

Social Roles and their Descriptions

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Abstract

This paper offers two main contributions. On the one hand, it establishes a general formal framework for developing a foundational ontology of socially constructed entities, in the broadest sense of this notion; on the other hand, it further contributes to understanding the ontological nature of roles. The key choice here is to put all social entities in the domain of discourse: besides social individuals, we also consider ‘reified’ social concepts and roles, as well as their descriptions, i.e. the ‘social conventions’ or ‘contexts’ that define them. This allows us to formally characterize in a first-order theory the relationships among all these entities.

1 Introduction

Natural things like rocks, animals or trees, are normally considered as inhabitants of our world. We face more hesitations with entities that appear to exist just because of social conventions, i.e., entities depending in various ways on communities of agents: these can be *social concepts* like bank, money, company, president, or *social individuals* like the Bank of Italy or the FIAT company.

Intuitively, it is possible to distinguish two senses of *sociality*. In the first sense, mostly used in this paper, an entity is social if it is an immaterial (more precisely, non-directly extended in space) product of a community, i.e., if it depends on agents who, by means of some sort of convention, constitute, make use of, communicate about and accept it. In this sense, ‘social’ is roughly synonymous of ‘conventional’. In the second and stronger sense, an entity is social, if, in addition to having a conventional nature, its very conventional constitution involves a network of relations among social agents. This network of relations can be interpreted (as argued in (Gilbert 1992, Searle 1990, Tuomela 1995) in different ways) in terms of (collective) intentionality, actions and deontic constraints. For example, the concepts of *quark* and *triangle* can be considered as social in the broader sense, since they are the result of a conventional agreement within of the communities of physicists and mathematicians, while the concept of *money* is also social in the strict sense, since its ‘definition’ refers to some conventionalized exchange between agents. We will not address the peculiarities of this stronger sense of sociality in this paper, even though most of the examples discussed here actually refer to this restricted sense.

Among social concepts, special relevance have *social roles* like catalyst, money, professor or president, as opposed to quark, bank, company or elder. Anticipating the discussion, let’s just say that roles are concepts that can be ‘played’ (in a contingent and temporary way) by certain entities, when they enter in relationships with other entities.

In this paper we focus on social roles, in their broader sense, with two goals in mind. On the one hand, we want to establish a general formal framework for developing a foundational ontology of social entities. On the other hand, we want to offer a further contribution to understand the ontological nature of roles and to clarify some pervading terminology confusion. The key choice here is to put all social entities in the domain of discourse: besides social individuals, we include in our domain also ‘reified’ social concepts and roles (which are traditionally represented as unary predicates¹) as well as the ‘social conventions’ or ‘contexts’ that define them (we call the latter *descriptions*). In this way we are able to formally characterize, by means of first-order axioms, the relationships existing among all these entities. This is indeed the main technical contribution of the present paper: we bind together, in the same first-order theory, all the various entities involved in the notion of social role.

The structure of this paper is as follows. In section 2, we summarize the main ontological features of roles, analyzing the literature in philosophy, computer science and linguistics. In section 3, we introduce our approach, based on a reification of *concepts* and *descriptions* and we formalize the features of roles individuated. In section 4, we model various relations between roles and some properties. In section 5, we briefly introduce the notion of social individual, and discuss some interesting cases where it is necessary to refer to (and count) individuals *qua* players of certain roles. We conclude with some reflections on other interesting uses of our formal approach, especially when we take a constructivist attitude towards ontology².

¹ Of course we *may* also need to reify social relations, represented by n-ary predicates. We do not discuss this issue here.

² A preliminary axiomatization of roles and descriptions has been presented (and applied) elsewhere (Gangemi and Mika 2003) in the context of the so-called ontology of descriptions and situations (D&S), whose intended coverage is wider than the theory presented here (cf. the conclusions in this paper).

2 Understanding roles

2.1 Roles in the literature

The nature of roles and the way of representing them have been discussed for a long time in different fields.

In *knowledge representation*, and more specifically in the field of *description logics*, the term ‘role’ is nowadays synonymous of an arbitrary binary relation (often a function) used to characterize the structure of a concept. The concept ‘person’, for instance, may have the role ‘likes’, which represents the relationship between a person and what she likes best. As discussed in (Guarino 1992), this was not the original KL-ONE view, however, where roles had a more linguistic flavor, and were not supposed to stand for arbitrary relations. A stricter notion of roles was the one proposed by Sowa (1988, 2000), who asserts that roles are concepts, i.e., unary predicates, although intimately connected to “patterns of relationships”. Guarino proposed a formalization of this intuition, based on Husserl’s notion of *foundation*, that expresses the intimate dependency between a role concept and other ‘external’ concepts: there cannot be a ‘student’ without at least a ‘subject matter’, for instance. A further constraint proposed by Guarino is that roles must be *anti-rigid*, i.e. they are properties that are contingent (non-essential) for all their instances (Guarino and Welty 2002). Accepting this general definition, Fan and colleagues (2001) limit roles to the representation of “the extrinsic features of an entity due to its participation in an event”, i.e. roles are linked to modalities of participation, as for the ‘participant roles’ of (Davis and Barrett 2002). Loebe (2003) notes though that roles must not be limited to the time of participation in specific events; a musician is still a musician while sleeping. He tries to characterize different approaches on the basis of the ontological nature of the *contexts* that ‘determine’ roles, and he individuates and analyzes in detail three kinds of role: *relational* roles (ways of participation in a relation), *processual* roles (ways of participation in an event), and *social* roles.

In *knowledge engineering*, the debate about roles started when *problem-solving methods* – originally thought of as completely separate from (and complementary to) ontologies, where proposed as *task ontologies*, where for instance a patient’s state could play the role of a *hypothesis* or a *diagnosis* during a problem-solving process (Guarino 1997). These roles have been called *knowledge roles* in the CommonKADS methodology (Schreiber et al. 2000). According to this school, knowledge roles should not be seen as predicates, but rather as individuals (Van Heijst, Schreiber and Wielinga 1997). After almost 10 years, we shall see here that this position had its own arguments.

In *object-oriented* and *conceptual modeling*, the representation of roles needs to take into account various modeling issues: multiple and dynamic classification, multiple inheritance, objects changing their attributes and behaviors, etc. In (Steimann 2000, Wieringa 1990) specific

solutions to these problems and good reviews of ways of representing roles are offered. We may quote in particular the Universal Modeling Language in which roles are represented as ‘labels’ of the entity types linked by a specific relationship, i.e. a role is a named place in a relationship (Fowler and Scott 1999).

