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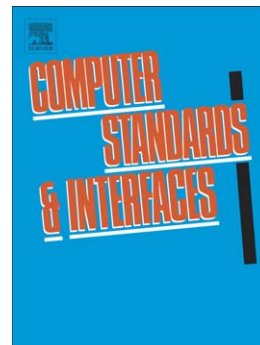
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An Ontological Analysis of the Notion of
Community in the RM-ODP Enterprise Language

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Abstract — **In our past work, we have shown that a number of theories from conceptual modelling and ontological analysis can be used to clarify the definitions of role-related and goal-related concepts in the RM-ODP [1, 2]. This paper builds up on our earlier efforts by providing an ontology-based account for the notion of communities in the reference model's Enterprise Language [38]. We address issues regarding the composition of communities, the filling of roles in communities, the decomposition of a community's objective into sub-objectives (delegated to community members). The use of an ontology that deals with aspects of social reality and intentionality [30] plays an important role in this account, revealing the intentionality of communities and enterprise objects; the social relations between communities and enterprise objects in the community; the social relations between objects in the community; the social relations between communities; the normative character of a community's contract, etc. The analysis allows us to propose well-founded recommendations for clarifications and identify potential amendments to the standard as well as issues for further investigation.**

Keywords: enterprise viewpoint, enterprise language, foundational ontology, social concepts, community

1 INTRODUCTION

As a comprehensive framework for open system specification, the Reference Model of Open Distributed Processing (RM-ODP) addresses the organizational environment in which the system is to be embedded, a concern addressed by the reference model's enterprise language [38]. The enterprise language has a sophisticated and widely applicable set of concepts capable of addressing a variety of phenomena in the organizational environment of a system, including the internal structuring of organizations and the establishment and evolution of networks of interacting and federated organizations.

While the concepts and definitions of the RM-ODP foundations have been very influential and are taken to be a reference for the modelling of open systems, some of these concepts or their definitions have been subject of criticism, debate and revision in the literature [44, 45, 20, 52]. As we argued for in [1], we believe this serves to strengthen the definitions and to further consolidate the RM-ODP conceptualization as a basis for communication, consensus and standardization in the context of open systems.

We have observed that a number of theories arising from conceptual modelling and ontological analysis can support us in the task of clarifying the intent behind some definitions in the reference model, as well as align competing proposals or interpretations for its concepts. These observations have led us to the analysis of RM-ODP's role-related concepts [1] and goal-related concepts [2] using the Unified Foundational Ontology (UFO) [29, 30] as our semantic foundation.

This paper builds up on the results reported in these earlier works studying in detail the aspects related to the composition of *communities*, the filling of *roles* in communities, the decomposition of a community's *objective* into sub-objectives (which are delegated to community members). Our analysis is centred on the notion of *community*, which is a fundamental structuring concept for enterprise specifications: "a community is a configuration of enterprise objects that describes a collection of entities (e.g. human beings, information processing systems, resources of various kinds and collections of these) that is formed to meet an objective." [38].

In this setting, we have identified that the study of the whole-part relations underlying some of the definitions in the standard is of great importance to provide a thorough ontological account of the notion of community in the enterprise language. Further, since our account of the enterprise language concepts is in line with [44], which points out "that enterprise behaviour has an additional dimension of social behaviour", the use of an ontology that deals with aspects of social reality and intentionality [30] plays an important role in this account, revealing the intentionality of communities and enterprise objects that play roles in it; the social relations between communities and enterprise objects in the community; the social relations between objects in the community; the social relations between communities; the normative character of a community's contract, etc. The analysis allows us to propose well-founded recommendations for clarifications and identify potential issues for amendments to the standard.

This paper is structured as follows: Section 2 reviews the fragment of the RM-ODP that is addressed in the scope of our investigation, focussing on the concept of community and the related concepts necessary to characterize communities. Section 3 presents the semantic foundation to be employed in our analysis. Section 4 presents the analysis of the reference model's fragment. Finally, Section 5 presents our conclusions and outlines some topics for future research.

2 CONCEPTS IN THE REFERENCE MODEL

The reference model defines a framework for the specification of ODP systems which has five viewpoints, called enterprise, information, computational, engineering and technology viewpoints. In each of the aforementioned viewpoints, a viewpoint language defines the concepts and rules for developing, representing and reasoning about the specification of an ODP system from that viewpoint [38].

This section reviews the fragment of the enterprise viewpoint which we consider in this paper. The definitions presented here are defined in ITU-T Rec. X.911 / ISO/IEC 15414 [38].

2.1 ISO RM-ODP Enterprise Language

The standard defines that "an enterprise specification states the objective of a community, how it is structured, what it does, and what objects comprise it" (including an enterprise object which is the ODP system). A *community* is "a configuration of enterprise objects that describes a collection of entities (e.g. human beings, information processing systems, resources of various kinds and collections of these) that is formed to meet an *objective*." Every community in an enterprise specification has exactly one objective, which is defined as "practical advantage or intended effect, expressed as preferences about future states." The purpose of an ODP system is expressed as one or more objectives (or sub-objectives) of the community or set of communities in which the ODP system fulfils roles.

The objective of a community is expressed in a contract which specifies how the objective can be met. More specifically, policies in the enterprise contract constrain the behaviour and membership of communities in order to make them achieve their objectives. The behaviour that the community is expected to exhibit is defined in terms of *roles* or *processes* or both, *policies*, and the relationships of these.

An enterprise specification may decompose the objective of a community into sub-objectives. A sub-objective may be assigned to a collection of roles; in that case, the behaviour of the collection of roles is specified to meet the sub-objective and the sub-objective is met by the collection of objects performing the actions of the collection of roles. Further, a sub-objective may be assigned to a process ("A collection of steps taking place in a prescribed manner and leading to an *objective*."). In that case, the process is specified to meet the sub-objective and the sub-objective is met by the actions of objects performing the process. In this case, the sub-objective defines the state in which the process terminates.

The composition of the objects in a community results in a composite community-object. Composition in RM-ODP Part 2 [37] is defined as "a combination of two or more objects yielding a new object, at a different level of abstraction. The characteristics of the new object are determined by the objects being combined and by the way they are combined." The use of composition is key to RM-ODP's hierarchical perspective on an enterprise specification, in which a community is regarded as a composite community-object which may fulfil a role in another community. In this case, the objective of the community of which the community-object is an abstraction is consistent with any sub-objectives assigned to that role in the other community. Moreover, "one or more roles in a

community may identify behaviour that includes interactions with objects outside that community; these are *interface roles*."

In addition to defining a number of related concepts, the enterprise language also defines a number of structuring rules, which are also the subject of our analysis in this paper. These structuring rules are introduced when necessary in section 4.

3 ONTOLOGICAL FOUNDATIONS

Ontology is that branch of philosophy that "studies the most pervasive features of reality" [17]. The idea behind *ontological analysis* is to provide a sound foundation for modelling concepts, if assumed that such concepts are aimed at representing reality [17]. Several recent efforts have shown the benefits of ontological analysis [3, 22, 23, 32, 56, 59], which include: (i) the rigorous definition of modelling languages in terms of real-world semantics for their modelling constructs; (ii) the identification of inappropriate constructs which can reveal problems in the definition, interpretation and/or usage of concepts, and (iii) recommendations for language improvement to reduce lack of expressivity, ambiguity and vagueness.

