Shanks et al. 2008), or (4) a relator class (Guizzardi 2005). Deciding which of these representations of ownership is the most appropriate relies on an in-depth understanding of what could be regarded as objects that can exist, each with a unique identity and its own attributes. It is this vital need for understanding identity and the importance of context that is the focus here.

Here, we draw on theories of language use, specifically speech act theory (Searle 1969, Habermas 1984) and social ontology (Searle 1995, 2006), as a way to understand object identity based on the idea that identity cannot be limited to the identity of *physical* things. A key feature is that conceptual modelling is not restricted to descriptions of already existing things. Rather, the emphasis is on how language is used to create conceptual entities in a way that maintains fidelity to physical reality and ensures reliable identification of entities across domains. Acknowledging this relationship between language and physical reality allows for ontology-based conceptual modelling that supports the identification of domain classes and their objects' possible relationship to physical things.

The paper proceeds as follows. Following a brief introduction to the background literature (Section 2), Section 3 provides a baseline for the analysis by examining the notion of object identity in philosophy. With this backdrop, Section 4 addresses object identity in ontology-based conceptual modelling, providing an overview in Section 5 of how object identification is treated within the two most widely used ontologies for conceptual modelling, namely the Bunge-Wand-Weber (BWW) ontology (Wand et al. 1999) and the Unified Foundational Ontology (UFO) (Guizzardi 2005,

Guizzardi and Wagner 2005); which is then contrasted in Section 6 from the perspective of language use in a social context. Section 7 extends the discussion more generally, whilst Section 8 summarizes and concludes the paper.

2 Background

In the literature, the predominant view is that an object, or entity, is a modelling construct used to represent things. Hence, the identification of things is seen as fundamental (Wand et al. 1999). For example, Chen (1976 p. 10) states, "An entity is a 'thing', which can be distinctly identified." Although the identification of things as a means to find objects is central, significant confusion and ambiguity exist as to what an object/entity is and its relationship to things. Date (2004, p. 411) remarks, "we cannot state with any precision exactly what an entity is." In object orientation, the problems associated with object identity are also recognized. For example, Wirfs-Brock and McKean (2002, p. 97) note, "Finding good objects means identifying abstractions that are part of your application's domain and its execution machinery. Their correspondence to real-world things may be tenuous, at best."

Similarly, Allen and March (2012) contend that people also ascribe identification to events and remember them in the same manner in which they remember physical things (e.g. events are conceptualized as having parts, despite them being immaterial and ontologically dependent on material things). Thus, the class construct, as used for instance in object-oriented conceptual modelling, could be used to represent other real-world phenomena than just material or physical things.

Problems that emerge because of inappropriate object identification are not only modelling problems – they can also carry a high cost. Eriksson and Ågerfalk (2010), for instance, report that the cost to rectify the unfortunate design of the national PIN in Sweden was estimated to be somewhere between €4,100,000 and €46,000,000, depending on the solution chosen.

With this in mind, scholars have attempted to create ontology-based guidelines for conceptual modelling (Wand et al. 1999, Guizzardi et al. 2002, Henderson-Sellers 2012) and to address specific problems: for example, meta-modelling and classification to solve the "ontological/linguistic paradox" (Henderson-Sellers 2012, Eriksson et al. 2013); object identity and candidate key selection based on the concept of institutional entities (Eriksson and Ågerfalk 2010); and identity management based on social ontology (Ågerfalk and Eriksson 2011). Wand et al. (1999, p. 502) propose object identity based on a unique set of properties as a basis for ontology-based design rules: "No two things possess exactly the same set of specific properties." Welty and Guarino (2001) suggest how identity and unity complement each other under a general notion of individuality and how this notion can be used to assess ontological consistency of taxonomies. Despite significant interest in the topic, formal agreement on how object identity should be represented in modelling languages remains an open question (Keet 2011). Thus, notwithstanding its importance, there is no common understanding of the concept of object identity in conceptual modelling. The next two sections detail how conceptual modelling based on either of the two dominant views of philosophy and ontology can represent object identity. Assuming that object identity lies at the heart of conceptual modelling, the models should focus on how object identity and identifiers are explicitly represented in class diagrams (see also Allen and March, (2012, p. 947)).

3 Object Identity in Philosophy

In conceptual modelling, we are interested in a range of topics, including the classification of individuals, which prompts us to ask whether pairs of both universals ("Human Being" and "Dog") and things ("Lassie" and "Fido") are the same. The notion of identity is said to be "obvious" by most philosophers and "an utterly unproblematic notion" (Noonan 2011) but that everything else to do with identity is controversial. Identity is formally given (e.g. Béziau 2004) by the expression $\forall x(x=x)$. This expression states little other than that different things are different or that a thing is equal to itself (Noonan 2011).

Noonan (2011),states that "things are identical is to say that they are the same." In a dictionary as well as common speech, "the same" and "identical" have two distinct meaning: (1) both names refer to the same entity and (2) two entities have (almost) duplicate properties (state plus behaviour) i.e. they are effectively clones.

This distinction is between (1) *qualitative* and (2) *numerical* identity or sameness.

(1) Things with qualitative identity have similar properties, so things can be more or less qualitatively identical. If we say that "Lassie" = "Fido", we must mean that they are qualitatively identical because they share the property (type) of being a "Dog". i.e. they belong to the same concept (Weiner, 2011)

(2) Numerical identity requires absolute, or total, qualitative identity at any specific point in time (since an individual that supplies an identity condition may have temporally changeable properties). It states that no two distinct things could have the same set of property values, meaning that there cannot be separate things that have all these values (including spatio-temporal location) in common. This is called "the identity of indiscernibles" or Leibniz's Law (e.g. Forrest 2000) – although its converse, "the indiscernibility of identicals", is also often called Leibniz's Law (Noonan 2011). This states that if two things are identical, then everything that is true of one thing is true of the other. Numerical identity defined in this way implies that it is the only identity relation in accordance with which we can properly count (or number) things (Geach 1973). Still, the principle of "the indiscernibility of identicals" is important to our understanding of identity and, more particularly, to our understanding of uniqueness. Thus, we infer from "*Fa*" and "*Not-Fb*" that *a ("Fido")* is not identical to *b ("Lassie")*. However, in the philosophical literature there are other uses of the term sameness (see 3, 4, 5 below), which makes the notion of numerical identity according to the "indiscernibility of identicals" ambiguous.