In *multi-agent systems* (MAS) roles are generally viewed as descriptions of agent’s acting and interacting, where agents include also societies or organizations of agents. The characterization of this kind of social roles (in the restricted sense) is founded on theories of action and behavior (involving tasks, goals, plans, etc.) and deontic notions. In (Zambonelli et al. 2003) a role is viewed as an “abstract description of an entity’s expected function” which is defined by four attributes: responsibilities (that determine the functionality of the role), permissions, activities, and protocols. Pacheco and Carmo (2003) clearly distinguish roles from agents (“agents can act, and roles cannot”) and they state that roles cannot be reduced to their deontic characterization (“mere sets of obligations, permissions or other normative concepts”) because this characterization can change in time, i.e. an agent playing exactly the same role can have, at different times, different obligations, permissions, etc. Another interesting aspect regards the link between an organization and the roles in it. The two approaches agree on the fact that an organization is independent of the players of its roles and it does not coincide with the collection of its roles: the dependences and the relations between roles are fundamental.

Leaving aside the fact that MAS consider generic agents, while *sociology* and *philosophy* are traditionally more interested in human actors, the characterizations of social roles (in the stronger sense) introduced in these disciplines are based on similar notions. In *role theory* (Biddle 1979) a role is defined as “those behaviors characteristic of one or more persons in a context”; i.e., roles focus on a limited set of behaviors that are characteristic of a set of persons and a context. Loudfoot (1972) analyses different notions of social role: (i) role as set of rights and duties; (ii) role as a part which one acts; (iii) role as expected pattern of behavior, etc. (i) seems very close to the deontic characterization of roles in MAS and, as stated by Loudfoot, even though it provides a ‘bridge’ between societies and individuals, it seems to suffer from some limitations: for example it is not clear how it is possible to define a ‘musician’ in terms of rights and duties (maybe ‘skills’ are needed). Tuomela (1995) proposes a complex framework taking into account tasks-right systems, norms, rule-based behaviors, collective acceptance, etc. He defines social roles (relative to a specific *collective*) in terms of sets of *social tasks* and *social rights*. The notion of ‘playing a role’ is defined here in terms of the agent’s acceptance of tasks and rights (of the specific role) and in terms of mutual beliefs (among the members of the collective) that the agent intends to achieve the social tasks (possibly) using its social rights.

The work of Searle (1995) focuses on the notion of *status*. Social roles (in the broader sense) and statuses have

similar features: entities ‘have’ statuses; statuses are created, accepted, and destroyed by a community of agents needing a notion of *collective acceptance*. Statuses are strongly connected to *status functions* which have the form: “X counts as Y in context C”, where X is a (physical or non physical) entity, Y is a status, and C a *context*, i.e., the system of constitutive rules defining the status.

In *linguistics*, roles are essentially studied as *thematic roles* (*agent, theme or patient, goal, instrument...*), an important notion in the syntax/semantics interface introduced by Fillmore (1968). From a syntactic point of view, thematic roles specify how the argument structure of a verb is realized in the sentence, while, from a semantic point of view, they specify the mode of participation of an entity in an event (Parsons 1990). In this sense, thematic roles are akin to both the relational and the processual views of roles in (Loebe 2003), and can be seen as the most generic ‘participant roles’ of (Davis and Barrett 2002, Fan et al. 2001). But most examples of roles are usually described through noun phrases, like ‘John is the president’ or ‘John is a musician’, rather than through the argument structure of a verb, like in ‘John presides’ or ‘John plays music’. Therefore, the study of nominals, particularly *relational nouns*, is also relevant here (Barker 1995, De Bruin and Scha 1988). Many role nouns, like ‘mother’, ‘president’, ‘friend’, ‘gift’... are in fact relational nouns, i.e., they refer to a binary (or n-ary, $n > 1$) relation, instead of a unary predicate as for ordinary nouns like ‘human’ or ‘horse’. This reference to relations recalls the relational nature of roles evidenced in knowledge representation. The noun phrase is *saturated* when all arguments of the relation are made explicit³, like in ‘my mother’, ‘the Italian president’, ‘a friend of John’s’ and ‘Mary’s gift to John’.

In *cognitive semantics*, roles are studied within the domain of mental representations. For example (Fauconnier 1988) treats roles as concepts within a *mental space* that can have values within another mental space by means of a *counterpart* relation. This treatment allows for a relative notion of role, as for ‘in France, the head of state is the *president* and currently the *president* is Jacques’, where ‘president’ may appear to be both a role and a role-player.⁴ Fauconnier's approach, designed to model various linguistic phenomena, such as counterfactuals and metaphors, constitutes also a depart from a purely grammatical account of roles. In fact, language expressions are not taken as carriers of propositional content, but “they can be viewed as ‘instructions’ to carry out certain kinds of mental constructions” (Ducrot 1985).

2.2 The key features of social roles

On the basis of the above analysis of the literature, we have retained four basic characteristics of social roles, leaving aside the aspects related to the stricter sense of sociality.

(i) Roles are ‘properties’. We take up here the position defended by Sowa (2000). The basic idea behind this assumption is that roles can be ‘predicated’ of different entities, i.e., in role terminology, *different* entities can *play the same* role.

Using logic (mathematics) we could easily represent a role as an unary predicate (a set) whose instances (members) are the *players*, but this solution cannot be used in several cases where the dynamic aspects of roles are important (see below). In addition, as mentioned in recent discussions⁵, this position has been questioned because of the desire to talk of roles as ‘first-class citizens’, similarly to more common entities like objects, events, etc. Using a reification mechanism, we shall achieve this result by introducing roles directly in the domain of quantification, and introducing a specific relation between roles and their players. Despite this technical move, conceptually we can still think of roles as properties.

(ii) Roles are anti-rigid and they have ‘dynamic’ properties. This aspect basically regards the temporal (and more generically modal) nature of the relation between roles and their players. From the 15 fundamental characteristics of roles individuated by Steimann (2000) we can sum up the dynamic ones into 5, illustrated and discussed with the help of the following examples:

- (1) In the second half-year of 2003, Berlusconi was simultaneously the Italian Prime Minister, the President of the European Union, the president of the Forza Italia party, the owner of the Mediaset company, an Italian citizen and a defendant at a legal trial.
- (2) In 1960 Berlusconi was a piano bar singer, now he is the Italian Prime Minister.
- (3) In the second half-year of 2003, Berlusconi had two presidencies / was president twice.
- (4) Today, the Italian National Research Council has 4319 researchers.
- (5) In 2000, the Italian Prime Minister was D’Alema, now it is Berlusconi.
- (6) Only Italian citizens can be Italian Prime Minister.
- (7) All professors have been students.