Besides providing a clear semantic account for language constructs, ontology-based techniques have shown to be useful for language comparison and integration [11, 17, 29, 34], as a basis for the communication between business and IT experts [40], and, when the ontology itself is described in a formal language, as a basis for model simulation and validation [6].

Before we perform an analysis of the enterprise language concepts, we present here an ontological foundation on which we base our analysis. We will use concepts of a reference ontology called Unified Foundational Ontology (UFO) discussed in depth in [29, 30, 33]. UFO unifies several foundational ontologies and has been developed with the purpose of providing foundations for conceptual modelling based on philosophically well-founded principles as well as capturing the ontological distinctions underlying human cognition and common sense. It has been developed by adapting and extending a number of theories coming from the areas of formal ontology in philosophy, linguistics, philosophical logics and cognitive science, and building in the works of various classical and contemporary authors from these disciplines such as Husserl, Kripke, Strawson, Quine, Goodman, Chisholm, Gardenfors, Simons, Wiggins, Montague, Lowe, Varzi, Bunge, among many others.

Our choice has also been justified by successful employment of the reference ontology in previous works to evaluate, re-design and integrate the models of conceptual modelling [29, 30] and enterprise modelling [3, 11, 34, 56, 42, 43, 18, 41]. For a fuller discussion regarding this foundational ontology, one should refer to the aforementioned references. Extensive discussion on the philosophical work that has influenced the reference ontology can be found in [29], as well as the position of UFO with respect to foundational ontologies such as the Ontology of Universals underlying OntoClean [25] and GFO/GOL [36]. A discussion on the basic criteria to justify the usage of theories and empirical evidence from cognitive sciences in the design of the reference ontology can be found in [24]. Further, [29] discusses how the chosen theories have been corroborated by thought experiments in philosophy and/or are supported by an extensive body of empirical evidence in cognitive psychology.

We focus here on the UFO fragment concerned with aspects of social reality and intentionality, as these aspects are pervasive in the organizational environments that form the universe of discourse of the Enterprise Language. We present only those elements needed for our ontological analysis, starting from the basic ontological distinctions in UFO's core and then proceeding to the layer of intentional concepts and the layer of social concepts.

3.1 Basic Elements

We start with the fundamental distinction between <u>universals</u> and <u>individuals</u>. The notion of universal underlies the most basic and widespread constructs in conceptual modelling. <u>Universals</u> are predicative terms that can possibly be applied to a multitude of individuals, capturing the general aspects of such individuals. <u>Individuals</u> are entities that exist instantiating a number of universals and possessing a unique identity. Individuals can be further classified into <u>Endurants</u> and <u>Events</u> (also known as <u>Perdurants</u>).

<u>Endurants</u> are individuals said to be wholly present whenever they are present. Endurants are in time in the sense that if we say that in circumstance c1 an endurant e has a property P1 and in circumstance c2 the property P2 (possibly incompatible with P1), it is the very same endurant e that we refer to in each of these situations. Examples of endurants are a house, a person, the moon, an enterprise and an ODP system.

A fundamental distinction in UFO is between the categories of Substantials and Moments. A Substantial is an Endurant that does not depend existentially on other Substantials[1], roughly corresponding to what is referred by the common sense term "object". In contrast with Substantials, we have Moments which are existentially dependent entities. For a Moment x to exist, another individual must exist, named is bearer. Examples of Substantials include a person, a house, a planet, and the Rolling Stones; examples of Moments include John's weight and John and Mary's marriage. Existential dependence can also be used to differentiate Intrinsic Moments Relational Moments (or Relators). Moments are classified into Intrinsic Moments when existentially dependent on a single entity and Relators otherwise. Examples of the intrinsic moments include a (objectified) colour, a headache, a temperature; examples of the relators include an employment, a covalent bond, and a marriage. For instance, John and Mary's marriage is an example of a Relator that is dependent on both John and Mary.

Another important distinction in the UFO ontology is within the categories of relations. Following the philosophical literature, it recognizes two broad categories of relations, namely, material relations and formal relations relations. Formal relations hold between two or more entities directly, without any further intervening individual. Examples include the relations of existential dependence (ed), Subtype, instantiation (::), formal parthood (<), inherence (i), among many others not discussed here [29]. Domain relations such as working at, being enrolled at, and being the husband of are of a completely different nature. These relations, exemplifying the category of Material relations, have material structure of their own[2]. Whilst a formal relation such as the one between Paul and his headache x holds directly and as soon as Paul and x exist, for a material relation of being treated in between Paul and the medical unit MU1 to exist, another entity must exist which mediates Paul and MU1. These entities are termed relators.

Relators are individuals with the power of connecting entities. For example, a medical treatment connects a patient with a medical unit; an enrolment connects a student with an educational institution; a covalent bond connects two atoms. Again, relators are special types of moments which, therefore, are existential dependent entities. The relation of mediation (symbolized m) between a relator r and the entities r connects is a sort of (non-exclusive) inherence and, hence, a special type of existential dependence relation. It is formally required that a relator mediates at least two distinct individuals [29].

An important notion for the characterization of relators (and, hence, for the characterization of material relations) is the notion of foundation. Foundation can be seen as a type of historical dependence [16]. Suppose that John is married to Mary. In this case, we can assume that there is an individual relator m_1 of type marriage that mediates John and Mary. The foundation of this relator can be, for instance, a wedding event or the signing of a social contract between the involved parties. In other words, for instance, a certain event e_1 in which John and Mary participate can create an individual marriage m_1 which existentially depends on John and Mary and which mediates them. The event e_1 in this case is the foundation of relator m_1.

Now, let us elaborate on the nature of the relator m_1. There are many intrinsic moments that John acquires by virtue of being married to Mary. For example, imagine all the legal responsibilities that John has in the context of this relation. These newly acquired properties are intrinsic moments of John which, therefore, are existentially dependent on him. However, these moments also depend on the existence of Mary. We name this type of moment externally dependent moments, i.e., externally dependent moments are intrinsic moments that inhere in a single individual but are existentially dependent on (possibly multiple) other individuals. The individual which is the aggregation of all externally dependent tropes that John acquires by virtue of being married to Mary is named a qua individual (in this case, John-qua-husband-of-Mary). A qua individual is, thus, defined as an individual composed of all externally dependent moments that inhere in the same individual and share the same foundation. In the same manner, by virtue of being married to John, Mary bears an individual Mary-qua-wife-of-John.

The notion of qua individuals is the ontological counterpart of what has been named *role instance* in the literature [66] and represent the properties that characterize a particular mode of participation of an individual in a relation. Now, the entity which is the sum of all qua individuals that share the same foundation is a relator. In this

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[1] Technically, a substantial does not existentially depend on other substantials which are disjoint from it [29].

[2] As discussed in [29], the distinction between formal and material relations is analogous to another distinction among relations, namely the one between bonding and non-bonding relations as proposed by Bunge [8]. For Bunge, bonding relations are the ones that alter the history of the involved relata.

example, the relator m_1 which is the aggregation of all properties that John and Mary acquire by virtue of being married to each other is an instance of the relational property marriage. Finally, there is an intimate connection between qua individuals and role universals: let T be a kind instantiated by an individual x, and let R be a role universal specializing T. We have that there is a qua individual type Q such that x instantiates R iff x bears an instance of Q. Alternatively, we have that for every role universal R there is a relator universal RR such that x instantiates R iff x is mediated by an instance of RR. Note that this conforms to the formal property of roles as relationally dependent types [62]. So, in the aforementioned example, John is not only an instance of a "Person" universal but also an instance of a "Husband" universal, while Mary is an instance of a "Wife" universal by virtue of being mediated by a relator of type Marriage.