(3) We may indeed say in contrast to the "indiscernibility of identicals" that two things are the same or identical when they have 100% commonality over all conceivable

properties – except of course material things that will have different spatial coordinates. An arguable example here is the set of widgets manufactured in the same batch. We could e.g. say that there are 50 widgets that belong to one and the same batch. The point is that the ascription of the numbers 50 and 1 is based on different qualitative identity criteria, and different numerical identities – because one cannot count without specifying what to count (Frege 1892a). The number you come up with is dependent of what the intention is with the count: if you want to count the number of batches or widgets within a batch. This relates to Coad's (1992) "Item Description pattern": a modelling pattern used for solving modelling problems in product lifecycle-management systems and product databases in which two or more manufactured items could be of the same product, i.e. have the same property values and product name.

(4) Another problem with Leibniz's Law is how identity and sameness should be accounted for in different spatiotemporal contexts. Based on the "indiscernibility of identicals" principle, the identity of the thing would change if one of its property values changes. Thus, it would be impossible to retain and re-identify the thing over time. In other words, identity cannot always be based solely on a summation of properties.

(5) "The same" is also used when we say that "Evening Star" = "Morning Star" = "Venus", i.e. these are three names for the same thing. Consequently, names cannot have anything to do with the identity of the thing because they all represent one thing with a unique set of property instances that provides the identity. However, this contradicts Frege (1892a), who made a distinction between 'reference' and 'sense', wherein the name (sense) identifies the referent (the thing named). Thus, the meaning of the proposition "Evening Star" = "Morning Star" = "Venus" is not the same as "Venus" = "Venus".

All this ambiguity implies an urgent need to discuss how to gain an understanding of the application of the notion of identity in conceptual modelling. Thus, to resolve the ambiguities described above, qualitative and numerical identity need to be more thoroughly discussed.

4 Identity in Ontology-based Conceptual Modelling

A key issue in conceptual modelling is how to identify and classify relevant entities and entity types in the target domain. To address this fundamental problem, scholars have developed foundational ontologies to support conceptual modelling. These ontologies serve as a reference for designing new conceptual modelling languages (Guizzardi 2005) and for analysing the ontological adequacy of existing ones (Wand et al. 1999, Opdahl and Henderson-Sellers 2002; Ruy et al. 2014). These ontologies define how modelling constructs, such as classes/types, objects and their attributes, could be grounded in real-world things, i.e. following natural science, the rigid foundation for these constructs has been sought primarily in the material or physical world.

4.1 Sortals and Things

In the context of natural science, one would talk of the notion of *universals*, conceived of as that concept in reality to which the general terms used in making scientific assertions correspond (Smith 2004). Instances of such universals, i.e. substantial things, exist in the material world of space and time. They are rigid because they endure within different space and time contexts. A rigid sortal is a universal, which is defined as a "concept [the] grasp of which includes knowledge of criteria of individuation and re-identification, such as dog or concerto, but not flesh or music" (Thefreedictionary 2013).

Thus, to be able to refer, count or quantify, qualitative and numerical identity must be considered. For example, to refer in a meaningful way to "Fido" one must implicitly or explicitly know that it is a thing that belongs to the sortal Dog. To count the number of Dogs one must know that "Fido" and "Lassie" count as distinct items. Thus, it is hard to separate classification (qualitative identity) from the identification of instances (numerical identity)

It is also important to consider that it is only rigid sortals that can provide a principle of identity; the most relevant RigidSortal being the BaseKind a.k.a. Kind. Guarino (1999) defines an entity (or more accurately an entity type) as being rigid if, "for each x if $P(x)$ is true in one possible world, then it is also true in all possible worlds". Typical examples of a rigid entity type are Human Being and Dog; examples of an anti-rigid entity type are Customer and Puppy, which can only carry an identity, not provide it. Paraphrasing the above, we can say that a rigid type is one that necessarily holds for all instances (e.g. Guarino et al., 1994).

The notion of qualitative identity relates to the human ability to classify, i.e. to judge whether things belong to a certain sortal or type (e.g. Guarino and Welty 2000a). To do this, one must seek guidance to determine whether a thing does or does not belong to (a.k.a. fall under) a specific sortal. This leads to the need for an 'identity criterion' (IC) (e.g. Guarino, 1999).

Taking a materialistic natural-science viewpoint on rigid sortals as a natural kind that is defined by a set of lawfully related properties (Wand et al. 1999, p. 501) leads to the idea of essential properties to provide the identity criterion in which the set of "essential properties" (property types) is granularity-dependent. For example, a human being without a brain is not a person, i.e. 'having a brain' is an 'essential property type' of the concept of Person (Guarino and Welty 2000b): all instances of Person have an instance of Brain. However, other living beings than humans also have the essential type Brain. Hence, an identity criterion based on some inherent essential general and physical property of a Substantial Sortal is difficult to argue for.

This implies that the identity criterion of (qualitative) identity for any specific sortal (e.g. Santos et al. 2013, p. 696) should be understood as a language rule that has to be agreed upon in a specific community and should be based on empirical evidence. Such philosophical and ontological arguments can be equated to the notion of an 'intension' in conceptual modelling (e.g. Frege 1892b, Martin and Odell 1995 citing Ogden and Richards 1923, Kühne, 2006, Gašević et al. 2007, Henderson-Sellers

2012). An intension is a predicate on a class (a type) that defines a concept and a class name, which could be used to judge whether an instance of that class conforms to the concept. Thus, the notion of type is conceived of as a linguistic construct – a common noun. For the Dog class, an explicit defining predicate could be "A domesticated carnivorous mammal (*Canis familiaris*) related to foxes and wolves", and for Human Being it could be "any living or extinct member of the family *Hominidae* characterized by superior intelligence, articulate speech, and erect carriage" (TheFreeDictionary 2013). Non-sortals, such as 'red', can also be classified and have an intension, but are considered not to be able to supply identity, being existentially dependent upon a rigid sortal. These are typically adjectival in the grammatical sense.