An entity can play different roles simultaneously. This is one of the most broadly accepted properties of roles and it requires a multiple classification, as exemplified by (1).

An entity can change role. In general, playing a role is *not a necessity*. Being a Prime Minister is not an essential property of people: for everybody that is a Prime Minister, it would be perfectly possible for her or him *not* to be a Prime Minister (anti-rigidity) or to play some other role (entities can ‘change’ role) (2).

An entity can play the same role several times, simultaneously. This is a difficult issue. In what sense can we say that, in the second half of the year 2003, Berlusconi

³ When these extra arguments are left implicit, the context provides them or there is an existential closure operating.

⁴ We give a different account of such an example in section 4.

⁵ See for instance the on-line debate performed within the “Content Standards” SIG of the OntoWeb project, <http://ext4-www.ics.forth.gr/mail/ontoweb-sig1/0032.html>

had the same role several times? We conjecture that it is because he was playing different specific roles (president of X, president of Y) which are all specializations of a more general one (president) (3).

A role can be played by different entities, simultaneously or at different times. Roles do not depend specifically on their players, even though some roles, like in (5), admit only one player at a time (4, 5).

The sequence in which roles may be acquired and relinquished can be subject to restrictions. This kind of dependence is illustrated by examples (6) and (7) even though they present a difference: the Italian Prime Minister is still an Italian citizen during his mandate while a professor is not necessarily a student.

A further interesting temporal aspect of social roles, not considered by Steimann, concerns *their own* behavior in time. Are roles temporally extended? Are they created? Can they disappear? Considering all social entities (in the broader sense) as dependent on communities of agents, and therefore created, accepted, and destroyed by these communities, social roles are certainly *in time*.

(iii) Roles have a relational nature. Features (i) and (ii) are not enough to characterize roles. Properties like *being tired* appear to satisfy (i) and (ii), but seem to clash with our intuition of roles. Indeed, as mentioned above, according to Sowa, roles imply *patterns of relationships*, i.e. roles *depend*—via these patterns—on additional ‘external’ properties.

In the literature various kinds of dependence relations have been analyzed (Simons 1987). Sowa assumes a sort of *identificational dependence*: to identify something as playing a certain role it is necessary to consider other entities, actions, or states. This is considered as not restricted enough by Guarino (1992), because in this case *being a car* would turn out as a role: to identify something as a car it may be necessary to consider other entities like its wheels or its engine, etc. According to (Guarino and Welty 2002), the kind of dependence we need here is what Simons calls *notional dependence*, which in turn is based on Husserl’s notion of *foundation*. Intuitively, the definition of foundation can be formulated as follows: “a property \square is *founded* on a property \square if, necessarily, for every instance x of \square there exists an instance y of \square which is not ‘internal’ to x ”. This definition is based on a *generic existential* dependence on external properties. Clearly, the notion of ‘internalness’ is complex: for example, if x is a car, things internal to it can be *parts* of it (its wheels), but also *constituents* of it (the metal it is made of) or *qualities* of it (its particular color). Once excluded the cases of internal properties, the notion of foundation still doesn’t avoid all trivial cases: for instance when an individual x (e.g., Socrates) exists its singleton (e.g., {Socrates}) exists as well, then all the properties of which x is an instance of are founded on the property of ‘being a singleton’.

To avoid such a problem, Fine (1995) introduces another notion of dependence: “to say that an object x depends upon an F is to say that an F will be ineliminably involved in any *definition* of x ”. This notion can be generalized to

properties considering that a property \square is *definitionally dependent* on a property \square if, necessarily, any *definition* of \square ineliminably involves \square ⁶. This notion is effective only if ‘definitions’ (and their content) are explicitly introduced in the domain of discourse. We will see that in our approach we consider these definitions as full-fledged entities that contribute to specify the ‘context’ of a role.

(iv) Roles are linked to contexts. As noted by Loebe (2003), most approaches described above consider roles as ‘determined’ by some external entities whose ontological nature is quite heterogeneous: Loebe, Searle (1995) and Biddle (1979) explicitly refer to contexts; Sowa and Guarino associate roles to patterns of relationships while Fan and colleagues (2001) and Davis and Barrett (2002) associate them to modalities of participation in an event; in MAS, roles are intimately related to (abstract) descriptions of agents’ behavior in organizations. It seems to us that since a context can refer to a variety of ‘ingredients’, including relationships, events, organizations and behaviors, a contextual approach subsumes the others.

Still, what exactly is a context remains to be clarified. The term ‘context’ has indeed received very different interpretations in the literature, but at least three senses can be identified (Bianchi 2003, Bouquet 1998, Penco 2002):

- *Metaphysical context.* A state of affairs holding in the world described only according to some chosen parameters, in which given sentences must be evaluated (Kaplan 1978, Lewis 1980).
- *Cognitive context.* A theory that provides definitions of concepts, to be used as a background for the interpretation of certain states of affairs; it is composed by a language, a set of axioms and a set of inference rules. This notion has been mainly used in artificial intelligence (Giunchiglia and Ghidini 2001, McCarthy 1993) although recently it has become fairly central in philosophy (Perry 1988, Recanati 2001).
- *Linguistic context.* The representational structure of the semantic contents of (previous) discourse, affecting the interpretation of a sentence, as in Discourse Representation Theory (Kamp and Reyle 1993). Such contexts have been modeled as abstract objects (complex logical formulas), akin to the cognitive contexts described above (Asher 1993).

The cognitive notion of context seems to be the most adequate for our purposes, as it is the closest to Searle’s view of context as a system of constitutive rules. Assuming that contexts can be introduced as entities in the domain of discourse, and provide explicit definitions of roles, the notion of *definitional dependence* (feature (iii)) can effectively be used to characterize roles. In addition, introducing contexts as explicit entities constitutes a way to account for the social nature of roles (both in the broad and

⁶ As in the case of foundation, we can add the condition that the \square s are external to the \square s.

restricted sense). It is this approach that we will follow in the remainder of the paper.