Situations are special types of endurants. These are complex entities that are constituted by possibly many endurants (including other situations). Situations are taken here to be synonymous to what is named state of affairs in the literature, i.e., a portion of reality that can be comprehended as a whole. Examples of situations include "John being with fever and influenza", "John being in the same location as Paul while Mary is in the same location as David", "Mary being married to Paul who works for the University of Twente".

Events (Perdurants), in contrast with Endurants, are individuals composed by temporal parts, they happen in time in the sense that they extend in time accumulating temporal parts. An example of an Event is a business process. Whenever an Event occurs, it is not the case that all of its temporal parts also occur. For instance, if we consider a business process "Buy a product" at different time instants when it occurs, at each of these time instants only some of its temporal parts are occurring. Finally, we can consider Events as possible transformations from a portion of reality to another, i.e., they may change reality by changing the state of affairs from one (pre-state) situation to a (post-state) situation.

3.2 Intentional Elements

UFO has been extended to incorporate *intentionality* to this basic core [30, 33]. In this context, UFO distinguishes between Agentive and Non-agentive substantial individuals, termed here Agents and Objects, respectively.

Agents are substantials capable of bearing special kinds of moments named Intentional Moments. As argued in [58], intentionality should be understood in a much broader context than the notion of "intending something", but as the capacity of some properties of certain individuals to refer to possible situations of reality.

Every intentional moment has a type (e.g., Belief, Desire, Intention) and a propositional content. The latter being an abstract representation of a class of situations referred by that intentional moment. The precise relation between an intentional moment and a situation is the following: a situation in reality can satisfy the propositional content of an intentional moment (i.e., satisfy - in the logical sense – the proposition representing that propositional content).

Whilst a desire expresses a will of an agent towards a state of affairs in reality (e.g., a Desire that Brazil wins the Next World Cup), intentions are desired state of affairs for which the agent commits at pursuing (an intention is an internal commitment) (e.g., the Intention of going to a beach resort for the next summer break) [12, 58].

Actions are intentional events, i.e., events with the specific purpose of satisfying (the propositional content of) some Intention of an Agent. (In this sense, an Action can be said to be caused by the Intention.) The propositional content of an intention is termed a Goal. UFO contemplates a relation between Situations and Goals such that a Situation (or possibly a number of Situations) may satisfy a Goal. In other words, since a Goal is a proposition (the propositional content of an Intention), we have that a particular state of affairs can be the truthmaker of that proposition.

Figure 1 shows a fragment of UFO (adapted from [29] and [30]), with an emphasis on the distinctions discussed so far.
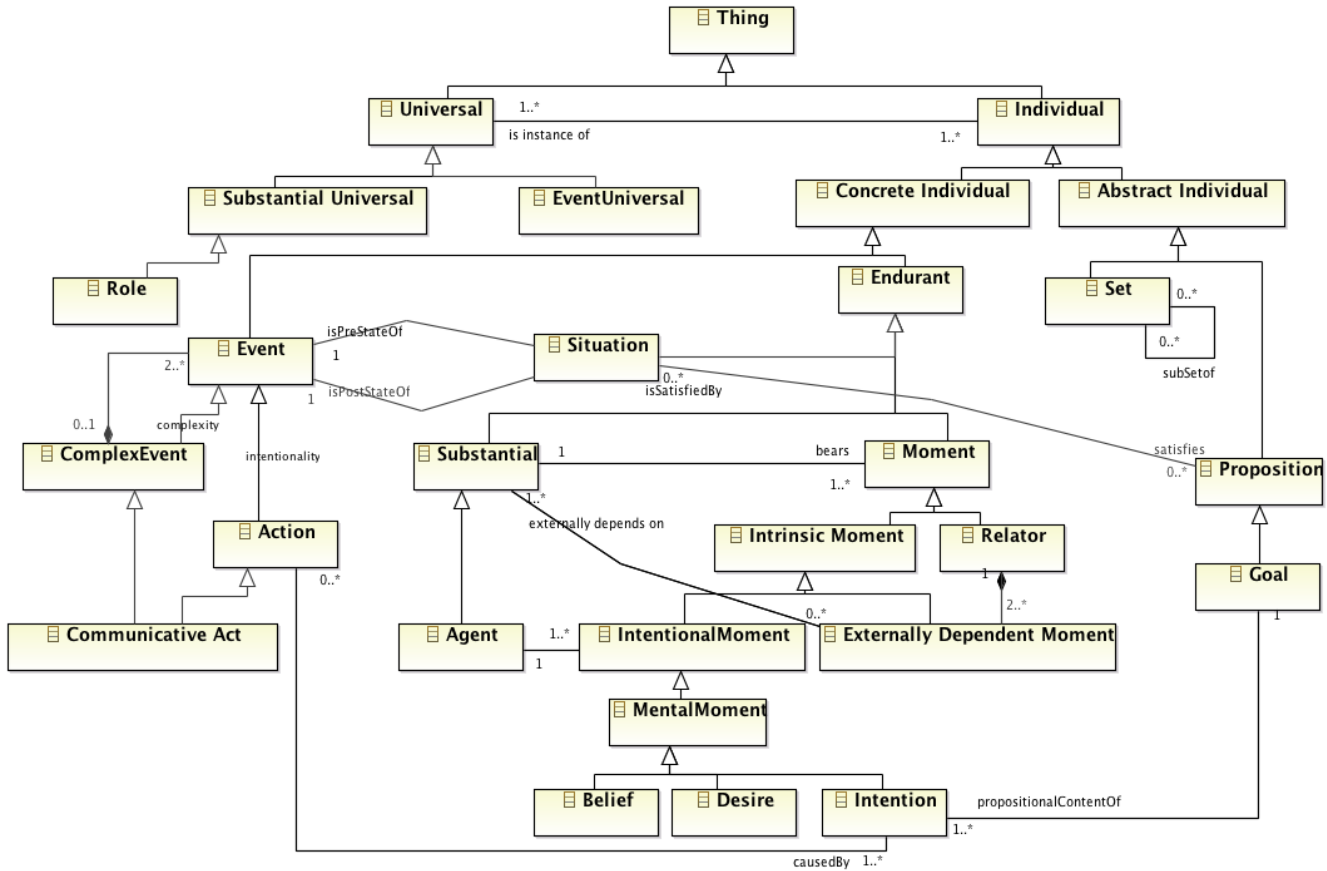
Figure 1 – UFO Fragment (adapted from [29] and [30])

3.3 Social Elements

Communicative Acts (special kinds of Actions) can be used to create Social Moments. In this view, language not only represents reality but also creates a part of reality [58]. Thus, social moments are types of intentional moments that are created by the exchange of communicative acts and the consequences of these exchanges (e.g., goal adoption, delegation [31]). For instance, suppose that John rents a car at a car rental service. When signing a business agreement, John performs a communicative act (a promise). This act creates a Social Commitment towards that organization: a commitment to return the car in a certain state, etc. (the propositional content). Moreover, it also creates a Social Claim of that organization towards John with respect to that particular propositional content. Commitments/Claims always form a pair that refers to a unique propositional content.