4.2 Principle of Identity (Numerical Identity)

A principle of identity supports the judgement of whether two things that belong to the same sortal or type are identical. Here, we review four possible basic principles of identity discussed in ontology-based conceptual modelling.

4.2.1 The property-set principle of identity

One basic principle of identity is the "indiscernibility of identicals" or Leibniz's Law (e.g. Noonan 2011), as previously mentioned. This principle, which we call here "the property-set principle of identity", often leads to the presumption that the identity of a particular thing is determined by its unique set of physical property instances.

Some authors suggest that two or more objects or entities are identical if they have all their property values in common. However, to base a principle of identity on such an assumption is problematical because most people would acknowledge that a human being who has lost an arm or a leg is still the same human being.

Another consideration is that of granularity. A pair of individuals may be indiscernible at one level of granularity but not at another, e.g. widgets in batch – as discussed above. Thus, the properties of the product description do not identify a substantial thing; rather, they identify any instance of a product. Property-set sameness may, for example, be attributed to the plethora of paperclips in a box of paperclips purchased at the office supply store

For the rest of our discussion, we assume that the set-property principle of identity implies that indistinguishable things can be viewed as 'clones' in the given context and at the granularity under consideration. This means that this approach is only useful if we assume the contextual assumptions either that things could be observed at a specific granularity and that change of properties is not considered, i.e. time and change is frozen, or if we accept temporalizing of properties.

4.2.2 The substantial-extensional principle of identity

For 'clones' (e.g. identical paper clips, widgets, identical robots), or twins (but not products), it may be possible to specify identity in terms of spatial location. As noted earlier, the notion of identity refers to our ability to discriminate or discern differences between two individuals that belong to a certain rigid sortal (e.g. Guarino and Welty 2000a). Important here is Kant's observation that even if two things are identical (because of exactly the same physical properties), they are "numerically different" if they are at two places at the same time. Thus, numerical identity is not based on properties but on the extension of things in the spatio-temporal dimension. This is also the idea behind an alibi wherein the accused attempts to prove that he or she was in some other place at the time the alleged offense was committed. It seems as if the substantial-extensional principle of identity is better than the property-based principle, as evidenced by the examples above and by the well-known 'ship of Theseus' or 'grandfather's axe' scenarios (Plutarch 75) in which identity seems not to be dependent on any property instance at all of the substantial thing. However, the substantial-extensional principle of identity does not explain how it is possible to recognize a thing as being the same at different points in time (Merricks 1998). This means that the principle of identity is based on the assumption that the spatio-temporal dimension is frozen.

4.2.3 The enduring-property principle of identity

A property-based principle of identity that is different from the property-set principle of identity is the idea of an enduring unique property. To base a principle of identity on such an assumption is advantageous over the property-set and substantial-extensional principles because the identity of the thing will be stable over different spatio-temporal contexts. Contemporary identification (by the police and security forces) often uses DNA to uniquely identify a human being across spatio-temporal contexts. However, this principle of identity only works in certain restricted contexts; it will not work with clones e.g. identical twins who share identical genetic material. Conversely, fingerprints are not identical for identical twins and could be used as a discriminator. However, not all human beings have fingerprints. Certainly, manufactured items such as vehicles have neither DNA nor fingerprints. Nevertheless, twins as well as people without fingerprints and manufactured vehicles clearly have an identity.

4.2.4 The rigid-designation principle of identity

Trying to identify a thing over the spatio-temporal dimension leads to the widespread idea of rigid designation and a rigid designator. Originally proposed in a series of lectures in 1970 (Kripke 1971) and formally published in 1980 (Kripke 1980), a rigid designator is postulated to be a construct that "designates the same object in all possible worlds in which that object exists and never designates anything else" (LaPorte 2011).

Kripke (1982) claims that (proper) names are rigid designators. The argument is that, in all possible worlds, a definite description (like the brightest non-lunar object in the evening sky) will not designate the object in all possible worlds. The description is only a contingent fact

that could change and is therefore not rigid. However, a name (proper noun) "Venus" will not change and is unambiguous and thus does provide a rigid designation. However, this is only viable if the social context where the name Venus is used to refer to a specific planet is highly constrained. Kripke also assumes this by stating that a rigid designator designates the same object in all possible worlds as it is used in the *actual world*, not as it is used in other possible worlds in which the object gets picked out "for although we identify objects in other worlds by our own names, natives of some of these worlds use other names" (Kripke 1980, p. 77). Indeed, proper names are dependent on the meaning they ascribe in different social contexts where they are used.

In a social context, we might have different identifiers for the same thing that communicate different senses. In addition, it is a necessary condition that the identifier is unique within a constrained domain. Otherwise, it will not work as a reference and identifying mechanism; for example, some form of social security number, which is unique within a country, or a person's name, which denotes a person within an environment that prohibits name duplication.

Consider Sally Smith who gets married and is now Sally Briggs. Clearly Sally is the same human being but, with a different "rigid designation". Indeed, in most countries of the world, a female has a different name before as compared with after marriage, so the name (proper noun) cannot be a rigid designator for such persons. Not only do people have name changes, countries do too. For instance, Tanganyika, Rhodesia, Gilbert, and Ellice Islands all still exist but with different appellations. Using a name (a proper noun) as an unambiguous identifier can work, however, if the social context is so restricted that this name is unique within the boundary so-defined (see also Lowe 1989, p16). In other words, there are many proper names that cannot be used as rigid designators and thus we can conclude that the use in general of a proper name as a synonym for a rigid designator is incorrect in the state sense of "all worlds" Its validity only exists in a highly constrained context because the name must be known to pick-out a single object in the context where it is used.