3 Our formal approach

The formal apparatus presented in this section is a first step towards the development of a first order theory able to represent social *concepts* (in the broader sense), and more specifically social *roles*⁷. The full formal characterization of these notions would require a rich set of ontological primitives in order to talk about actions, agentivity, intentionality, linguistic expressions, abstract semantic contents, etc. The theory we propose makes use of a simplified ontology, and therefore only partially characterizes social entities. However, we believe that the general schema sketched out here makes it possible to flesh out the missing parts without large restructuring, and it is in any case sufficient to take into account the features of roles described above.

3.1 Framework

General strategy. Our general strategy can be resumed in three points:

- ‘reify’ social *concepts* to be able to predicate on them: $CN(x)$ stands for “*x is a social concept*”;⁸
- explicitly introduce concept definitions, called *descriptions*, to deal with the social, relational, and contextual nature of social concepts: $DS(x)$ stands for “*x is a description*”, while $DF(x, y)$ stands for “*the concept x is defined by the description y*”;
- introduce a *temporalized classification* relation to link concepts with the entities they classify, while accounting for the dynamic behavior of social roles: $CF(x, y, t)$ stands for “*at the time t, x is classified by the concept y*” or, more explicitly, “*at the time t, x satisfies all the constraints stated in the description of y*”.

Let’s take, for example, the present Italian Constitution. This can be seen as a *description* defining the current concepts of Italian President, Italian government, Italian Prime Minister, etc. Berlusconi during 2003 and D’Alema 4 years ago are classified by the latter concept.

The time parameter in the classification relation does not refer to the time at which the classification is done. Rather, it identifies a particular interval of the temporal extension of the classified entity, during which the entity satisfies all the constraints in the concept definition. During 2000, Berlusconi did not have all the necessary characteristics to be an Italian prime Minister, while he had them in 2003. This means that, at different times, entities can be classified by different concepts, while concepts themselves are ‘static’ with respect to the entities they classify, i.e.,

they do not change during their life, although we assume they have a limited life.

Basic features of descriptions. Before proceeding, to further clarify our intuitions, let us state some basic features of descriptions (and, indirectly, of the concepts they define) that will not be formalized here:

- descriptions are created by (communities of) intentional agents at the time of their first encoding in an expression of a ‘public’ (formal or informal) language;
- different expressions (possibly in different languages) can be associated to the same description, provided they have the same semantic content. I.e., descriptions have a unique semantic content;
- descriptions must be encoded on (possibly multiple) physical supports⁹;
- descriptions are usually accepted (adopted) by (communities of) intentional agents, but a description can exist even if no one accepts it, as long as it remains encoded; acceptance can change in time;
- descriptions cease to exist when their last physical support ceases to exist.

It follows that descriptions, and therefore the concepts therein defined, have a definite temporal extension, and therefore may or may not be present at a given time.

The internal structure of descriptions can be complex: they can be decomposed into simpler descriptions (as occurs for example with laws subdivided into articles), they can reuse concepts introduced in previous descriptions, etc. This structure is intimately related to the logical structure of the *semantic contents* of descriptions. As we do not account explicitly for such contents in this simplified framework, we introduce an ad-hoc relation, $US(x, y)$, standing for “*the concept x is (re)used in the description y*”.¹⁰ This relation enables the representation of definitional dependence between concepts and between their descriptions.

The ground ontology. The primitive predicates above only make sense when embedded within a more comprehensive ontology (called *ground ontology*) through which they can be related to more basic ontological categories. The categories of the ground ontology are assumed to be not contextual, i.e., not explicitly dependent on a social construction. In this work we take DOLCE as the ground ontology (Masolo et al. 2002). Categories (and relations) in DOLCE do not commit to a strictly referentialist metaphysics related to the intrinsic nature of the world, but they reflect a common sense bias. However, as opposed to what we propose now for social concepts, the contextual dependencies and dynamics of DOLCE’s categories and relations remain unexpressed within DOLCE itself, i.e.,

⁷ Social individuals will be introduced (only informally) in section 5.

⁸ We avoid second order quantification problems assuming a finite number of concepts, which is not limiting for our purposes.

⁹ Printed or recorded texts obviously count as physical support, but memory or other cognitive processes should probably be considered as well (think of orally transmitted tales, rules and contracts).

¹⁰ An explicit US relation has been preferred to a part-of relation between descriptions, which should take into account not only the structure of their abstract contents but also their social and dynamic aspects.

DOLCE's categories are simply represented as unary predicates. Hence, this means that DOLCE's categories constitute a basic conceptualization of the world that we *assume* to be static and context-independent.

In the remainder, we will explicitly refer to the following predicates of DOLCE:¹¹

- ED(x) standing for “*x is an endurant*”, i.e., an entity that is *wholly* present at any time it is present, e.g., a car, Berlusconi, K2, a law, some gold...;
- PD(x) standing for “*x is a perdurant*”, i.e., an entity that is only partially present, in the sense that some of its temporal parts may be not present, e.g., reaching the summit of K2, a conference, eating, being open...;
- NASO(x) standing for “*x is a non-agentive social object*”, i.e., an endurant that: (i) is not directly located in space and, in general, has no direct spatial qualities; (ii) has no intentionality; (iii) depends on a community of intentional agents, e.g., a law, an economic system, a currency, an asset...;
- TL(x) standing for “*x is a temporal location*”, i.e., a temporal interval or instant;
- P(x, y, t) standing for “*the endurant x is part of the endurant y at time t*”;
- P(x, y) standing for “*x is part of y*”, for perdurants and temporal locations;
- PRE(x, t) standing for “*x is present at the time t*”.

3.2 Formal characterization

Descriptions and Concepts. Descriptions and concepts are two (disjoint) sub-classes of DOLCE's category of non-agentive social objects. This constraint (partially) reflects the social and linguistic nature of these entities by introducing, as stated in DOLCE, a dependence on (communities of) intentional agents.