A Social Relator is an example of a relator composed of two or more pairs of associated commitments/claims (social moments). Finally, a commitment (internal or social) is fulfilled by an agent A if this agent performs an action x such that the post-state of that action is a situation that satisfies that commitment.

Communicative Acts can also be used to distinguish between Physical Agents (e.g., a person, a dog) and Social Agents (e.g., an organization, a society). Social Agents are created by communicative acts. In an analogous manner, objects can also be categorized as Physical Objects (e.g., cars, rocks and threes) or Social Objects (e.g., a currency, a language, the Brazilian constitution). Social Agents are composed by a number of other agents, which can themselves be Physical Agents, or other Social Agents. When Social Agents are integral wholes formed by multiple agents playing different roles they are further classified as Institutional Agents. An Institutional Agent exemplifies what is named a Functional Complex, i.e., a mereologically complex entity whose parts play different roles with respect to the whole. By instantiating each of these roles defined in the characterization of that Functional Complex Universal, each part contributes in a different way to the integral behaviour of the whole.

Communicative Acts can result in social objects called Normative Descriptions. The characteristics of descriptions have been discussed in [48], including (among others) that: "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"; "descriptions are usually accepted (adopted) by (communities of) intentional agents" and "acceptation can change in time." In the case of a social functional complex such as an Institutional Agent, the characterization of the universal instantiated by that agent is made via a Normative Description [5], which is said to define the institutional agent (including its Social Roles (e.g., president, manager, sales representative), Social Agent Universals (e.g., a political party, an education institution), Social Agents (e.g., the Brazilian Labour Party), Social Object Universals and other Social Objects (e.g., a piece of legislation, a currency) or other Normative Descriptions. Figure 2 shows a fragment of UFO (adapted from [29] and [30]) focussing on the social elements of the ontology.
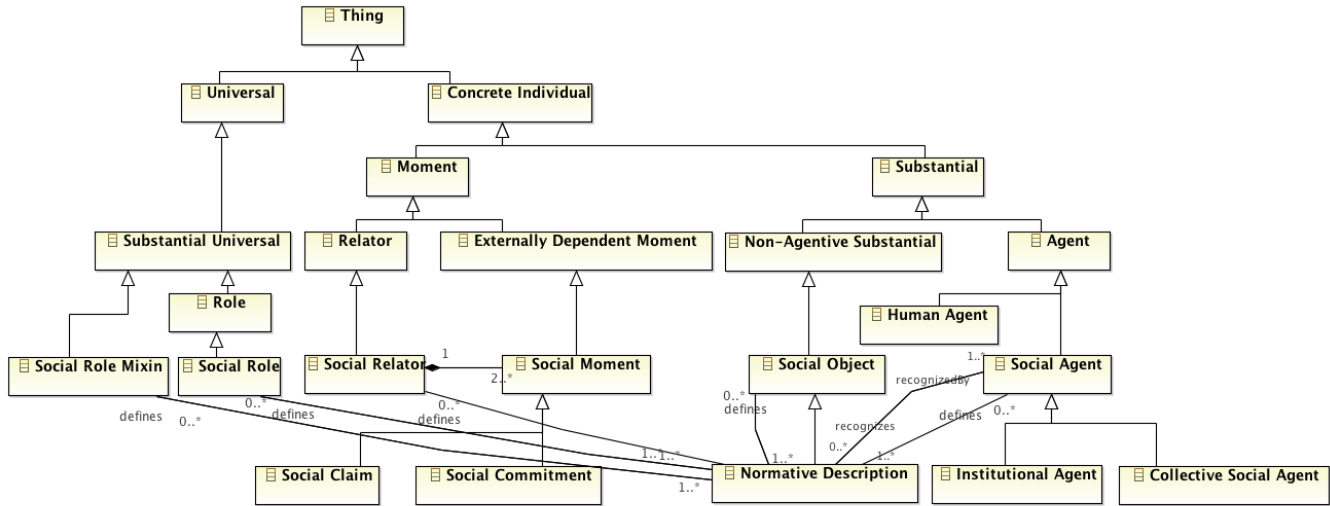

Figure 2 – UFO Fragment (adapted from [29] and [30])

3.4 Whole-Part Relations

In practically all formal theories of parts (Mereologies), the relation of (proper) parthood (symbolized as <) stands for a strict partial ordering, i.e., irreflexive, asymmetric and transitive relation [60]. Although necessary, these constraints are not sufficient, i.e., it is not the case that any partial ordering relation qualifies as a parthood relation. Most authors require at least an extra axiom termed the *weak supplementation principle (WSP)*, which basically requires that if an entity is not atomic then it must be composed of at least two disjoint parts [60]. The theory which incorporates the strict partial-order axioms plus WSP is termed Minimum Mereology (MM). However, for certain kinds of entities (e.g., quantities, events), a theory even stronger than MM is required, named Extensional Mereology (EM). EM strengths MM by including the so-called Strong Supplementation Principle (SSP) which implies an extensional principle of identity for entities that have a mereological structure governed by this theory. So, according to EM, two entities are the same iff they are composed by exactly the same parts.

As discussed in depth in [29], although mereological theories can provide sound and characterized formal semantics for whole-part relations, they are not sufficient to fully characterize the many different aspects of conceptual whole-part relations. These aspects include different modal properties of whole-part relations: for instance, while some whole-part relations characterize a relation of generic dependence, termed *mandatory parthood* (e.g., a car must have a carburettor), other whole-part relations characterize a relation of specific (or existential) dependence, termed essential parthood (e.g., a car must have that very specific chassis).

Another important aspect fundamental for a conceptual theory of whole-part relation is the characterization of complex entities as Integral Wholes. According to Simons [60], the difference between purely formal mereological sums and, what he terms, *integral wholes* is an ontological one, which can be understood by comparing their existence conditions. For sums, these conditions are minimal: the sum exists just when the constituent parts exist. By contrast, for an integral whole (composed of the same parts of the corresponding sum) to exist, a further

unifying condition among the constituent parts must be fulfilled (in other words, a "principle of unity" for the whole). As discussed in [29]: "the distinction between a mere sum and an integral whole also appears in Bunge's work [8, 9] in the form of the distinction between, what he terms, a mere aggregate and a system. Bunge defines a mere aggregate as 'a compound thing, the components of which are not coupled, link, connected or bounded [, and which…] therefore lacks integrity or unity' [9]. In contrast, the components of system are 'interrelated rather than loose'."

A unifying condition or relation can be used to define a closure system, i.e., a (perhaps complex) relation holding between the components of that whole and only between them. This is an important distinction between classical mereological theories, which focus solely on the relation from the parts to the wholes, and a suitable conceptual theory of parthood, which must also account for the relations holding between the parts that compose a whole. As discussed in [29], the principle of unity of an integral whole is strongly related to its properties: determining the parts of a whole is to determine those elements that contribute with the causal network of the properties of the whole. An integral whole persists in time maintaining that network, or, as system-theorists would say, maintaining its *organization* [50, 64]. Moreover, in parity with Bunge, the individual is the same as long as this network is maintained [8]. The view on integral wholes defended here is also in line with Hayek's view where he states that: "the coherent structures in which we are mainly interested are those in which a complex pattern has produced properties which make self-maintaining the structure showing it." [35] Given this characterization of integral wholes, we should note that both physical-mechanical and complex (biological or social) systems are "integral wholes" from the perspective of UFO.

