Abstract vs. Social Roles – A Refined Top-Level Ontological Analysis

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Abstract

For decades, the notion of roles has been discussed and applied in various fields of computer science in a number of different ways, but apparently no consensus at an integrative definition has been reached yet. Therefore, roles qualify for a comprehensive analysis with the aim of covering and generalizing recurrent understandings and uses of roles. Regarding ontology development, this would further allow to relate or integrate this notion into top-level ontologies. For these purposes, this paper extends and refines an earlier analysis of roles which is primarily based on the notions of *role*, *player*, and *context* and their interrelations (Loebe 2003). In particular, the classification of roles therein is refined in the light of recent papers and discussions on recurrent role issues. We argue that roles can be understood in two distinct ways which are mixed in the literature. Firstly, *abstract roles* provide a means of viewing something in a context, whereas *social roles* are complex social objects for which a relation to players (frequently referring to material objects) is of primary interest.

Introduction

Roles – e.g. student, customer, patient, factor, driver – are a strange kind of entities. They seem to classify entities which "actually" are something different. From an object vs. quality point of view many roles appear like objects since they are complex and have qualities themselves, but they also depend on other entities, which proposes an understanding as a quality, such that altogether they seem to be somewhat in between objects and "simple" qualities. From a temporal perspective, roles exhibit a more dynamic character in comparison to those entities which play roles. Moreover, in the literature the notion of roles appears in various contexts, and high relevance for modeling and representation is acknowledged in various fields.

This situation produces a formal ontological interest in roles, in particular when dealing with top-level ontologies, since roles may take a very basic position. In (Loebe 2003) we have made an attempt to characterize the notion of roles as general as possible, for integration into the General Formal Ontology (GFO) (Heller & Herre 2004), which is a top-level ontology. This has yield a very broad notion of roles incorporating fairly distinct types. Nevertheless, several issues have remained unsolved, and more recent literature and discussions have led to reconsiderations and refinements of that approach.

The organization of the paper is as follows. This section ends with some ontological and terminological clarifications as a foundation for our role account, as well as indicating some of the primary literature which has been analyzed. Next, the main route of our earlier analysis is introduced and several core issues involving roles are discussed. On that basis our approach is refined and extended in order to provide a general model of roles as a foundation for more specific approaches. After an application to a larger example the paper concludes with summarizing remarks.

Ontological and Terminological Preliminaries

Our approach to roles is based on certain ontological assumptions which shall be explicated in advance and related to the varying terminology of other role accounts. The ontological background is primarily provided by the GFO, but for simplicity slight modifications are necessary, together with some terminological deviation.

Instantiation is considered first. An *instance* instantiates a *universal*, and instances which cannot further be instantiated are *individuals*. Relating to object-oriented (OO) terms, individuals correspond to objects, and universals to classes. Note that the distinction between individuals and universals can be combined with most other notions, and we either leave it to context or, if necessary, clearly indicate which reading applies.

Further, we will refer to *objects* which are understood as persistent entities with *qualities* (more precisely, qualities *inhere in* other entities), standing in certain *relations* and *participating* in *processes*. Table 1 provides examples for each of these categories.

Category	Examples		
Object	a stone	a human	a patient
Quality	a color	a weight	a patient id
Relation	close to	child of	treated by
Process	a fall	a walk	an operation

Table 1: Basic Ontological Categories with Examples

Some more remarks about these categories[1] are required. First, processes are considered as referring to the most complex entities. They are viewed as four-dimensional entities occupying space-time, which "contain" their participants. Qualities and relations are considered as spatially non-extended entities, in philosophical terms they can be understood as tropes and relational tropes, respectively (cf. (Bacon 2002)). Sometimes we call a relation individual a *relator*, conforming to the GFO. Thinking in OO terms, qualities correspond to attributes, as well as relations to associations. Moreover, note that the category of objects is a simplification of the GFO account of persistence, which actually involves presentials (entities restricted to a single time instant) and persistants (universals reflecting identity).

Linking to the Literature

For the purpose of our analysis, literature from various areas in computer science has been studied and grouped into two main streams.