- (A1) $DS(x) \sqsubseteq NASO(x)$
 (A2) $CN(x) \sqsubseteq NASO(x)$
 (A3) $DS(x) \sqsubseteq \sqsubseteq CN(x)$

Concept Use and Definition. Concepts and descriptions are linked by the relations *used-by* (US) and *defined-by* (DF). (T2) below captures the fact that a concept must be defined by a single description. This is not true for the US relation: concepts can be inherited or used by different descriptions. By (A7), a description must *use* at least one concept, defined in itself or in another description. Note that we do not require that a description must *define* at least one concept: complex descriptions may be just the ‘union’ of simpler ones without introducing new concepts and additional links; also, they can only use predicates and constants belonging to the ground ontology, on which, in any case, descriptions must ultimately be anchored. Note that (A8) implies that descriptions defining the same concepts are identical, i.e. they are DF-extensional. This is not true for the US relation: (i) the definitions of two different concepts can reuse the same concepts and still

differ in the logical structure and the formal constraints imposed on them; and (ii) different communities of agents can reuse the same concepts at different times. (T3) expresses the mutual existential dependence between a concept and its definition. This entails that concepts cannot change their definition, i.e. new descriptions define new concepts. Moreover, during their life, descriptions always define and use the same concepts (i.e. concepts are static with respect to their semantic content). This is clearly reflected by the fact that DF and US are not temporalized.

- (A4) $US(x, y) \sqsubseteq (CN(x) \sqsubseteq DS(y))$
 (A5) $DF(x, y) \sqsubseteq US(x, y)$
 (A6) $CN(x) \sqsubseteq \sqsubseteq y(DF(x, y))$
 (A7) $DS(x) \sqsubseteq \sqsubseteq y(US(y, x))$
 (A8) $(DF(x, y) \sqsubseteq DF(x, z)) \sqsubseteq y = z$
 (A9) $US(x, y) \sqsubseteq (PRE(y, t) \sqsubseteq PRE(x, t))$
 (A10) $DF(x, y) \sqsubseteq (PRE(x, t) \sqsubseteq PRE(y, t))$
 (T1) $DF(x, y) \sqsubseteq (CN(x) \sqsubseteq DS(y))$ (A4),(A5)
 (T2) $CN(x) \sqsubseteq \sqsubseteq y(DF(x, y))$ (A6),(A8)
 (T3) $DF(x, y) \sqsubseteq (PRE(x, t) \sqsubseteq PRE(y, t))$ (A5),(A9),(A10)

Classification. Since endurants are the most frequently addressed category in the literature about roles, in this work we concentrate on the classification of this kind of entities (A11). However, we believe that our general framework can be adapted to the classification of other kinds of entity, like perdurants, abstracts, etc., useful for representing complex notions such as plans and rules (Gangemi and Mika 2003).¹² (A12) states that the temporal parameter in CF only constrains the temporal extension of the classified entity, while the concept's temporal extension remains independent of it. This implies that concepts can classify endurants that exist before, during, or after their existence, reflecting the fact that we assume here a purely ontological approach.¹³ Note that there are no axioms avoiding the possibility that: (i) two different concepts classify the same entities; and (ii) that a concept be ‘empty’ or classify several entities simultaneously.¹⁴

From (A1) and (A2), together with DOLCE's axioms, it follows that descriptions and concepts are endurants, and therefore they can themselves be classified. In order to avoid circularity, (A13) states that descriptions can only be classified by concepts used or defined in other descriptions. (A14) and (A15) ensure ‘stratification’ in concept classification, avoiding direct circularity¹⁵.

¹² Clearly this operation requires some work; for example, in the case of perdurants, it is not clear whether CF must be temporalized or not.

¹³ ‘Epistemological’ aspects of classification are thus excluded; in particular, considering an endurant at a specific time, we cannot classify it under a certain concept on a certain occasion and negate such classification on a later occasion on the grounds that we have acquired additional knowledge on the endurant.

¹⁴ In a language including modalities, such possibilities could be positively expressed.

¹⁵ To prevent circularity in general, (A14) and (A15) are not enough. Consider the counter-example $CF(x, y, t) \sqsubseteq CF(y, z, t) \sqsubseteq CF(z, x, t)$. To avoid such loops one should introduce an ad-hoc three-place relation R, such that the first two arguments form a linear order (with the third

¹¹ For their axiomatization, please refer to (Masolo et al. 2002).

- (A11) $CF(x, y, t) \sqsubseteq (ED(x) \sqsubseteq CN(y) \sqsubseteq TL(t))$
(A12) $CF(x, y, t) \sqsubseteq PRE(x, t)$
(A13) $(CF(x, y, t) \sqsubseteq DS(x)) \sqsubseteq \sqsubseteq US(y, x)$
(A14) $CF(x, y, t) \sqsubseteq \sqsubseteq CF(y, x, t)$
(A15) $(CF(x, y, t) \sqsubseteq CF(y, z, t)) \sqsubseteq \sqsubseteq CF(x, z, t)$

3.3 Characterizing the features of roles

Not all the social concepts introduced in our formal framework are roles. In this section we show how the features of roles evidenced in section 2 can be taken into account in this framework.

The first feature, the fact that roles are ‘properties’ is embedded in the CF predicate, and already applies to all concepts. The fourth feature regarding the contextual nature of roles is also already accounted for by the notion of description and the relation DF (cf. (T2)). For the second and third features, we will now focus on the notions of anti-rigidity and foundation. The additional dynamic properties of roles actually apply to all concepts; these will be illustrated on the examples in section 4.3.

The concept properties of *anti-rigidity* (AR) and *foundation* (FD) can be defined in our formalism. We can say that a concept is anti-rigid if, for any time an entity is classified under it, there exists a time at which the entity is present but *not* classified under the concept:

$$(D1) \quad AR(x) \equiv_{df} \sqsubseteq y, t (CF(y, x, t) \sqsubseteq \sqsubseteq t' (PRE(y, t') \sqsubseteq \sqsubseteq CF(y, x, t')))^{16}$$

The defined predicate AR is only ‘temporally’ characterized, and therefore this definition appears to be too strong: a role could be accidentally rigid. Here again, using a modal language, we could easily obtain a better characterization of these notions by introducing a possibility operator in the consequent of this definition.

A concept x is *founded* if its definition involves (at least) another concept y (definitional dependence) such that for each entity classified by x , there is an entity classified by y which is external to it (generic existential dependence on external properties):

$$(D2) \quad FD(x) \equiv_{df} \sqsubseteq y, d (DF(x, d) \sqsubseteq US(y, d) \sqsubseteq \sqsubseteq z, t (CF(z, x, t) \sqsubseteq \sqsubseteq z' (CF(z', y, t) \sqsubseteq \sqsubseteq P(z, z', t) \sqsubseteq \sqsubseteq P(z', z, t))))^{17}$$

With these new notions, we can define what a role is:

$$(D3) \quad RL(x) \equiv_{df} AR(x) \sqsubseteq FD(x)$$

4 Properties and relations on roles

After having dealt with the definitional properties of roles, we now turn to relationships holding between them and to

argument fixed) and $CF(x, y, t) \sqsubseteq R(x, y, t)$. We do not discuss this point here.