Finally, another aspect that should be accounted for is the fact that cognitively speaking, parthood is not a single relation but four distinct relation types, namely: (a) *subquantity–quantity* (e.g., alcohol–wine), modelling parts of an amount of matter which are unified in a whole due to a topological connection relation; (b) *member–collective* (e.g., a specific tree–the Black Forest), modelling a collective entity in which all parts play an equal role with respect to the whole; (c) *subcollective–collective* (e.g., the north part of the Black Forest–the Black Forest); (d) *component–functional complex* (e.g., heart–circulatory system, engine–car), modelling an entity in which all parts play a different role with respect to the whole, thus, contributing to the functionality of the latter.

As discussed in depth in [27], the <u>componentOf</u> relation connecting functional complexes to their parts is a complex relation implying both a formal mereological relation and a relation of Functional Dependence. So, for instance, the relation between a particular Body (a functional complex) and a particular Heart denotes a relation of parthood but also represents the fact that for the body to work as functioning body, there must be a Heart playing the role of a Blood Pump (i.e., a Heart exhibiting the behaviour of a Heart-qua-blood-pump) [27]. Moreover, <u>componentOf</u> is not itself a formal relation but a material one: the fact that Brazil is part of the United Nations or the fact that Paul's transplanted heart is part of his body demand for the existence of founding <u>events</u> and consequent <u>relators</u>. So, a Functional Complex <u>Universal</u> is characterized by a complex of Functional <u>Roles</u> (and implicit <u>Relator</u> and <u>Qua Individual Universals</u>) such that a Functional Complex <u>Individual</u> is an Integral Whole unifying all those entities that in a given circumstance play (instantiate) those Functional Roles. Finally, as formally demonstrated in [27], <u>componentOf</u> cannot be considered a classical mereological relation, since unlike all classical mereological relations, unrestrictive transitivity does not hold for <u>componentOf</u>. For instance, while Paul's heart is part of Paul and Paul is part of the Liverpool FC, Paul's heart is not part of the Liverpool FC. The chain of transitivity of the <u>componentOf</u> relation is restricted to certain scopes. Patterns to isolate these *scopes of restrictive transitivity* for a given situation are formally proved in [27].

4 ANALYSIS OF THE NOTION OF COMMUNITY IN THE ENTERPRISE LANGUAGE

We start with preliminary observations on the *community* concept as a key structuring element for enterprise specifications in section 4.1. A thorough account for the concept will require us to review the concept of role (in section 4.2), the whole-part relations involved in the composition of a community (in section 4.3) and the agentive and social nature of a community (in section 4.4). Finally, in light of the interpretation for community in terms of UFO, we discuss the concepts of contract, objectives and sub-objectives, which are essential to account for the social aspects of the hierarchical structuring of communities.

4.1 Communities: Preliminary Observations

A community is defined in the standard as "a configuration of enterprise objects that describes a collection of entities (e.g. human beings, information processing systems, resources of various kinds and collections of these) that is formed to meet an *objective*." A *configuration* (of objects) is defined in the RM-ODP foundations (Part 2) as "a collection of objects able to interact at interfaces."

The text seems to suggest some sort of whole-part relation between communities and enterprise objects, with the community being the whole and the enterprise objects parts of it. However, the use of the term "collection" is informal in the standard and conceals the precise intention behind the term. In different parts of RM-ODP, the term "collection" is used to denote a variety of kinds of relations including structured descriptions of <u>Events</u> (e.g., in the enterprise language definition of a *process* as a "*collection* of steps") and the mathematical concept of <u>Set</u> (e.g., "a policy may specify which of some *collection* of policies is to be applied in certain circumstances.") The term is semantically overloaded to denote concepts with different ontological standings and different consequences for the conceptualization being defined. For example, set membership is an abstract mathematical notion where all members of the set are related in the exact same way with the set (they are simply said to be members of the set). Moreover, set membership does not comply even with minimal requirements for a relation to be considered a relation of parthood [28]. Examples include the weak supplementation axiom which is falsified by the unitary set. Finally, the identity of the set is defined by the identity of its members. In contrast, in the case of whole-part relations for events (e.g., processes composed of steps), events are arranged in temporal/causal relations, and thus each part has a different value to the whole. These two notions are certainly different from the notion of configuration used in the definition of community, a notion that implies that objects interact with each other (which is not the case in the set of policies nor in the structured process definition). Thus, in order to consider the ontological standing of the community concept, a closer look is required to consider what kind of whole-part relation is applicable to the enterprise language definition of community.

In this setting, a number of characteristics of the community concept become relevant. First of all, the enterprise language defines that "the assignment of actions to the enterprise objects that comprise a community is defined in terms of roles". Given its importance in the definition of communities, we propose to account for the concept of roles[3] before we attempt an interpretation of the community concept.

4.2 Roles

The concept of role has attracted considerable attention not only in the scope of the RM-ODP [20, 45], but also in the scope of the general literature in object-oriented modelling (e.g., [62, 61, 66]) and conceptual modelling (e.g., [29, 25, 26, 49, 51, 61, 62]). We discussed the interpretation for the RM-ODP role concept in [1] and have shown that the interpretation in terms of the UFO foundational ontology clarifies the definition in the standard and makes the alignment of competing proposals (by Linington [45] and by Genilloud and Wegmann [20]) possible.

The following noteworthy characteristics of the notion of the role concept have been identified and are assumed in this paper:

(i) roles are always defined with respect to relationships between objects, in the context of which objects exhibit particular (contingent) behaviours [1]. The close link between the concept of role and the notion of relationship is clearly identified in the conceptual modelling literature as discussed in [29, 62] and as quoted in [21]: "as suggested by the work of Sowa and Guarino, a role is meaningful only in the context of a relationship."

(ii) roles are defined in the scope of "composite object definition" (even if implicitly, as emphasized by Linington in his contribution to [39]) *and dually* in the scope of "collaborative behaviour definition" (as emphasized by Genilloud and Wegmann [20].)

These characteristics are closely linked to a number of important notions in UFO:

− That an object exhibits contingent behaviour in the scope of a relationship defined in terms of roles means that an object may "acquire and abandon roles dynamically" (one of the salient characteristics of many approaches to "role" as discussed in [62]). This is accounted for in UFO, since role universals

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[3] We focus here on the concept of role as applicable to "community-role", and not the general notion that could be applicable to "action" role, for example.

(and role-mixins) are characterized as anti-rigid universals, i.e., those that apply contingently to objects as opposed to necessarily.

- That roles are defined in the scope of relationships is accounted for in UFO since qua-individuals (moments that inhere in objects when they instantiate a role universal) are characterized as externally dependent moments. The aggregate of qua-individuals which depend on each other form a relator (roughly speaking, a "reified" material relation.)