Knowledge Representation and *Knowledge Engineering*
Here, works of Sowa as well as of Guarino et al. turn out to be most influential for role analysis, comprising:

- (Sowa 2000) on role types
- (Guarino 1992; Guarino & Welty 2001; Masolo *et al.* 2004)

Conceptual, Object-Oriented, Agent-Oriented Modeling
These fields offer a wide variety of role approaches, where the following are significant (among others):

- *rolenames*, *qualifiers*, *classifier roles*, *actors* and *role types* in the Unified Modeling Language (UML) (Rumbaugh, Jacobson, & Booch 1999)
- representational issues of *roles* in (Steimann 2000)
- object-oriented *role* models (Wieringa, de Jonge, & Spruit 1994; Dahchour, Pirotte, & Zimányi 2004)

The study was further supplemented by some works from the fields of linguistics (Parsons 1990), sociology (Biddle 1979), and philosophy (Searle 1995).

For a detailed discussion of various approaches the reader is referred to (Loebe 2003). Moreover, (Masolo *et al.* 2004) contains a shorter overview of role-related literature which is similarly broad in thematic scope.

A General Approach to Roles

Basic Notions

The analysis of the literature, driven by the search for an integrated approach to roles, results in an account of roles which involves three recurrent, interrelated notions shown in figure 1. Note that all figures except for figure 4 use UML notation (cf. (Rumbaugh, Jacobson, & Booch 1999)).

The main connection among these notions can be termed a determination relationship, such that players are determined by roles, whereas roles are determined by contexts. In the following, the relation between players and roles is called

[1]Herein we understand categories as a special kind of universals, primarily as those which appear in a top-level ontology.

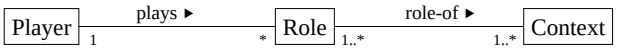

Figure 1: Simple Role Model

plays, that between roles and contexts *role-of*. Roles form the central and mediating element of this model, because it does not comprise a direct relationship between players and contexts.

Examples may provide some intuition. First, assume that John is a student. The term student refers to a role played by the human John within his university, which in this case provides the context for that role. The second example refers to the fact that 2 is a factor of 4. Yet, we argue that factor is a role term whose context is provided by the relationship being a factor of. The number 2 plays this role in relation to 4, whereas 4 plays the role of a multiple in relation to 2.[2] Similarly, when John moves a pen, he plays the role of a mover in the context of the overall movement process.

With these examples at hand, the relations between players, roles, and contexts can be examined further. But before these explanations can be given we need to anticipate the commitment to the view that, regarding instantiation, all notions from above come in an individual and a universal flavor. That means, for example, there are player individuals and player universals. Concerning roles, the correctness of this assumption is discussed in the section on role issues. In the remainder of this section, when using the terms player, role, or context we refer to individuals.

Interconnections of the Basic Notions

We start with *role-of*, for which it was stated that a context determines a role. More precisely, a context is to be understood as a more comprehensive whole in which a role may be interpreted as a part. Indeed, assuming a very general notion of part-of, one can consider role-of as a specialization of part-of. The examples above indicate that contexts can have a very different nature, e.g. *relation* as in the 2-4 example, or *process* as in the mover example.

For the *plays* relation no uniform account can be given like in the case of role-of, apart from mentioning that players are determined by roles but not vice versa. However, in order to understand the plays relation, one can examine types of roles.

Role Types

Studying the literature we have found that contexts of roles can be classified according to the top-level ontological categories of relations, processes, and social objects. Due to the characterization of roles as being determined by contexts it appears reasonable to classify roles by a reflection of these context categories. Regarding the literature, this appears to

[2]This example exceeds the basic ontological categories introduced in the first section. It is included in spite of the unresolved ontological status of numbers in order to demonstrate the intended range of applications of our model.

be a novel aspect of our approach, since most formalisms explicitly or implicitly refer to only one of our role types.[3]

Consequently, the following three role types can be distinguished:

- *relational role*: corresponds to the way in which an argument participates in some relation
- *processual role*: corresponds to the manner in which a single participant behaves in some process
- *social role*: corresponds to the involvement of a social object within some society

Let us first sort the examples with respect to these types. 2 as a factor of 4 refers to a relationship, hence factor is considered a relational role universal, whereas John's moving some pen is categorized as a process, hence mover turns out to be a processual role universal, equal to the moved. Finally, at first glance, student should be classified as a social role universal because the context is provided by some university society.