4.3 Summary

In summary, these various philosophical discourses provide arguments for and against rigidity more generally, a concept that is used extensively in foundational ontologies (e.g. Guarino and Welty 2000b, Guizzardi and Wagner 2005) and which Inan (2008) points out as being a semantic notion in contrast to the metaphysical notion of being always tied to a thing. To view a proper name not as a rigid designator tied to a substantial thing but rather as a language construct (an identifier) that is used to identify an object by virtue of its sense (Frege 1892a) in different spatio-temporal and social contexts will make it possible to solve many problems that concern the modelling of social entities as part of social reality. Before elaborating this further, we will look more closely at how object identity is described in BWW and UFO, two of the most widespread foundational ontologies referred to in the software engineering and information systems literature.

5 Object Identity in BWW and UFO

In this section, we evaluate how identity is discussed in two well-known ontological approaches to conceptual modelling.

5.1 Classification (Principle of Application)

According to BWW (Wand et al. 1999, p. 506), the class construct is used to represent a thing in a model of a given real-world domain. Identifying things in a domain is the prerequisite for eliciting the remaining semantics of that domain (e.g. attributes, relationships and classes). According to Postulate 1 of BWW (Wand et al. 1999, p. 497), "the world is made of things that possess properties". Although "things" refer only to substantial (physical) individuals (e.g. a human being called John), constructions such as "bank account" are also things if someone conceives of them as such. In BWW, there are no things (e.g. human beings) without properties; a thing must have one or more properties (e.g. height). In BWW modelling theory, properties of substantial things are called substantial (physical) properties (or simply properties). A distinction is made between

– intrinsic properties that depend on one thing only; and

– mutual or relational properties that depend on two or more things

(Wand et al. 1999, p 498). This distinction is exemplified by the argument that the height of a person is an intrinsic property of a person. In contrast, having a student number in a given university represents the mutual property of being a student at that university because it depends on the existence of both a human being and an educational institution.

In a materialistic foundational ontology, a thing (e.g. an individual human being) is considered as a set of properties that could be abstracted into classes (e.g. the Human Being class), which represent certain aspects of human perceptions of the real world. Importantly, objects in a conceptual model represent individual things while types (classes) represent views of things. Thus, one object/thing could be classified into several classes.

According to the UFO approach, classification is based on sortals (Guizzardi 2005, p. 106-108), themselves subtypes of substantial universals. Sortals (e.g. Human Being) represent concepts that apply to a number of individuals so that a sortal can be mapped into the UML meta-model construct of Class. The basic sortal is the RigidSortal. Postulate 4.2 in the UFO modelling theory states that "An individual represented in a conceptual model of the domain must instantiate exactly one C[onceptual]M[odelling]-Type representing an ultimate Substance Sortal."

If we compare how the notion of classification was conceived in BWW and UFO (Guizzardi 2005, p. 197, 262–264), a number of significant differences emerge. In UFO, an object in a conceptual model always belongs to one and only one base class because an object always represents a single instance of exactly one rigid sortal.

The implication is that in a conceptual model a substantial thing could only be mapped into exactly one base type. This is not the case in BWW because classes (types) are only views of things (Wand et al., 1999, p. 508).

5.2 Object Identity (Principle of Identity)

The principle of identity in BWW is expressed by Principles 1 and 2 (Wand et al. 1999, p. 502): (1) "No two things possess exactly the same set of specific properties" and (2) "A thing, if named, shall keep its name throughout its history as long as the latter does not include changes in natural kind–changes which call for changes of name". A name does not represent any intrinsic property of a thing; rather, "It is an attribute that stands for the individual as a whole (assuming that the name is unique)" (Wand et al. 1999, p. 499).

This first principle of identity in BWW, which we earlier called the "property-set principle", is equivalent to Leibniz's Law (see Section 4.2.1). This principle is slightly different compared with Principle 2, which rests on the idea that identity is tied to a Natural Kind, or equally that a Rigid Sortal is equivalent to the enduring-property principle of identity (see Section 4.2.3) because it is based on the idea that there are some inherent properties of a thing that endure between different spatio-temporal contexts and that these are tied to a rigid sortal. Thus, if these enduring properties change, the identity of the thing will change. However, Principle 1 must take precedence in a conceptual modelling context because, if a thing can belong to several (concrete) classes in a conceptual model (Parsons and Wand 2000), the principle of identity of a thing is not tied to a Sortal/Natural Kind.

The principle of identity can be exemplified with a vehicle in a showroom, which is identified by a human being observing the substantial thing. The thing can be identified because it has a set of identifying properties that make it unique – this illustrates the property-set principle of identity because individual vehicles do not have names like people and countries.

A vehicle has a set of intrinsic properties (e.g. chassis, number of seats, number of doors, weight, length, colour, engine, and gearbox) that makes it a unique object (by perception) among all other objects in the showroom.

This principle of identity appeals to empiricists, because there is empirical evidence for a discernible thing. However, this principle of identity only holds for the object if we do not consider change. Because there is no stabilizing identity criterion, the identity of the object will change if some of the object's property values change. If the vehicle is repainted blue, for example, the identity of the object will change because the perception of the thing has changed. Note that sometimes properties that appear intrinsic are actually mutual (Wand et al. 1999, p. 500). For example, at first glance, the licence number (like DCA 001) appears to be an intrinsic property of the vehicle. However, it depends on the existence of both a vehicle and a transport authority and thus it is a mutual property.

To assume that identity can be isolated from classification contradicts UFO because only substantial sortals, i.e. sortals that collect physical things founded on matter (Guizzardi 2005, p. 215), can provide a principle of identity. The principle of identity depends on an identity criterion, which is provided by the sortal type. In UFO, the basic position is "no identity without a Sortal". This position is formalized as:

> "Postulate 4.1: Every individual in a conceptual model (CM) of the domain must be an instance of a conceptual modeling type (CM-Type) representing a sortal."