We provide the following interpretation for role-related concepts in RM-ODP:

- The RM-ODP concept of role (in fact what Genilloud and Wegmann call more specifically "role object type") is interpreted as representing a role universal (or role mixin).
- An object filling a community-role is interpreted as representing that an entity instantiates a role universal (or role mixin).
- The behaviour of an object filling a community-role is interpreted as that behaviour implied by the qua-individual that inheres in the object instantiating the role universal.
- The fact that objects acquire and abandon roles dynamically, indicates that a full account for the role concept should include an account for the act of "binding a role" [1] or being "bound to a role" [45] (or it should at least "capture the way in which the potential behaviour of an object is modified by creation of a community and by the object filling a community-role;" [45]). This is reflected in the UFO through the notion of founding events (or foundation) on which a qua-individual depends historically (see [63] for the notion of historical dependence).

As discussed in [34], Social Roles are special types of Roles (i.e., Anti-Rigid and Relationally Dependent Universals) which are characterized by a number of Social Moment universals, typically, commitments and claims. Both Social Roles and the Social Relators that defined the binding conditions for these roles are prescribed by a Normative Description accepted by a certain social agent (society). Moreover, these commitments are typically commitments towards other agents in a given society by virtue of the other social roles the latter play in that society. Finally, as discussed in [13], the commitment universals that characterize social roles are typically meta-commitments, i.e., they are commitments to commit do perform certain actions or pursue certain goals. For instance, when accepting to play the role of a reviewer, an agent *commits to* a PC chair to *commit to* review all papers assigned to him in his expertise area for that conference. In this manner, the definition of social roles also define relations of *influencing*, power and delegation from Agents to Agents given their social Roles [13], where these agents can be either Social Agents or Individual ones. In summary, a given normative description accepted by a Social Agent defines not only its Social Roles, the Moment Universals that characterize the former, the Social Relators that define their binding conditions, but also a number of Social Relations between them.

4.3 Communities Revisited

We return to the notion of community, and to the observation in the standard that "the assignment of actions to the enterprise objects that comprise a community is defined in terms of roles". Could a community be understood as the "composite object" which is referred to (even if implicitly) in the definition of the various roles that form it? And, further, could the notion of community be reducible to the *formal (mereological) sum[4]* ([60]) of the objects playing the roles defined for a collaborative behaviour?

A first answer can be found in the examination of a community's principle of identity, which becomes clear in a number of excerpts from the standard. The enterprise language states that "the enterprise objects assigned to roles in the community can be changed during the lifetime of the community. As a consequence, a role can, subject to other constraints, have no enterprise object assigned to it." Part 2 states that "the specification of a configuration may be static or may be in terms of the operation of dynamic mechanisms which change the configuration, such as binding and unbinding." Thus, we can say that the community identity may be preserved in the face of changes to the specific objects fulfilling roles in it (an example of a community following such principle of identity would be the Federal Republic of Brazil, whose identity remains unaltered when a new President of the Federal Republic swears in to take office). In other words, a community (the whole) may outlive the lifetime of the qua-individuals and may persist even in face of changes to the set of objects bound to the roles it defines. This is

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[4] or *mere aggregate* (in the sense put forward in [8])

different from a formal sum, whose identity would be defined solely by the identity of the objects considered together (a purely extensional principle of identity). Thus, a community is more than merely the aggregation of the objects that play a role in it. This conclusion can be further emphasized by the observation that, even regardless of change of objects in the community, two communities composed exactly with the same objects are different from each other as their members play different roles within the structure of the community. Consider the example discussed in [29]: "First, we can easily imagine two different organizations which share the same members. Imagine the situation in which John Lennon, Paul McCartney, George Harrison and Ringo Starr are also the members of the indoor football team Liverpool FC. The Beatles and the Liverpool FC are clearly different individuals despite of sharing the same parts." Thus, from the sole perspective of their identity, we can conclude that communities are more than the sum of their composing parts. The relation between the community and the sum of the objects filling roles in the community at a particular point in time is a relation called "constitution" [47].

The relation of constitution is not technically a whole-part relation as it also does not satisfy the minimum requirements for a theory of parthood such as Weak Supplementation. An example of a constitution relation is the one holding between a statue of Goliath made of clay and the lump of clay that constitutes the statue. In this case, the statue has one single constituent (the lump). Nonetheless, the statue and the lump are distinct entities since (to name a few reasons): (i) they have different essential properties – while having a particular form is an essential property of the statue it is only an accidental property of the lump; (ii) they have different lifecycles. As a statue can thus be constituted by different portions of clay in different situations, a community can be constituted by different collectives of enterprise objects in different occasions [28, 29].

Aside from the issue of identity, the RM-ODP provisions for a community to be able to enter into commitments and fulfil roles in the scope of other communities ("a community may be regarded as a composite community-object which may fulfil a role in another community."). In our example, consider that the Liverpool FC may participate in the local indoor football league as a member, something which the individual players cannot accomplish on their own. The community depends on the composing members to function but is different from them. Likewise, composing objects depend on the community to function in fulfilling their roles in the community. Paul McCartney would not be able to function as a football player without a community to accept him in that role. The functional dependence between a community and each of the objects filling roles in the community is a natural consequence of our account for roles: there is a material relation between the whole and each of its parts. We conclude by identifying the relation between a community and each enterprise object as of type <u>componentOf</u> [29] or Component/Functional Complex [67]. As discussed in [27], these are <u>material relations,</u> which demand for the existence of founding <u>events</u> and consequent <u>relators</u>.[5] It is important to highlight that a number of authors in the literature have proposed a view which is akin to the one defended here, namely, one that conceptualizes structure/organization of organizations as *a set of interrelated roles* [15, 54, 55]. This view is also accounted for in [53] in which integral wholes are claimed to be *aggregates of qua types*.

Further characteristics of the whole-part relation between objects and communities can be inferred from the following excerpt: "an enterprise object may be a member of a community because: by design the community includes the object; the object becomes a member of the community at the time of creation of that community; or the object becomes a member of the community as a result of dynamic changes in the configuration of the community." We can identify the following possible relations between the community (as a whole) and the composing objects (as parts): (i) the community may depend on a specific object (an essential part, a case of specific functional dependence); (ii) the community may depend on there being an object (any object) to fulfil a particular role (a mandatory part, a case of generic functional dependence); (iii) the community has a role that may be filled (an optional part). These and other meta-properties of the whole-part relation are discussed at length in [29].

As previously mentioned, in RM-ODP, *"a community is a configuration of enterprise objects […] that is formed to meet an objective."* This definition is an indication that the shared goals of the community direct the stipulation of the constitutive norms in the normative description of that community [5]. In other words, the

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[5] As we will see later in this paper, the founding events are explicitly discussed in the RM-ODP foundations (Part 2), clause 13.2.1 ("Establishing Behaviour"). The consequences of the execution of *establishing behaviour* are discussed in clause 13.2.2 ("Established Behaviour").

constitutive norms of a community define <u>Social Roles</u> and <u>Social Relators</u> whose commitments and, consequent, <u>Action Universals</u> contribute for the achievement of these community goals. As a consequence, we have that the members of that community, *qua members* and by virtue of the roles they play inside a community adopt these community goals and contribute to their achievement (sometimes via the achievement of subgoals). The relation between these community goals and the subgoals whose adoption is prescribed for the social roles inside the community is conformant with the Functional Dependence of the former to the latter: in order to function as that community (which is defined by its goals), the community needs to have entities playing exactly those roles that satisfy the subparts of the community goals (subgoals). In an alternative formulation, we could say that the community *delegates* the fulfilment *parts of its goals* to its members. As discussed in [34], a delegation relation is a kind of material relation. So, the <u>componentOf</u> relation between a community and its members is a whole-part relation plus a relation of delegation that is created to fulfil a relation of functional dependence.