Now the nature of the plays relation can be studied with respect to each of these role types, and it is informative to reconsider the role-of relationship as well.

Relational Roles (RR) For relational roles, the *plays* relationship is subsumed by inherence, and accordingly, relational roles are special qualities.[4] This subsumption implies a dependence of relational roles on their players. Indeed, the *non-migration principle* which applies to qualities therefore applies to relational roles as well:

$$\forall xyz(\ \mathrm{RR}(y) \wedge \mathrm{plays}(x,y) \wedge \mathrm{plays}(z,y) \rightarrow x = z\ ) \quad (1)$$

Their distinctive feature compared to "usual" qualities like weight or age is an additional dependence on "complementary" relational roles. Assume, for example, that John is medically treated by Sue, i.e., there is a relator (a relation instance) connecting John and Sue such that John plays the role of the patient and Sue that of the attending physician. Here, the particular patient role of John and the physician role of Sue are interdependent, and either is dependent on its player. By means of role-of these two roles form a relator which connects John and Sue.

The use of *role-of* as subsumed by a general notion of part-of may appear debatable in particular for relational roles and relators, due to the question of what a part of a relator should be. We consider relational roles as homogeneous, "indivisible" entities which form "atomic" parts of relators. This may seem even more counter-intuitive, if abstract relations are considered as in the 2-4 example. However, relational roles have definitely found their place in modeling and representation, and there they exhibit the character of parts with relations as their wholes (cf. rolenames and association ends as parts of associations in UML (Rumbaugh, Jacobson, & Booch 1999, p. 414), roles in the associations of Topic Maps (Pepper & Moore 2001), and rolesets in the Simple Common Logic effort (SCL WG 2004)).

Processual Roles (PR) In connection with processual roles, *role-of* is more convincingly seen as a special part-of relation. However, in contrast to the frequently met understanding of parts of processes as merely temporal parts, processual roles rely on a different basis in dismantling a process. They "slice" processes with respect to the dimension of participants. When John moves his pen, he and the pen form participants of that process, and the processual role which John plays captures what John does in that participation. Thinking of a mime who moves an imaginary pen should be a good illustration of the notion of a processual role.

Since their contexts are processes, processual roles are parts of processes and therefore processes themselves. Note that there is a mutual interdependence among all processual roles of a process (e.g., the mover and the moved from above), in best analogy to relational roles. This in turn yields a distinction among processes such that independent and dependent processes exist, and an independent process p can be split into dependent processes $q_1, \ldots, q_n$ – its processual roles – based on the participants of p.[5]

From such an understanding of processual roles it becomes clear that participation of x in a process y, $\mathrm{par}(x,y)$, can be defined in terms of *role-of* and *plays*:

$$\forall xy(\ \mathrm{par}(x,y) \leftrightarrow \exists z(\mathrm{PR}(z) \wedge \mathrm{plays}(x,z) \wedge \text{role-of}(z,y))\ ) \quad (2)$$

Social Roles (SR) These are the third type of roles thus far distinguished, for which we just name the options for interpreting plays and role-of, but decisions for any of these need to be based on the consideration of recurrent issues discussed in the next section.

Regarding the *plays* relation being applied to social roles, two options can be derived from the literature. One is instantiation, reading "John is a student" as John is an instance of the universal student. Otherwise, some genuine notion of playing a role is assumed, which is vaguely similar to inherence but viewing roles as "complex qualities". What is relevant here is the fact that social roles are often defined with their own qualities and processes in which they (may) participate (cf. (Steimann 2000)).

Switching to *role-of*, this relation remains fairly obscure for social roles. At least, searching for better examples than a university society as the context for students has proven to be hard. For the time being, we stick to the phrase "belonging to a (social) context" for role-of in the social case.

[3] This does not hold for UML, but there an integrated view is missing.

[4] More precisely, the inverse of the plays relation is subsumed by inherence, because $\mathrm{inh}(x,y)$ refers to the quality in its first argument, whereas $\mathrm{plays}(x,y)$ does so in the second.