Thus, the basic universal in UFO used to represent things, the RigidSortal, can provide both a principle of application (a type/class) and a principle of identity for the substantial objects it collects. Thus, according to Guizzardi, classification into kinds and identification are interdependent. Referring to a number of psychological experiments, Guizzardi claims (2005, pp. 116-118 & 216) that an identity judgement can only take place with the support of the existence of a substantial sortal universal. The identity of an object that can supply, and not just carry, identity is based on these assumptions: "(i) objects travel on spatiotemporally connected paths; (ii) two objects cannot occupy the same space at the same time, and (iii) one object cannot be in two places at the same time." In other words, the extension in space and time of a physical thing provides the principle of identity. Guizzardi (2005, p. 118) reasons that the principle of identity is determined by the extension (the physical existence of the individuals) of a substantial sortal. He also claims (Guizzardi 2005, p. 116) that "spatiotemporal evidence for a single object changing properties overrides perceptual property information". For example, the sortal Vehicle is the unique substance persisting through changes in colour, chassis, number of doors, engine, gearbox, etc. as the same individual (Guizzardi 2005, p. 100). The principle of identity supplied by a sortal is essential to judge the validity of all identity statements about an individual. Thus, changing the property 'colour' will not alter the identity of the object.

How the identity is supplied by the existence of a substantial individual and overrides perceptual property information is explained by introducing the notion of an individual concept, which refers to a singleton property that only holds for one individual.

(1) Guizzardi (2005, 2014) claims "The intension of the proper name John is represented by an individual concept J, i.e. a function that maps to a snapshot of John x_i in each possible world w." Notice that it is J that is the proper name not "John" which is only a contingent (anti-rigid) name of a person.

However, it is not explained exactly how a substantial rigid sortal could be used to provide a principle of identity across different spatio-temporal contexts. UFO only reassures us that a Rigid Sortal (actually a BaseKind) could provide it in every situation.

(2) Guizzardi (2005, p. 100) maintains "Person can only be the sortal that supports the proper name Mick Jagger in all possible situations because it applies necessarily to the individual referred by the proper name, i.e. instances of Person cannot cease to be so without ceasing to exist. As a consequence, the extension of a substance sortal is world invariant. This meta-property of universals is named Modal Constancy (Gupta 1980) or rigidity".

(3) Guizzardi (2005, p. 289) claims "this is because, due to Leibniz Law, identity holds necessarily and that identical things necessarily share all their properties (principle of indiscernability [sic] of the identicals)".

(4) Guizzardi (2014) states "to decide which points constitute the sequence of points representing an individual in a time-indexed conceptual space, we need the support of a kind K. This kind K will supply a principle of cross-world identity which reports on the properties that must be present in all instances of K (i.e. which dimensions must have non-zero values for points in a given region) and the property values that must remain the same for an entity to remain the same K (i.e. which coordinates must be present for points in a conceptual space to represent the same instance of K)."

However, this is all very confusing because the principle of identity in UFO seems to rest on a combination of all the principles of identity that were described in Section 4.2. The first (1) seems to rest on the rigid-designation principle of identity (see Section 4.2.4), whereas (2) seems to rest on the substantial-extensional principle of identity (see Section 4.2.2) and it this principle that UFO emphasizes (Guizzardi 2005, p. 116), (3) seems to rest on the property-set principle of identity (see Section 4.2.1), and (4) on the enduring-property principle of identity (see Section 4.2.3). However, these principles are not compatible with each other.

It seems as is UFO is trying to combine (1) the rigid principle of identity with the other three in order to get an exact true match (correspondence) between the individual concept, which is an individual type represented by a proper name J, and a substantial individual. For example, in the case of a person J is it (2) the mere extension of the person, or (3) the combination of all conceivable properties of the person, or (4) the DNA, the fingerprint or the brain that provides the match. UFO never tells us exactly how identity could be established, because if it did it would be obvious for everyone that identity is context dependent and not a universal constant. Each of the four principles of identity, which were described in Section 4, rests on implicit contextual assumptions, and procedures that, often like in UFO, are never explicitly spelled out.

6 A Social Constructive Perspective on Object Identity

As shown above, the identification and classification of objects are two basic activities in conceptual modelling, because to identify we must be able to classify, although how this could be done differs between the ontological modelling approaches.

UFO and BWW base their principles of identity primarily on substantial things. In this section, we will elaborate on the matter of object identity based on speech-act theory, and especially on the work of Searle (1969), in order to articulate a social-constructive principle of identity. In contrast to ontological approaches with a strong focus on material entities (substantial universals), Searle (1969) maintains that the principle of identity (and identification) must be grounded on an understanding of the use of propositions in speech acts and how utterances relate to the world.

6.1 Object Identity

The existential statement "DCA001 is a vehicle", uttered by a speaker and interpreted by a listener, in the context of a car showroom, is an example of a proposition wherein an identifier is used and the statement classifies the identified object as a vehicle. It is tempting to see an existential proposition such as "DCA001 is a vehicle" as describing a previously defined object. However, an existential proposition, in fact, instantiates an object into a conversation and thus into social reality. To quote Mead (1934, p. 78), "Language does not simply symbolize a situation or object which is already there in advance – it makes possible the existence or appearance of that situation or object, for it is part of the mechanism whereby that situation or object is created." Searle (1969, p. 93) continues, "One might say: underlying our conception of any particular object is a true uniquely existential proposition."

The social-constructive principle of identification is crucial because of the possibility of using the identifier in a non-existential form. For example, "DCA001 is red", which is an assertive, in which the identifier "DCA001" is used to refer, and the predicate "is red", is used to ascribe an attribute to the object rests on the assumption that DCA001 exists as a meaningful, inter-subjectively agreed upon conceptual object in social reality.

Thus, it is important to distinguish between a class (type) and its objects, which are conceptual and language constructs that belong to social reality, and substantial things, which are entities of the material world (e.g. Bowker and Star 1999, Bergholtz et al. 2013). When identifiers are used in successful existential proposition acts such as "DCA001 is a vehicle", they refer neither to an existing object nor to a thing. "If it did the precondition of its having a truth value would guarantee its truth, if it were in the affirmative, and its falsity, if it were in the negative." (Searle 1969, p. 165). Thus, the negative statement "DCA001 does not exist" should be self-defeating if it were understood as a reference because to refer successfully, the object must exist as a unique shared conceptual entity in the social world. "An existential statement does not refer to an object and state that it exists, rather it expresses a concept and states that that concept is instantiated." (Searle 1969, p. 165).