As explained in [34], a delegation relation is founded on a social relator and its composing commitments and claims. So, for instance, a PC chair can delegate a paper review to a Reviewer because of the previous (meta)commitment of the latter towards the former. In general, the (meta)commitment universals that characterize social roles inside a community are (meta)commitments towards the community itself (or some proper part of it, e.g., one of its sub-communities, or one of its members). There are, however, Social Roles which are characterized by (meta)commitment universals which are directed to entities outside the community, i.e., entities which are not members of the community. Let us take the example of a community which counts with a *Public Relations* role. The agent playing this role becomes part of this community and commits to adopt a number of goals of the community. However, it adopts also a number of meta-commitment towards entities which are not part of the community (e.g., Government Bodies, Competitors, Clients).

Notice that the members of a community *qua members of that community* cannot have goals which conflict with those of that community. This is not the case with entities related to the community via the so-called *Interface Roles*. For instance, a competitor or a government agent which relates to the community via these *interface roles* can clearly have goals which are conflicting to those of the community. This distinction is reflected in the intuition put forth in [46] that a *community role* (but not an *interface role*) is one that contributes to the "essence" of the community. In fact, if for a community to function as such and satisfy its goals it is functionally dependent on members playing its social roles then these roles do contribute to the "essence" of the community, i.e., for the community to be what it is. Moreover, it is important to point out that the relation between members of the community with the community itself, as a whole-part relation, must satisfy the general constraints of a <u>componentOf</u> parthood relation (irreflexivity, asymmetry, restricted transitivity and weak supplementation); this is certainly not the case for the material relations established between a community and external entities that relate to it.

4.4 Agentive and social nature of a community

Some important characteristics of the community concept are revealed by Linington, Milosevic and Raymond in [44]: "The ODP enterprise concept of community is introduced to model how a group of enterprise objects achieve their individual objectives through commonly agreed patterns of interaction. This agreement is institutionalised through the contract. If an object wishes to participate in a community, it is obliged to comply with policies set out in the contract of that particular community." The authors have considered the implications of filling a role in a community in the following statement: "In filling a role in a community, the enterprise object is obligated to accept the (direct or delegated) authority of the community over the corresponding participant-roles, and constrain their physical behaviour accordingly."

The language used in the text seems to grant enterprise objects an intentional aspect, with the terms "their individual objectives" and "wish" and the distinction between "physical" and "social" actions. We believe here that the intention of the authors was to emphasize the agentive elements in the community, leaving out information processing systems and resources that have no agentive nature. We will put forward similar emphasis, concluding that agentive enterprise objects in a community form an <u>Institutional Agent</u>. An institutional agent is a social, agentive functional complex composed of one or more agentive entities. This opens up the community as a potential bearer of intentional moments (such as intentions, which will allow us to provide an account for the notion of community objective) and social moments (such as social commitments and claims). Further, since

agents that are part of an institutional agent may themselves be institutional agents this account is consistent with the hierarchical decomposition of enterprise objects as proposed in the enterprise viewpoint.

Further the statements considered role playing can be analysed systematically by observing that when an object fills a role in a community there exists a <u>Social Relator</u> between the community and the object (and the object can be said to instantiate some sort of "community member" <u>Social Role</u>). When an enterprise object commits to performing some sort of behaviour we can regard the relation between the community and the enterprise objects as some sort of <u>plan delegation</u> [30] (or *closed delegation* [12]). In other words, there is a pair of social commitment/claim between the community and the agent, in which the agent promises to "constrain its physical behaviour" according to the *community contract*.

4.5   Contracts

The concept of a contract is grounded on the RM-ODP foundations Part 2, being defined as "an agreement governing part of the collective behaviour of a set of objects." It further defines that "a contract specifies obligations, permissions and prohibitions for the objects involved", and states that "the specification of a contract may include: a) a specification of the different roles that objects involved in the contract may assume, and the interfaces associated with the roles; b) quality of service attributes (see 11.2.2); c) indications of duration or periods of validity; d) indications of behaviour which invalidates the contract; e) liveness and safety conditions."

The enterprise language specializes this concept describing the elements of the contract of a community in detail: "This contract: states the objective for which the community exists; governs the structure, the behaviour and the policies of the community; constrains the behaviour of the members of the community; states the rules for the assignment of enterprise objects to roles." This allows us to support our interpretation of the notion of the contract of a community as a <u>Normative Description</u> that defines the <u>Social Roles,</u> <u>Social Moment Universals</u> and <u>Social Moments</u> (such as <u>Social Relators</u> and <u>Qua-Individuals</u>) in the scope of the community. Objects that are part of the community instantiate the <u>Social Roles</u> and bear <u>Social Moments</u> defined in this <u>Normative Description</u> (or instantiate the universals defined in this description). The community contract (a <u>Normative Description</u>) must be recognized by at least the community itself (an <u>Institutional Agent</u> on its own right) and by the enterprise objects that instantiate roles in the community.

The standard also defines in its Part 2 the notion of "establishing behaviour" defining it as "the behaviour by which a given contract is put in place between given objects". The establishing behaviour can be: "a) explicit, resulting from the interactions of objects that will take part in the contract; or b) implicit, being performed by an external agency (e.g. a third party object, not taking part in the contract) or having been performed in a previous epoch." This notion can be accounted for in the foundational ontology since <u>Communicative Acts</u> (performed by the objects in the community or by third parties) can produce <u>Normative Descriptions</u>.

Finally, the community contract "states the objective for which the community exists", ascribing certain <u>intentional moments</u> to the community. The interpretation of the objective of a community is discussed in the sequel, as a preparation to discuss the relation between objectives and sub-objectives.

4.6   Objectives

The enterprise viewpoint defines the *objective (of an <X>)* as a "practical advantage or intended effect, expressed as preferences about future states." At first observation, this definition seems neutral with respect to the commitments of a community, which seems to imply that the reference model makes no distinction between an *objective* as the propositional content of a <u>Desire</u> or of an <u>Intention</u>. Nevertheless, objectives are captured in a community as a contract, which establishes how the objective is to be achieved. In this sense, we can say that the community is committed to achieving the *objective* characterizing the *objective* as the propositional concept of the community's <u>Intention</u>. Thus we can interpret *objectives* as <u>Goals</u> in UFO.

UFO contemplates a relation between <u>Situations</u> and <u>Goals</u> such that a <u>Situation</u> (or possibly a number of <u>Situations</u>) may satisfy a <u>Goal</u>. In other words, since a <u>Goal</u> is a <u>Proposition</u> (the <u>propositional content of</u> an <u>Intention</u>), we have that a particular state of affairs can be the truthmaker of that <u>Proposition</u>. We interpret the term *state* in the RM-ODP definition of *objective* as <u>Situation</u>. A "preferred" future state is a situation that would satisfy the <u>Goal</u>.