[5] The latter seems to violate the idea that roles are determined by contexts. However, with the distinction of individuals and universals available, the phrases (a) "players are determined by roles" and (b) "roles are determined by contexts" can be grasped more precisely. (a) refers to individuals, since individual roles say something about their individual player. On the contrary, (b) needs a universal interpretation: in order to explain a certain role universal, one will refer to the appropriate context universal rather than to the player universal.

To sum up, there are difficulties in aligning social roles with the general model of roles, players, and contexts in the same way as compared to relational and processual roles, which indicates that social roles may have a different status. Hence, selected role issues shall be analyzed next in order to gain some insights on social roles and on their relations to relational and processual roles. Moreover, we have only dealt with plays and role-of for individuals so far, but it will be instructive to consider their lifting to universals.

Role Issues

Are roles individuals or universals?

This appears to be one of the most frequent issues in role-related literature, with two options. (1) On the one hand, one may assume role individuals and role universals, which is the view assumed in the previous section. (2) On the other hand, role can be understood as a term for a certain kind of universals, without admitting instances of roles which are different from their players, i.e., the plays relation coincides with instantiation.

Conceptual Considerations *Conceptually*, we admit that these options are mutually exclusive and one of them should be chosen. For relational and processual roles the first option is assumed without further discussion, referring to (Loebe 2003). Rather, social roles are put into the focus. One observes that recent object-oriented works directly advocate the first option (Dahchour, Pirotte, & Zimányi 2004), whereas in knowledge representation, Guarino and colleagues (Guarino 1992; Masolo *et al.* 2004) clearly promote the second option, which may also be attributed to Sowa (Sowa 2000, p. 81)[6]. However, (Masolo *et al.* 2004) also concedes that it may be useful to consider individuals which they call *qua-individuals* and which seem to correspond to role individuals.[7]

In our opinion, there are situations which can better or even only be modeled if role individuals are at hand which differ from player individuals. For instance, role individuals allow to solve the famous *counting problem* (How many passengers vs. how many people were transported? (Wieringa, de Jonge, & Spruit 1994)), and they are required for representing *multiple instantiation* which is admissable for some role universals (Steimann 2000).[8]

A closely related issue in the object-oriented field is whether there is *role identity* in addition to object identity (ibid.), i.e., do roles have their own identity? Advocating role individuals does not necessarily lead to the acceptance of role identity, but this choice is considered more adequate for social roles. For example, someone studying twice at the same university with a long break in between will formally be a different student (e.g. identifiable by a different registration number) than the first time.

One drawback of role individuals is a multiplication of entities, i.e., that apart from John there is another entity John-as-a-student (cf. (Masolo *et al.* 2004)). However, we consider this conceptually more appropriate and would prefer to tackle the arising complexity by appropriate representation formalisms. Ideas for that may be drawn from the common use of natural language terms for both, role universals as well as the player universals which they induce, e.g. the subuniversal of humans presently playing a student role. For instance, the term student in the sentence "all students should now leave the room" needs to be understood as a player universal, whereas "all students have a registration number" refers to the corresponding role universal. Hence, *delegation* in the sense of object-oriented role models (Dahchour, Pirotte, & Zimányi 2004) needs to work in either direction between a role and its player.

Terminological Considerations Having settled the conceptual part, yet *terminological* issues need to be accounted for. For *role individual*, the literature provides terms like *qua-individual*, *adjunct instance* or *role* itself; analogously, for *role universal* there are *role type*, *role class*, *role kind*, etc., again including *role* itself. We do not aim at prescribing the use of non-role terms like qua-individual, all the more as there may be other facets of its underlying meaning which do not fit our notion of roles.

Regarding the term *role* itself we suggest leaving it unspecified with respect to instantiation. This proposal is inspired by (Genilloud & Wegmann 2000), which also contains a discussion of the individual-or-universal question for roles, initially stating that it is the false question to ask because commonly in natural language the same term denotes some instance of a universal or some sub-universal of it. Following this route explains why natural language phrases need careful reading, with varying adequacy for individuals and universals. For example, for roles it is often required that "different entities can play the same role", which can be read meaningfully in three ways:

1. "different entity individuals can play different role individuals of the same role universal"
2. "different entity universals are possible player universals for the same role universal"
3. "different entity individuals can play the same role individual"

Admittedly, the third reading may be a moot point, but it is still conceivable for temporally extended role individuals

[6] However, Sowa's hierarchies of categories also suggest the first option (ibid., p. 87 and 502 ff.), such that it is not completely clear to us which option Sowa advocates.