¹⁶ From this definition it follows that ‘empty’ concepts are rigid.

¹⁷ This definition excludes only internal parts. In order to avoid internal constituents and qualities as well, as explained in section 2.1, we need to refer to other predicates of DOLCE that we have not imported in this work.

further interesting potential properties. The majority of these are actually relevant for concepts in general.

4.1 Relations between roles

Sub-concept. The first relation that can be conceived of is akin to subsumption between unary predicates: concepts can be organized in a purely ‘extensional’ hierarchy on the basis of the entities they classify, as in the following examples.

- (8) All Italian Prime Ministers are Prime Ministers.
(9) All Italian Prime Ministers are Italian citizens.

We first define $SB_T(x, y, t)$, the *temporalized sub-concept* relation, standing for ‘ x is a sub-concept of y at time t ’, i.e., at t , all entities classified by x are also classified by y (D4). Next, we can abstract off time and define the atemporal sub-concept relation $SB(x, y)$ (D5).¹⁸ PSB is the proper sub-concept relation.

(T5)-(T7) below state that SB (SB_T) is a sort of (temporalized) partial order. SB is not extensional: $SB(x, y) \sqsubseteq SB(y, x)$ does not imply that $x = y$. Indeed, two different concepts may have exactly the same players, as for President of the Italian Republic and Commander-in-chief of the Italian armed forces. This reflects the fact that, besides ‘extensional’ ones, concepts have ‘intensional’ properties dependent on the contents of their definitions.

- (D4) $SB_T(x, y, t) \equiv_{df} \sqsubseteq z (CF(z, x, t) \sqsubseteq \sqsubseteq z (CF(z, x, t) \sqsubseteq CF(z, y, t))$
(D5) $SB(x, y) \equiv_{df} \sqsubseteq t (SB_T(x, y, t))$
(D6) $PSB(x, y) \equiv_{df} SB(x, y) \sqsubseteq \sqsubseteq SB(y, x)$
(T4) $SB_T(x, y, t) \sqsubseteq (CN(x) \sqsubseteq CN(y) \sqsubseteq TL(t))$ (D4), (A11)
(T5) $(SB_T(x, y, t) \sqsubseteq SB_T(y, z, t)) \sqsubseteq SB_T(x, z, t)$ (D4)
(T6) $(SB(x, y) \sqsubseteq SB(y, z)) \sqsubseteq SB(x, z)$ (D5), (T5)
(T7) $\sqsubseteq z (CF(z, x, t)) \sqsubseteq SB_T(x, x, t)$ (D4)
(T8) $(CF(x, y, t) \sqsubseteq SB_T(y, z, t)) \sqsubseteq CF(x, z, t)$ (D4)
(T9) $(CF(x, y, t) \sqsubseteq SB(y, z)) \sqsubseteq CF(x, z, t)$ (D5), (T8)
(T10) $(CF(x, y, t) \sqsubseteq PSB(y, z)) \sqsubseteq CF(x, z, t)$ (D6), (T8)

Most examples of sub-role relations are more constrained than these sub-concept relations. We need to distinguish at least two cases, *specialization* and *requirement*.

Specialization. In (8), Italian Prime Minister is clearly a proper sub-concept of Prime Minister, but there is something more, happening at the intensional level of the concept descriptions. Being Prime Minister means that there is some specific nation to be Prime Minister of (in terms of that nation’s legal system). In linguistic terms (see section 2.1), the relational noun ‘prime minister’ is not saturated, so that in (10) the implicit nation argument is filled by existential closure.

- (10) Berlusconi is Prime Minister.

Berlusconi is a Prime Minister *because* he is the Italian Prime Minister. We thus say that Italian Prime Minister *specializes* Prime Minister.

¹⁸ Note that in SB_T , as well in SB, empty concepts are excluded.

With a theory strong enough to compare the semantic contents of descriptions, it would be possible to capture this intensional link and *define* the relation “*x is a specialization of y*”, noted $SP(x, y)$. Without such a theory, we are here forced to consider SP as a new primitive relation. By (A18), as soon as some concept has a specialization, the more specific concepts must collectively cover all the entities classified by the more general one. In other words, the more specific concepts fill the variables that are not filled by the more general one.

(A16) $SP(x, y) \sqsubseteq PSB(x, y)$

(A17) $(SP(x, y) \sqsubseteq SP(y, z)) \sqsubseteq SP(x, z)$

(A18) $(\exists u(SP(s, u) \sqsubseteq CF(x, u, t)) \sqsubseteq \exists u'(SP(s', u') \sqsubseteq CF(x, s', t)))$

(T11) $(SP(x, y) \sqsubseteq CF(z, x, t)) \sqsubseteq CF(z, y, t)$ (T9),(A16),(D6)

Requirement. In (9) as well as in (6), we have again a proper sub-concept relation between Italian Prime Minister and Italian citizen. However, it is not because Berlusconi is the Italian Prime Minister that he is an Italian citizen. On the contrary, the definition of the role of Italian Prime Minister is based on that of Italian citizen: being an Italian citizen is an explicit *requirement* for becoming Italian Prime Minister.

The requirement relation probably corresponds to an often-mentioned feature of roles, coined as “roles can play roles” in (Steimann 2000), and illustrated in example (11); the same property appears to be underlying Fauconnier’s approach to roles, described in section 2.1, whose example in taken up here in (12).

(11) Only employees can be project leaders.

(12) In France, the head of the state is the president, and currently the president is Jacques.

Despite the expression “roles can play roles”, the examples above do not correspond to classification relationships: it is not the role of employee itself which is playing the role of project leader, but a specific person playing the role of employee who is playing also the role of project leader. This kind of double role-playing can be a consequence of the definition of one of the roles and therefore constitutes a case of requirement. In (11)-(12), any project leader must be an employee, and the head of the French state must be the French president (and in the latter case, perhaps reciprocally, the president must be the head of the state).

For the same reasons as in the case of specialization, the requirement relation $RQ(x, y)$ stands for “*x requires y*”) is introduced as a primitive. Given $RQ(x, y)$, by (A21), x ‘definitionally’ depends on y (partial representation of the fact that the definition of x is based on that of y), and, as a result, x existentially depends on y (T12).