Thus, an object has to be instantiated in a class (type) and subsequently be referred to as belonging to a concept because to "secure continuity of reference we need a criterion of identity, and the general term associated with the name provides the criterion" (Searle 1969, p. 167). For example, the statement "DCA001" would not qualify as an identifying statement if it did not have an implicit or explicit link to a class name of an ontological 'basekind' (a link to a concept, a type) because it would have no meaning. This is all about learning and using different language and social rules because, in order to succeed with the speech act, we must follow certain language rules and conventions. In the car showroom context, we first had to agree on that DCA001 exists as an instance of a vehicle. The point of object identity is that when the object is known to exist in a certain social context, we could go on to communicate about it. Of course, after something has been identified, one may still ask "what?"

in the sense "tell me more about it", but one cannot ask "what?" in the sense of "I don't know what you are talking about?".

When informal natural language is used in ordinary life, the conventions of natural language are implicit, vague and in constant flux under the pressure of language use in different contexts (Wittgenstein 1958, Michel et al. 2011). In order to succeed with the speech act "DCA001 is red" uttered in the car showroom the speech act could be interpreted in different ways and still succeed. We could, for example, associate to "DCA001" an instance of a Vehicle or a Car because both concepts could provide a "quality identity criterion" and, combined with the identifier DCA001, this would be sufficient to create a mutual understanding of the speech act (i.e. to provide a meaningful identity statement). However, if we build a formal and institutional language system we must be more precise and restrictive about these rules and definitions e.g. when modelling classes in a conceptual model.

According to Searle (1969), we can use language to refer to and thus identify an existing object in two ways:

1. By using *an identifier*, such as the code "DCA001", an identifier can also be a name or a number as long it is unique.
2. By using *complex noun phrases in the singular*. These expressions are also called "definite descriptions": for example, "the red vehicle in the showroom".

Assuming that both the identifier and the definite description are unique, the particular object can be successfully identified, but only after it has been linguistically introduced by an act of language (e.g. Lowe 1989, p10, Searle 1969, Eriksson et al. 2013). Thus, we can use an identifier and definite description to refer to an object in an identifying statement. Both reference mechanisms can then be used to represent the existence of an object and a thing.

Furthermore, identifiers have to communicate a descriptive content: otherwise, there would be no way of establishing a connection between the expression and the object (Searle 1969, p. 93). If the listener does not understand the speech act "DCA001 is red", he may ask, What is "DCA001"? The speaker can clarify by saying "the red vehicle in the showroom". Referring and identifying are two sides of the same coin (Searle 1969, p. 166,). If someone refers to an object, he or she at the same time identifies the object or is able to identify the object on demand (Searle 1969 p. 91). However, from a language use perspective, an identifier is not the same as a definite description. If this were the case, the meaning of the identifier would change if there were any change at all in the non-essential properties of the object, as discussed above (the set-property principle), and it would not be able to represent the existence of the object over time (Searle 1969, p. 166, Eriksson and Ågerfalk 2010).

6.2 The Identifier Construct

The important conclusion to help understand the identifier construct is that it is the ultimate construct for separating the referring function, which is used to identify objects in a language, from the descriptive function in language that is used to describe objects. Making the reference mechanism independent of the attributes, as is done with identifiers (names, numbers or codes), is important in order to make the reference mechanism robust against contingent changes induced by space and time (i.e. changes in the material world, such as changes in colour and other properties of a single physical vehicle). This is what UFO assumes by its use of the idea of rigid designators. Although a name may be more useful than a definite description, UFO does not make explicit that the meaning of a name may vary across social contexts – what Wittgenstein (1958) referred to as different language games, because UFO permits and utilizes the much-maligned idea of an 'individual concept' (e.g. Abbott, 2011) as a single instance in its extension. For example, J is an individual concept of the Substantial Sortal Person, which means that J is a function that maps to a snapshot of J x_i in each possible world w. Notice that it is J that is the proper name not "John", which is only a contingent (anti-rigid) lexical term with four letters which we use in some contexts.

This implies that an individual concept, which is an individual type (like J), is a rigid designator, i.e. it refers to the same individual in all possible situations, factual or counterfactual. This is confusing because this means that if you state that the fact that "John is a person" you do not refer rigidly, because it is J that rigidly refers to the substantial individual not John. According to UFO, the name of a person or the name of a country is only a contingent fact (i.e. anti-rigid) as was shown in Section 4.2.4, so that what we normally think are names of people like John or Sally Smith, or countries like Zimbabwe, are not proper names at all. However, Searle (1969 p. 74) maintains that this is an absurd conclusion. Of course, it is so that when you state "John is a person" you use John to refer not J, and it is John which is the proper name, not J. Proper names are lexical objects that are used to represent objects, not the other way around as assumed by UFO, and, most importantly, they are not rigid – all proper names are anti-rigid because all proper names i.e. identifiers (names, codes, numbers) depend on the meaning they have been ascribed in the different social contexts in which they are being used. You can only use a proper name to identify (i.e. to pick out) an individual, if the object is uniquely known by that proper name because (Searle 1969, p. 82) "There must exist one and only one object to which the speaker's utterance of expression applies". In order to use, e.g. a name of a person, to refer, it must be unique, and there is no rule that guarantees that a person's name is unique in all possible worlds once you consider the social aspect of the context.

7 Object Identity and Substantial Things

To summarize the discussion about object identity and its relationship to substantial things from a social-constructive perspective, it is assumed that:

1. An object is a language construct that belongs to social world; it is an instantiation of a concept (type). A thing or a substantial individual belongs to the material world.
2. A concept (type) is a general term with an intension but no extension. It provides a language rule for a

principle of application, by which we judge whether a general term applies to an object.