[7] Note that we are not familiar with all philosophical roots of qua-individuals. It seems that their origin is not directly related or even restricted to the problems of roles. Further, there is a varying degree of the flexibility of this notion up to the general idea of qua-phrases, i.e., phrases of the form "x qua y". This includes expressions like "to be good qua cook" which are not within the scope of this paper. A discussion of these from a knowledge representation perspective can be found in (Sowa 2000). For a deeper elaboration on the notion of qua-individuals including philosophical connections the reader is referred to (Masolo *et al.* 2004) and the paper of Bottazzi, Ferrario, et al. in the same volume.

[8] We disagree with (Masolo *et al.* 2004) in that multiple instantiation could be tackled in every case by specializing role universals. For instance, one may hold two mail accounts at the same mail provider, which means that there are two mail account owners played by the same human.

which may undergo *role transfer*, e.g. an individual prime minister role may be viewed to continue even if its player changes. Of course, the latter is only possible for social roles, since all role individuals are dependent on exactly one player at a time (cf. the non-migration principle for relational roles above).

Concerning the commitment to role individuals which are distinct from players, there is not yet a difference between social, relational, and processual roles since that commitment applies to all types. However, note that some issues from above involve roles with qualities, which primarily occur in connection with social roles.

Players, Natural Universals and Ontological Levels

In the second reading of "different entities can play the same role" from above the phrase "possible player universal" was used, which leads to another recurrent notion in connection with roles, namely that of *natural universals*. There are several terms in the literature which are more or less synonymous, e.g. *natural type* (Guarino 1992), *natural kind* (Wilkerson 1995), *phenomenon* (Sowa 2000, p. 80), *base classifier* in UML (Rumbaugh, Jacobson, & Booch 1999, p. 194 ff.), *basic concept* in (Kozaki *et al.* 2002), or *object class* like in (Dahchour, Pirotte, & Zimányi 2004). For example, human is a natural universal as contrasted with the role universal patient. Note that each of those terms is a meta-universal, in line with Guarino's introduction of *natural type* and *role* as an account of types of universals.

It is one of the most salient features of role accounts in computer science to contrast role universals with natural universals. Instances of the latter are frequently used to model admissible universals for particular roles, i.e., to express restrictions on the players of certain roles. Put differently, natural universals are a means to refer to (admissible) players of a role by their internal structure. In contrast, role universals themselves induce universals of role players.

Natural and role universals can be linked by a lifting of the *plays* relation to the universal level, with an appropriate reinterpretation. In its weakest form, this reading is such that individuals of some natural universal *can* be player individuals for some role, but there may be other, unspecified natural universals from which players could be recruited. Stronger interpretations restrict all players of a role to belong to one of those natural universals specified, hence applying a closed-world assumption to models in this respect. Some proposals even admit only a single natural universal for a role (Dahchour, Pirotte, & Zimányi 2004), which we consider too restrictive, though.

How do the role types relate to natural universals? Asking for top-level categories subsuming natural universals with respect to our role types, it seems that any entity may play a relational or a processual role, which means to have no restrictions for these types. On the contrary, social roles are commonly played by objects, often *material objects*.

Therefore, and not least due to the term "*natural* universal", the question arises of how these relate to the distinction between *material* and *social entities*. This distinction reminds one of *ontological levels* (Poli 2001). Roughly speaking, several levels of entities are assumed and related by existential dependence, which introduces an orthogonal dimension for ontologies compared to common category hierarchies like the GFO. However, the notion of natural universals in the sense of (Guarino & Welty 2001) or (Wilkerson 1995) is broader than just capturing entities of the material level, hence social roles cannot be tackled by ontological levels only. *Customer* is a good example in this connection (cf. (Steimann 2000)), since not only (material-level) humans can be customers, but also (social-level) companies.[9]