(A19) $RQ(x, y) \sqsubseteq PSB(x, y)$

(A20) $(RQ(x, y) \sqsubseteq RQ(y, z)) \sqsubseteq RQ(x, z)$

(A21) $(RQ(x, y) \sqsubseteq DF(x, d)) \sqsubseteq US(y, d)$

(T12) $RQ(x, y) \sqsubseteq (PRE(x, t) \sqsubseteq PRE(y, t))$

(A21),(A9),(A10)

(T13) $(RQ(x, y) \sqsubseteq CF(z, x, t)) \sqsubseteq CF(z, y, t)$ (T10),(A19)

Role kinds. Examples (13) and (14) are *not* special cases of some sub-concept relation: Berlusconi is the Italian Prime Minister but not an Italian public office.

(13) Italian Prime Minister is an Italian public office.

(14) Earl is a title of nobility.

Here there is a change in levels, since in (13) and (14), the subjects refer to the roles themselves, not to their players. The role ‘Italian Prime Minister’ is simply classified (in the sense of the CF relation) by the concept ‘Italian public office’. Notice that the latter is not a role, because it is rigid; we call such concepts *role-kinds*.

4.2 Properties of roles

Unique/multiple concepts. Some concepts, and in particular some roles, can classify a *unique* entity at a time (D7), e.g., ‘king’ or ‘Italian Prime Minister’; linguistically, these usually take a definite determiner. Other concepts are mostly *multiple*, i.e., non-unique, like ‘Italian citizen’, ‘passenger of the flight #AZ120’, or ‘student’; they usually take an indefinite determiner.

(D7) $UNI(x) \equiv_{df} \exists y, z, t ((CF(y, x, t) \sqsubseteq CF(z, x, t)) \sqsubseteq y = z)$

Unique/multiple concepts have to be distinguished from what we could call *singular/plural* concepts, as ‘student’ vs. ‘orchestra’ or ‘soccer team’. In this case, instead of considering how many entities *can* be classified, the distinction is based on their ‘numerical’ ontological nature (which requires additional ground predicates to specify whether an entity is singular or plural, i.e., a collection).

Saturated/unsaturated concepts. As described above concerning the specialization relation, some roles are *unsaturated*, like ‘president’ or ‘passenger’, while other are *saturated*, like ‘President of the Italian Republic’ or ‘passenger of the January 1rst, 2004 Alitalia flight #AZ120’. Saturated concepts are not specialized by any other concept, i.e, they are atoms of the hierarchy entailed by the specialization relation.

(D8) $SAT(x) \equiv_{df} \neg \exists y (SP(y, x))$

There can be several degrees of unsaturation: ‘passenger’ is specialized by ‘passenger of an Alitalia flight’, which in turn is specialized by ‘passenger of the Alitalia flight number #AZ120’, although none of them are saturated, as they are specialized by ‘passenger of the January 1rst, 2004 Alitalia flight #AZ120’. So, conversely, we can define what is a *totally unsaturated* concept:

(D9) $TUSAT(x) \equiv_{df} \neg \exists y (SP(x, y))$

Note that the notion of saturation which is used here is more refined than the linguistic one used for relational nouns. Linguistically, ‘President of some Republic’ is as saturated as ‘President of the Italian Republic’.

4.3 Illustration on examples

We are now in the position to illustrate our approach, showing how to represent the propositions expressed in our examples. (For brevity we will use *6-12/2003* for the

second half of the year 2003, *IPM* for Italian Prime Minister, *b* for Berlusconi and *td* for today.)

- (1) $CF(b, IPM, 6-12/2003) \sqcap CF(b, EUPresident, 6-12/2003)$
 $\sqcap UNI(IPM) \sqcap UNI(EUPresident) \dots$
- (2) $CF(b, PianoBarSinger, 1960) \sqcap CF(b, IPM, 1960) \sqcap$
 $CF(b, IPM, td) \sqcap UNI(IPM) \sqcap$
 $\sqcap CF(b, PianoBarSinger, td)$
- (3) $\sqcap x, y (SP(x, President) \sqcap SP(y, President) \sqcap x \neq y \sqcap$
 $CF(b, x, 6-12/2003) \sqcap CF(b, y, 6-12/2003))$
- (4) $\sqcap x_1, x_2 \dots x_{4319} (CF(x_1, CNR_Researcher, td) \sqcap$
 $CF(x_2, CNR_Researcher, td) \sqcap \dots)$
- (5) $CF(b, IPM, td) \sqcap CF(D'Alama, IPM, 2000) \sqcap$
 $UNI(IPM)$
- (6,9) $RQ(IPM, ItalianCitizen)$
- (7) $CF(x, Professor, t) \sqcap \sqcap t'(t' < t \sqcap CF(x, Student, t'))$
- (8) $SP(IPM, PrimeMinister)$
- (10) $CF(b, PrimeMinister, td)$
- (11) $RQ(ProjectLeader, Employee)$
- (12) $RQ(HeadFState, FPresident) \sqcap UNI(HeadFState) \sqcap$
 $UNI(FPresident) \sqcap CF(Jacques, FPresident, td)^{19}$
- (13) $PRE(IPM, t) \sqcap CF(IPM, ItalianPublicOffice, t)$
- (14) $PRE(Earl, t) \sqcap CF(Earl, TitleOfNobility, t)$

5 Further refinements

In this section, we informally discuss some ways of extending our ontology of social entities.

5.1 Social individuals

Descriptions do not only define social concepts, but also *social individuals*. Like concepts, social individuals are defined and can be used in descriptions, but, as individuals, they do not classify entities. Typical examples include *organizations* (e.g. FIAT, the United Nations, the Italian Republic, the INTER Football Club) and *facta* (e.g. Pinocchio, the Land of Toys). In addition, we will here consider *figures* (e.g., the Italian Presidency, the Holy Host), or *officers* in terms of (Fales 1977).

A majority of social individuals are agentive. Agentive social individuals often receive a (legal or social) *empowerment*, which enables them to accept or to create descriptions. The same description can both define an agentive social individual, typically an organization, and an associated ‘representative’ social role whose players may *act for* them, as occurs for the FIAT and the FIAT-legal-representative. There are also complex relations among organizations that need to be characterized, e.g., the relations holding between the Italian Republic and the European Union, where the former is *member* of the latter and when Italy has the presidency of the EU.