3. The principle of identification implies that a sender (speaker) performs a successful referring act in performing a communication act in a social context. The communication act must mediate facts to a hearer (audience), which holds uniquely of the object referred to, or the sender must produce it on demand. It follows directly from the principle of identification that every successful communication act must communicate a fact: a proposition that must be agreed upon. There must be a mutual understanding of the proposition (or a set of propositions) in order to make the reference succeed.
4. By object identity, we mean that there should be no longer any doubt or ambiguity about exactly what is being discussed or communicated about in a certain social context.
5. We need a reference mechanism in order to fulfil the principle of identification i.e. to identify the object in a certain context. The reference mechanism could be an identifier or a definite description.

This implies that "Object Identity" is nothing physical or subjective or universally constant. On the contrary, it is a social and institutional construct that is relative to different contexts. For example, consider John Smitherton, who is a person from London who moved to Sweden in 2012 to study Information systems. He was identified as a student at Uppsala University and was assigned the student number 871129-T999 in order to be given the right to attend lectures and to get access to the computer lab. After a year, he was identified and given a Swedish PID-number 871129-9999 when he was registered as a Swedish Citizen in the Civil Registry. At the same time, he changed his name to just John Smith because his former name always got misspelled in Sweden. Moreover, he had also a twin brother, Perry Smitherton, who was also enrolled as a student at Uppsala and who was given the student number 871129-T977. The brothers were clones in the sense that it was impossible to discern between them only based on the perception of their physical appearance. However, Perry only stayed for 6 months because he got a job back in London and so he never became a Swedish citizen.

The example shows that we use reference mechanisms, i.e. identifiers or definite descriptions e.g. John, or 871129-9999, which are not too long and easy to remember, because the object is known to exist by these reference mechanisms in different social and institutional contexts. This means that this individual is now uniquely known by the name John Smith by his friends, and John by his closest family. He is known as 871129-9999 in the context of the civil registry of Sweden, and known as 871129-T999 in the student registry of Uppsala University. However, all these reference mechanisms cannot be used to identify persons universally because there is nothing that guarantees their uniqueness in every context, and each of them have their pro and cons in different contexts. For example, we do not normally refer to a friend using the PID-number although it is unique and we would know it. Notice that Perry Smitherton in contrast to John is not an individual of the Swedish State context. The reason is that he never was registered as a Swedish citizen, because he never interacted directly with the Swedish state.. He only had a relationship with Uppsala University.

Thus, there is no such thing as 'universal identity' based on materiality. Rather, as an alternative, identity can be explained in terms of language use in a social context. Identity should be understood as a successful representation of a reference act – an intentional symbolic act that is performed in a context to create a mutual understanding of the identity of an object. To refer means that one must be able to represent the reference: it is possible to use both identifiers and definite descriptions to do that. The advantage of identifiers is that they can be used to identify without specifying identity descriptions. However, if the use of the identifier is unsuccessful, descriptions of facts must be provided to secure the reference. It is a necessary condition to secure the identity of an object that some descriptive facts must be true of the object. However, these facts should not be understood as a definition of the identifier (Searle 1969, p. 172), and these facts do not have to be brute (material and observable) facts that have a 1:1 correspondence to a substantial thing and its properties. It is sufficient that a disjunction but unspecified number of facts is true of the object. It is this looseness that makes identifiers such a pragmatic and convenient device in language use, because they enable us to refer and identify objects without being forced to raise issues about descriptive attributes (Searle, 1969, p.172). This makes the identifier construct extremely efficient to represent the identity of objects, and is important to information systems design. This constitutes an important insight crucial to conceptual modelling.

One important implication for conceptual modelling is that there are no natural basekinds that could be used as concrete classes in every modelling context. For example, in UFO it is suggested that a student should always be modelled as a subclass of the basekind Person. If we model the example described above using the UFO ontology we get the model shown in Figure 1.

In order to explain the model we start with the objects instances at the middle bottom of Figure 1. These are two snapshots that represent the momentary states of the substantial individual in two different spatio-temporal contexts W1 (Uppsala, 2012), and W2 (Sweden, 2013). In WI, J is called "John Smitherton" and, in W2, J is called "John Smith". Notice again that these are not proper names, only property values. They represent only the contingent personal name of the substantial individual at two states respectively. In other words "John Smitherton" and "John Smith" are instances of the anti-rigid (moment) universal person name (Guizzardi, 2005, p 119).

Furthermore, Guizzardi (2014) maintains that instances in UML diagrams, object identifiers (OIDs), are not snapshot entities. They are supposed to connect various snapshots at the instance level, although this is not made explicit in the definition of the UML standard. This implies that an OID such as J:Person can be interpreted as an individual concept, at the type level. OIDs are proper names i.e. functions from worlds to substantial individuals - or state of individuals. Consequently, we end up with a model that describes an

individual concept J:Person that refers to a substantial individual. We also get two subtypes of this individual type, because student and citizen are anti-rigid sortals,