Complementary and Pure Roles

Natural universals have provided a first distinction between social vs. relational and processual roles, thereby referring to the *plays* relation lifted to universals. The equivalent lifting of *role-of* will be considered next. Put differently, the question arises which role universals *complement* a given role universal in a certain context. An instructive example is provided by kinship relations (hence speaking about relational roles), e.g. asking for roles which are complementary to the father role. There are several possibilities, comprising child, son, or mother, among others. This shows the requirement to explicate role complements also among universals (cf. role bases in (Loebe 2003)), which can be achieved by assigning role universals to context universals. As a trivial example, father and son may be assigned to the context of the father-son relation. Another example can be derived from the sentence "John is a student of mathematics at Leipzig University.", which is analyzed by means of two relations. First, in r_a John plays a relational role q_{a1} and the subject of maths plays q_{a2}. Secondly, in r_b John takes the role q_{b1}, whereas q_{b2} is played by the university. In both cases the roles of John, q_{a1} and q_{b1} could be termed a "student" role in natural language, which would mean that q_{a1} and q_{b1} are instances of one universal Q_x. However, we argue that q_{a1} and q_{b1} instantiate distinct universals Q_{a1} and Q_{b1} of relational roles, in conformance with the two different contexts r_a and r_b instantiating R_a and R_b. Accordingly, when describing, say, R_a on a universal level, we need to specify that its instances involve roles of the types Q_{a1} and Q_{a2} which is equivalent to saying that Q_{a1} and Q_{a2} are complementary roles. Q_x may in this case be understood as a universal subsuming Q_{a1} and Q_{b1}. For Q_x one would have to look for an appropriate complementary universal Q_y.

These examples show further that subsumption among role universals exists, e.g. a father is a parent, and a son is a child.[10] One can further observe that some universals originate from a mixture of role aspects and structural aspects, e.g. a father is a male parent, where *male* originates from the natural universal human and *parent* refers to a role. Such knowledge should be explicated in modeling, marking *pure* role universals like parent and child.

[9] For such cases, an appropriate modeling pattern involving *role mixins* is provided in (Guizzardi *et al.* 2004), which can be used to model hierarchies with both, natural universals and role-induced player universals (i.e., leaving roles implicit).

[10] Note that this relates to the question of *role-playing roles*, which we cannot be discussed here due to space restrictions. Cf. (Loebe 2003, sect. 3.5.4).

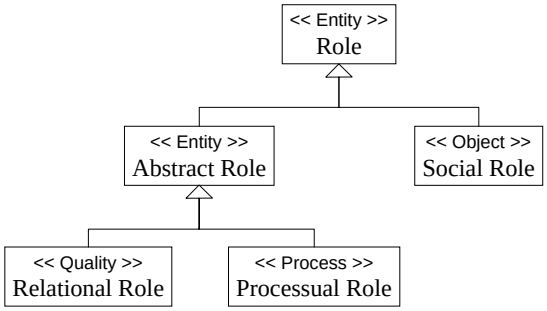

Figure 2: Types of Roles

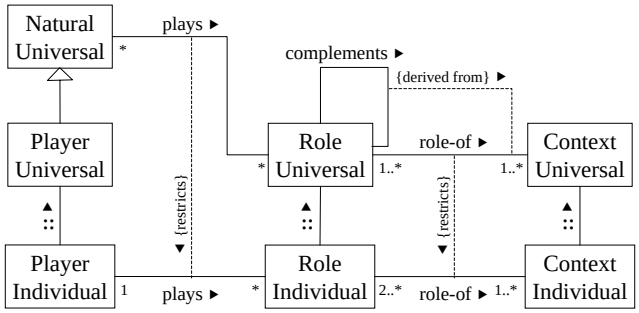

Figure 3: Extended Role Model

A Revised Approach to Roles

The considerations in the previous section lead us to an extension of the role model described thus far with respect to the status of the three role types and an extension of *plays* and *role-of* to the universal level, as summarized in figures 2 and 3.[11]

Abstract Roles vs. Social Roles

Due to their similarity, relational and processual roles are subsumed by a new role type called *abstract roles* which is contrasted with *social roles*. Abstract roles can be functionally characterized in a uniform manner, namely as a mechanism of viewing some entity – namely the player – in a defined context, i.e., in a more complex entity with interrelated other "notional components". Put differently, players of abstract roles are looked at in an *external* manner in contrast to viewing them as self-contained entities focussing on their *internals* like their qualities or parts.