The need for figures may appear less obvious than that for organizations and facta. As they are often associated with a social role, e.g., Italian Presidency/Italian President,

¹⁹ A stronger interpretation could add the conjunct $RQ(FPresident, HeadFState)$

they may seem quite redundant, especially when the role is unique. Moreover, linguistically, the figure is often designated through the role noun. Still, there is evidence for the need to attribute properties to a single, global, agentive (which is not the case for roles) individual, among which linguistic examples such as:

- (15) From the birth of the Italian Republic, the (Italian) President/Presidency has signed three thousand laws.
- (16) The king never dies (or its French counterpart, *Le roi est mort, vive le roi !*)

Figures could be considered as some kind of mereological fusion of the player-stages of a given role (or rather, quantities, to which we now turn). But one may argue that the figure exists even when the corresponding role is ‘empty’ (not played by any entity), and thus the need to introduce it as a new entity is further justified.

5.2 Qua-individuals

Another kind of entity may be relevant to solve a famous puzzle occurring for social roles, exemplified by:

- (17) In 2002, Alitalia carried a million passengers.
- (18) In 2002, a thousand gondolas passed under the Ponte dei Sospiri.
- (19) In 2002, the Italian Prime Minister participated in 30 industrial meetings.
- (20) In 2002, the owner of Mediaset participated in 20 industrial meetings.
- (21) In 2002, Berlusconi participated in 45 industrial meetings.

In the conceptual modeling literature, the puzzle raised by (17) is well known (Wieringa 1990). As there certainly are persons who flew Alitalia more than once in 2002, counting passengers cannot mean counting persons that have played the Alitalia-passenger role sometime in 2002, but persons-playing-the-Alitalia-passenger-role, for each occurrence of the classification relation. We could therefore consider adopting the solution to the classical example (18), which shows that, since there are not a thousand gondolas in the whole world, we are actually not counting boats but ‘boat-stages’, or, if we renounce to such a 4-D perspective, boats-passing-under-the-bridge events (Musan 1995). Applying such an approach to (17) would mean counting the events of “Alitalia carrying a single person” in 2002. However, this approach has difficulties with examples (19)-(21), and with any case in which the event type doesn’t select the specific role that the participant is playing during the event. For example, the same person, Berlusconi, can participate in the same kind of events in the quality of player of different roles, and, in fact, can even participate in the same single event with several roles²⁰.

²⁰ The assumption expressed in (19)-(21) is that, in 2002, Berlusconi participated to 5 industrial meetings both as the Italian Prime Minister and as the owner of Mediaset. In fact, the Italian Prime Minister and the owner

An alternative solution, quite similar to Wieringa's, may be considered. It amounts to not counting events or entity-stages, but *qua-individuals*, a new kind of entity. *Qua-individuals* would be created each time an entity is classified by a saturated social role and would have a different identity criteria than the player entity; they would inherit some of its properties *plus* those conferred by their classification by a role.

Problems associated with this solution have to do with the multiplication of entities. It seems reasonable to assume that these new entities are agentive. Then, at a meeting in which Berlusconi participated 'twice', *qua* Italian-Prime-Minister and *qua* owner-of-Mediaset, counting participating agents would mean counting, not one, not two, but three of them: Berlusconi, Berlusconi-*qua*-Italian-Prime-Minister and Berlusconi-*qua*-owner-of-Mediaset. Solving a counting problem with *qua*-entities may then leave us with a new one. However, we can report a poll at which the same person, playing two different roles, had to vote twice, and an interview in which it became essential, to officially keep track of the duration of political party speeches, to know, for each sentence, whether it had been pronounced by the person or by the person-*qua*-elected-representative.

6 Conclusion: beyond roles

The extension of DOLCE presented in this paper allows to distinguish between two levels of 'categorization': (i) the *ground level* dealing with the basic categories of the ground ontology, represented as unary predicates; (ii) the *conceptual level* dealing with social concepts and their descriptions, reified as elements of the domain of quantification, which have temporal extensions and are existentially dependent on cognitive agents.

We have shown how this framework may be usefully applied to the representation of roles, but its generality sets out other potential interesting uses.

From an applicative point of view, this approach has already obtained encouraging results in various application domains, such as communication theory, peer-to-peer computing, and Web Services (Gangemi and Mika 2003), and assessment of legal regulatory compliance across different legal systems or between norms and cases (Gangemi et al. 2003).

From a philosophical point of view, our framework may be seen as reflecting a 'constructivistic' attitude. Indeed, we may choose to move concepts from the ground ontology to the conceptual level whenever it seems appropriate to consider them as embedded in 'world views' which are built up by the intentionality of an observer.

For instance, we could acknowledge the social and conventional character of most concepts, such as 'table',

of Mediaset may be independently invited to a given meeting, and, in this case, Berlusconi could delegate his participation to two different persons.

'plant' or 'planet', and accordingly move all but a few fundamental primitives into the conceptual level.

Consequently, the approach described here for the case of social entities can be generalized to take into account some important features of human cognition emerging from current research in cognitive sciences. This generalization, which includes the individual dimension as well as the social one, subscribes to the idea that mental representations (concepts, beliefs, theories) are not complete or faithful replicas of 'what is in the world' (Churchland et al. 1994), but rather the result of the interaction between an active agent, guided by needs, goals and expectations, and the physical and cultural environment she lives in (Light and Butterworth 1992).

Clearly what we propose in this paper is only a first step toward a formal account of the whole theoretical framework we have sketched. In particular, additional work is needed in four directions: (i) representing, in first order logic, the structure of the abstract semantic contents of descriptions in order to deal with the semantic characterization of a given concept, and define in a precise way some of the relations between roles that we have here introduced as primitives. This is by no means an easy task, although inspiration can be derived from (Asher 1993); (ii) representing collective intentions and mental attitudes of communities of agents that create, maintain and accept descriptions; (iii) providing the same detail of axiomatization to other types of concepts (e.g. tasks, parameters) already represented in preliminary applications of our framework (Gangemi et al. 2003); (iv) exploring the possible analogy between the *re-description* ability exhibited by cognitive agents (Karmiloff-Smith 1992) and the fact that a description can be classified by a role within another description.

Acknowledgements. We would like to thank Stefano Borgo, Alessandro Oltramari, and Gerardo Steve for the lively discussions and comments on the notions involved in this paper. This work was jointly supported by the EC-IST Project 2001-33052 WonderWeb (Ontology Infrastructure for the Semantic Web) and the National project TICCA (Cognitive Technologies for Communication and Cooperation with Artificial Agents).

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