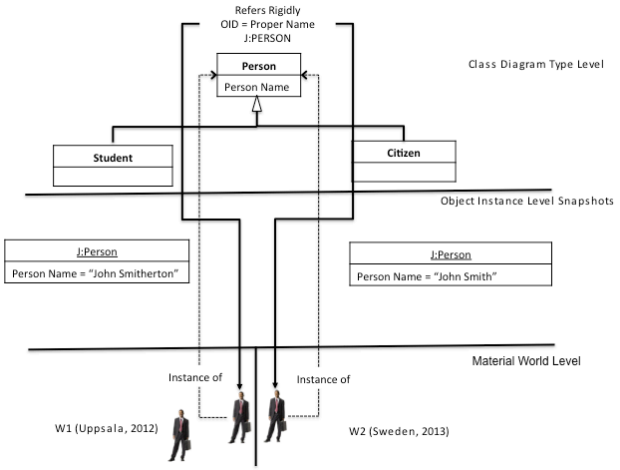

Figure 1: UML Model of students

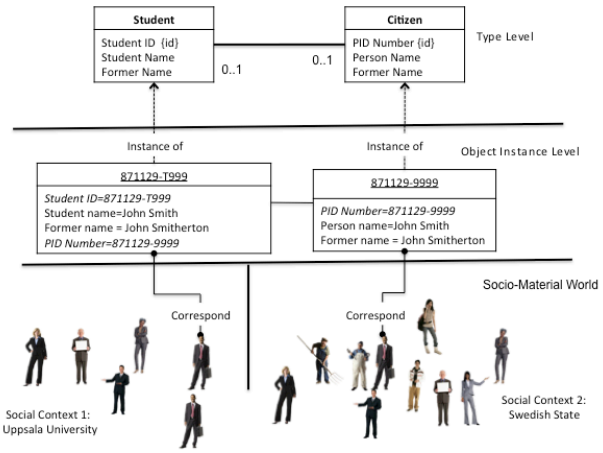

Figure 2: UML Model based on a social ontology

which cannot provide a principle of identity; they could only carry it.

However, if you want to be explicit about the principle of identity, which we claim is important, the models becomes very complicated because this means that every substantial individual should be modelled this way because every principle of identity is represented by a constant at the type level. The notion of an individual concept (individual type) refers to a singleton property that only holds for one individual (Guizzardi, 2005). For that reason we have not modelled the twin brother of J:Person but only indicated his substantial existence. The model in Figure 1 seems to work only in very limited modelling contexts:

1. where it must be acknowledged that J is the given proper name to that particular individual;
2. someone must guarantee that it is unique is all possible worlds;
3. we must assume that there is something that remains the same across different worlds, that will supply the cross-level identity so that J could be mapped to the substantial individual in every possible world. However, UFO never tells us what that is, e.g. how could we universally discern between identical twins or clones?
4. where it is useful to model a substantial individual in all possible worlds , although it is very difficult to imagine such an application because normally we do not model biographies of substantial individuals.

If we restrict our model to a particular domain and model several individuals as they interact in a social and institutional context, we must approach the problem from another angle.

We must first define the social context of our model (Figure 2). If we start by analysing the Uppsala University context, we realize that we must be able to identify each individual student. Thus, one of the first questions we have to ask is if there is a common reference mechanism that every person already possesses we could use to identify all persons that we want to enrol as students, and the answer is NO. There is no universal principle of identity that is provided by the substantial individual person that we could use. We could not use the DNA because people are not known by their DNA; twins have the same DNA and the long string would be impossible to use. The Swedish PID number could not be used because, by analysing the university context, we learn that the laws that govern the enrolment of students at Swedish universities have never required that they be Swedish citizens. This implies that a special student identifier has to be assigned to each student. However, the student identifier is not the same as a surrogate key; even if it were, for example, a random number. One problem with the distinction between natural and surrogate keys is that it gives the false impression that there is a special set of identifiers (natural keys) just because they include descriptive information. This also implies that Student should be a base class (a concrete class) of its own because the Student class must both provide a principle of identity and a principle of application. Thus, Student should not be considered as a subclass of Person in this context. Students are institutional entities (Eriksson and Ågerfalk, 2010). They are objects that represent rights, responsibilities, obligations, commitments or duties,

If we analyse the Swedish State context, we come to the same conclusion there is no EU PID number that we could use to refer to foreigners who have moved to Sweden. The Swedish state must use its own reference mechanism. Thus, a Swedish PID number has to be assigned to foreigners when they interact with the Swedish state, e. g. when paying income tax. They have to be identified as Swedish citizens in order to be given the proper rights and responsibilities. This means that we get a model with two concrete classes: Student of Sweden and Swedish Citizen because both classes have their own principle of identification, which we have explicitly modelled using the property modifier 'id'. We do not have to model each individual object at the type level because in this model identity is not a universal constant

at the type level. The principle of identification is represented by the property modifier {id}..

This means that the definition of the social context to be modelled and the decision of the concrete classes and the principal of identification of these classes used in this context are the most important design choices in conceptual modelling. It is also important to notice that the type-instance relationship is between the type level and the object instance level and that the relationship between the substantial individual and the object level is a correspondence relationship (cf. Eriksson et al., 2013)

8 Summary and Conclusions

In summary, we find that, firstly, the identity of objects is at the core of conceptual modelling when one seeks an ontological foundation, and thus to model the world it is crucial to explicitly represent the notion of identity.

Secondly, we maintain that the identity of objects does not have to have anything to do with substantial things and their properties. Many important entities in social reality (such as organizations or juridical persons) do not have a substance or a set of identifying substantial properties or an enduring intrinsic property. The reason that identity should not be understood as something material is that identity is based on the meaningful reference to conceptual objects. Thus, an object does not have to have a 1:1 correspondence to a substantial thing. It is true that, in cases in which the object does have a 1:1 correspondence to a substantial thing, the principles described above could be used to reassure that the identity of the object corresponds to the right thing. However, this does not mean that these principles define the identity of the object.

Thirdly, identity has to do with meaning not physicality. Frege (1892a, 1892b) argued that the reference has a meaning, and physical things can be designated as different identities that can have different meanings. Searle (1969) further developed Frege's idea by showing that the ideas of reference and identity can be understood as a successful representation of a reference act, i.e. an intentional symbolic act performed in a social reality to pick out a unique entity in the world. Searle (1969) claims that the principle of identification must be based on an understanding of the use of propositions in language acts and how language relates to the world. It is the existential proposition that instantiates a conceptual object as an instance of a concept into social reality. This is a pre-condition needed to refer successfully because there must exist one and only one object to which the reference applies. The concept associated with the reference provides that criterion.

The theoretical implications of this work are primarily the new perspective of conceptual modelling afforded by social ontology, and the formal introduction and ontological grounding of institutional entities, which have so far been treated rather incidentally. Practical implications include a better foundation for designing and selecting identifiers and classes. The idea that there are classes that always provide an identity, and subclasses (e.g. roles such as Student) that only carry an identity is misleading, because there is no rigid principle of identification that can be used in all possible worlds. (contexts).

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