This general reading of abstract roles is contrasted with *social roles*, which captures certain individual objects on a social ontological level, hence possessing a dependence on other objects (frequently, but not exclusively from the material level) which "count as" (Searle 1995) something else.[12] Due to being objects, social roles have their own qualities, relations, and processes in which they participate. Relations and processes seem to be of prior relevance for social roles.[13] Viewing a patient as a social role, with a patient ID and possibly some assignments in the form of rights, norms or duties makes it hard to determine clear complements as compared to relational roles in a patient–physician relation. Indeed, social roles rather aggregate various relational and processual roles. Accordingly, for an understanding of social roles, the context becomes rather vague and implicit, and the focus shifts to the internals of social roles as well as to their relations to players, as discussed above.

[11] The stereotypes $\ll \ldots \gg$ in figure 2 indicate role-independent supercategories. For example, Relational Role is subsumed by Quality. In figure 3, :: denotes instantiation.

[12] Note that in addition to objects, "counts as" seems to be applicable at least to processes. However, as indicated in figure 2, we argue that social role terms exclusively apply to objects, whereas the case of processes requires further analysis.

[13] In a sociologal, role-theoretic understanding, roles are even identified with "patterns of behavior", cf. (Biddle 1979).

Relations to the Literature

In our opinion, the aspects of abstract and social roles are intermingled in the literature. For example, from a general perspective, the given characterization of roles is in line with those of (Sowa 2000), (Guarino 1992; Masolo *et al.* 2004) and (Kozaki *et al.* 2002), who refer to a dependence of roles on (patterns of) relationships to external entities. But here, relationship needs to be understood as general as our context. However, if relations are understood as a certain modeling element, possibly in distinction from processes or other ontological categories, it is proposed to not follow this definition any more, since it then coincides with our relational roles, no longer covering the other types.

Further, Guarino et al. take anti-rigidity as the second criterion to distinguish role universals from other kinds of universals (Guarino & Welty 2001). A universal is anti-rigid if for each of its instances it is not essential to belong to that universal. For example, it is not necessary for any human to be a patient or a student – even in case one is a patient from birth on due to some chronic illness. However, in our opinion there are a few cases where this definition rules out certain roles. The role universal child should be an illuminating example, understood as someone who was born by a woman.[14] According to this definition each human is necessarily a child. In the case of processual roles, one may also find processes for which it is necessary for certain natural individuals to participate in, for instance breathing for humans.

Extension of *Plays* and *Role-of*

Lifting the plays and the role-of relations to the universal level represents the second aspect of the extension of our role model. Note that we have not introduced new terminology for that level, but the interpretation of plays and role-of differs from their individual readings discussed above. In brief, *plays* on the universal level is used to link natural universals as potential players to role universals. *Role-of* links role universals to a context universal, thus expressing the fact that such contexts are composed of such roles, from which one can derive which role universals complement each other.

[14] Note that we consider the definition of child as a human aged under 18 as a different concept.

Status of *Player*, *Role* and *Context*

Finally, a remark on our understanding of the notions of player, role, and context is required. These are not considered to refer to entities in their own right, but themselves refer to roles certain entities play in respect to each other. As described above, possible natural universals for the role of providing a context are relation, process, and social entity. This consideration seems to apply to roles as well, which is supported by the distinct ontological nature of entities instantiating the presented role types. Their commonality of being named "roles" could indeed be derived by features of role universals, which would conform to approaches like (Guarino 1992). Nevertheless, the analysis has uncovered some seemingly novel entities like processual roles. We argue that these require attention in an analysis process. In order to rename these instead of calling them roles, a more structural definition of them would be required, which remains future work.

A Comprehensive Example

Figure 4 illustrates an analysis in the domain of clinical trials in terms of our revised role model. This situation can be described as follows:

> John is a patient in the clinical trial CLL9. He has the patient id 1054B32 and is treated within the trial by Sue, who is a physician.

The primary organization of the figure corresponds to the distinctions between individuals and universals (vertically separated by the imaginary line along the :: symbols) and between material and social entities (horizontally, sue is the right-most material entity). The first observation concerns the lower left-hand side, where John and Sue are understood as individual humans john and sue.

The next question concerns the notion of patient. It is understood as a social role (patient john), because it exhibits a quality – 1054B32, an instance of the universal Patient ID.[15] In a sense, representing patient as a social role is also a modeling decision. The other option is to stop the analysis by modeling patient as a relational role in some relation to the clinical trial. Here, instead, patient as well as clinical trial are to be further analyzed.

If patient john is a social role, there should be a context for that role. It is provided by cll9 which instantiates Clinical Trial (Context), a social object universal. cll9 is very closely related to the actual trial process (the unnamed instance of Clinical Trial), but it is not considered the same herein. Rather, that context object appears to emerge from the interaction of people involved in planning and execution

[15]Note that this example of a quality is not particularly nice, and a deeper analysis involving symbols and denotation may result in a better analysis, rather than using instantiation as a "modeling shortcut". Moreover, relational and behavioral characteristics seem to be much more relevant for social roles than intrinsic qualities (cf. (Biddle 1979)). However, as these would require an even more complex example, we have considered this simplification to be appropriate.

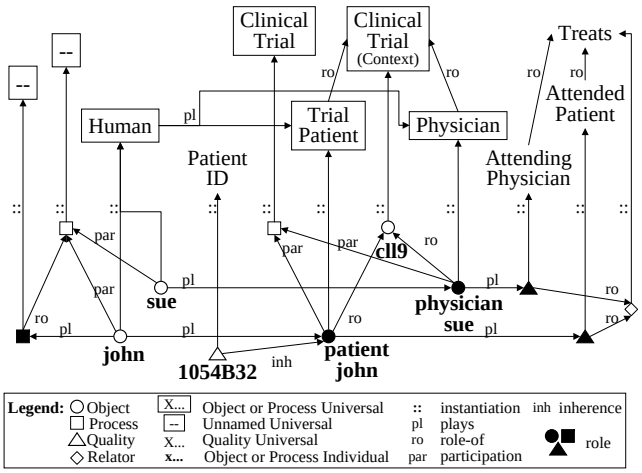

Figure 4: Comprehensive Example with All Role Types.

of the trial, and it does not have that outstandingly temporal nature of the trial process.[16]

The trial process is a social process with a material reflection. We are not aware of a suitable, short term for this type of entity, therefore an instantiation of an unnamed universal is indicated for this reflection process (a line to the trial process is omitted). joe and sue participate in that process (on the material level), hence it serves as a context of processual roles for each of them. Note that the processual role of sue is not depicted for space reasons.

Sue also plays a social role, because for the physician sue the same arguments apply as for patient john above. In contrast, the fact that Sue treats John is not further analyzed and thus modeled as a Treats relator with two relational roles. Finally, note that on the universal level several constraints are expressed by means of "lifted" plays and role-of connections (cf. above). In this simple example it can easily be verified that the individual level satisfies all of them.

This example demonstrates two aspects of our role account. On the one hand, it provides various distinctions which allow for fine-grained analyses. On the other hand, as such it is hardly directly applicable for modeling, and it requires support in terms of some representation mechanism. Moreover, some open problems remain, like the interrelation of Clinical Trial and Clinical Trial (Context).

Conclusion

The main contributions of this paper can be summarized as follows. Firstly, we have presented a general account of roles involving the notions of *player*, *role*, and *context* as well as their interrelations on an individual and universal level. Moreover, a classification of roles is provided, dividing roles into *social* and *abstract roles*, and the latter further into *relational* and *processual roles*. This classification is a refinement of the one developed in (Loebe 2003), in that

[16]Unfortunately, clinical trials are not institutionalized – at this point an example with a student role whose context is provided by a university could be more convincing.

the importance of contexts is no longer stressed for social roles. Rather, the comparative reconsideration of selected issues for social and abstract roles has revealed that their internal structure is more relevant for social roles than providing an explicit context. On the contrary, abstract roles are understood as a mechanism for viewing something in a given context.

We hope to provide an expressive account of roles which should be general enough to integrate others, e.g. more specialized approaches with a focus on one of our role types. Of course, there are many other aspects frequently discussed with roles, like their dynamic character, which could not be covered herein. Another line of extension of this work amounts to the integration of our results into representation formalisms or methodological approaches.

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