(An alternative would be to ascribe some notion of "utility" to situations in order to be able to compare them. This "utility" could be agent-indexed in order to capture the notion of "perceived utility". In that case, we could discuss "preferences" from the perspective of an agent in terms of the "utility" of possible situations or future states. While we do not pursue this interpretation further in this paper, we by no means intend to rule it out. This interpretation may be particularly interesting to account for the behaviour of agents when facing conflicting objectives and when considering the possibility of violation of norms.)

4.7   Objective Decomposition and Community Decomposition

The reference model defines structuring rules for objectives (Clause 7.7 "Objective rules") such that objectives can be structured and assigned to roles: "An enterprise specification may decompose the objective of a community into sub-objectives. A sub-objective may be assigned to a collection of roles; in that case, the behaviour of the collection of roles is specified to meet the sub-objective and the sub-objective is met by the collection of objects performing the actions of the collection of roles."

This structuring rule implies that (i) objectives can be refined into sub-objectives; and (ii) objectives may be assigned to roles.

With respect to (i), while the reference model defines that "an enterprise specification may decompose the objective of a community into sub-objectives" it does not define the kinds of decompositions that may be considered. Objectives are thus subject to refinement without further qualification in the reference model (differently from communities and processes/behaviours whose refinement is treated explicitly in the reference model.) Our treatment of goals as propositions allows us to account for objective refinement in terms of logical relations between propositions. For example, we can consider two kinds of decompositions here: AND-decomposition and OR-decomposition (reflecting those defined in the goal modelling technique called Tropos [7]). If we have that goals $G_1 \ldots G_n$ AND-decompose goal G_0, this relation should be interpreted as: $(G_0 \leftrightarrow (G_1 \wedge G_2 \wedge \ldots \wedge G_n))$. In an analogous manner, and OR-decomposition $G_1 \ldots G_n$ of goal G_0 should be interpreted as: $(G_0 \leftrightarrow (G_1 \vee G_2 \vee \ldots \vee G_n))$. The recursive combination of AND and OR decompositions can represent a great number of objective refinement relations.

With respect to (ii), we could explain assignment of goals using two sorts of delegation: goal delegation [30] which involves an agent that commits to accomplish a goal on behalf of another agent without committing to particular actions and plan delegation which involves specific actions. However, the text for the structuring rule seems to imply that only *plan delegation* is possible by prescribing that the behaviour of the roles be specified to meeting the sub-objective ("in that case, the behaviour of the collection of roles is specified to meet the sub-objective"). We believe the text of the standard should be adjusted to avoid the interpretation that only plan delegation is possible, which would result in a more general reference model. This is particularly relevant to preserve the freedom an object may have in pursuing goals in different ways, and may be required in a number of settings when it is undesirable to prescribe an object's behaviour *a priori* while at the same time it is desirable to formalize the commitment to purse a (delegated) goal.

It is worth noting that while [44] uses the term "individual objectives" referring to enterprise objects, this is not explicit in the reference model, which uses the term "objective" only to characterize communities. We believe the ontological account discussed here corroborates the observations in [44] further emphasizing the importance of the extension of the reference model to account for individual objectives (or objectives of agentive enterprise objects which are not community-objects). Since agents which constitute a community are autonomous, their behaviours may violate the community contract leading to undesirable behaviours from the community point of view. This arises from the fact that agents may be more or less committed with community objectives according to the extent to which their own objectives are compliant with the community's objectives. Again, there is an issue of conformance of the agent's actual behaviour and the behaviour implied by social commitment (what is called "social behaviour" in [44]). Thus, it is up to the agent to internalize a social commitment into an internal commitment (an intention to "constrain its behaviour accordingly") to fulfil its social commitments with the community. Differences between an agent's social commitments and its internal commitments is what accounts for *violations*.

In addition, when considering a hierarchical perspective on community forming, the reference model defines that "a community may be regarded as a composite community-object which may fulfil a role in another

community. In this case, the objective of the community of which the community-object is an abstraction is consistent with any sub-objectives assigned to that role in the other community." We can state that the community-object *A qua* member of community *B* does not have a goal which contradicts (in the logical sense, since goals are propositions) the goals of community *B*. Assignment of objectives to roles filled by community-objects seems to open up the path for goal delegation for community-objects; the *delegatum* is the sub-objective assigned to the role by "the other community". Since goal delegation seems to be allowed in this case, we argue that the text for the structuring rule in clause 7.7 should be reviewed to avoid proscribing goal delegation for enterprise objects which are not community-objects. Again, we favour that interpretation to grant communities and other enterprise objects uniform treatment.

4.8   Summary

Table 1 summarizes some of the key correspondence between the enterprise language and UFO concepts.

Table 1 – Correspondences between RM-ODP and UFO

RM-ODP	Ontological concept (from UFO)
Community	Institutional Agent
Enterprise Object	Agent
Enterprise Role	Social Role
Community structured into Objects (through Roles they fill in the community)	ComponentOf whole-part relation (component/functional complex) (Each *object* instantiates a Social Role defined in the *community*'s *contract*. There exists a Social Relator between the *community* and the *object*. There are Social Relations between the various objects in the community.)
Contract	Normative Description (a kind of Social Object) that defines Social Relators, Social Commitments/Claims and Social Roles
Community and Set of Objects filling Roles in the Community	Constitution (The set of objects are said to "constitute" the community at a particular point in time. Constitution does not qualify as a whole-part relation.)
Establishing Behaviour ("Role binding")	Foundation (There must be a founding Event for a Social Relator. This founding Event creates Qua-Individuals.)
Established Behaviour	Qua-Individuals which characterize the objects that instantiate Social Roles defined in the *community*'s *contract*.
Objective	Goal (propositional content of an Agent's Intention) that is satisfied by Situations
Objective refinement	The propositional content of the Goal is the conjunction/disjunction of the propositional contents of sub-Goals
Assignment of objective to roles	Plan delegation (and possibly also Goal delegation)

5 CONCLUSIONS

In this paper, we have discussed an ontological analysis of the Enterprise Language notion of *community* and the associated notions of *roles*, *contracts* and *objectives*. We have employed a foundational ontology which incorporates concepts to deal with some aspects of social reality and intentionality, which enabled us to provide an interpretation of the notion of community as well as a number of structuring rules for communities.

In line with [44], we propose here interpretations that emphasize the intentionally of communities and enterprise objects in communities. In our view, communities and community members are potential bearers of intentional moments (such as intentions) and social moments (such as social commitments and claims). By considering *communities and community members as bearers of intentional moments*, the ontological analysis corroborates the observations in [44], indicating a potential extension of the reference model to include a notion of "individual objectives". Currently, the standard only uses the notion of "objective" to characterize "communities" and "community-objects". By considering *communities and community members as bearers of social moments*

such as social commitments and claims, our interpretation accounts for what is called informally "social behaviour" in [44]. In our interpretation, when an object enters into a community it instantiates social roles defined in the contract of the community, establishing a social relation with the community that defines its behaviour as a member of the community. By considering *communities and community members as bearers of both intentional moments and social moments*, our interpretation accounts for non-conformant social behaviour and contract violations: in this case, failure to fulfil social commitments may be motivated by conflicts between the objectives of community members and the objectives of a community as a whole.

Other observations we have made (for example, with respect to goal delegation) show that the standard may have restricted the generality of the conceptualization unnecessarily, as the text seems to exclude (open) goal delegation while allowing only closed delegation for a community. Again, the ontological analysis signals a potential amendment that would contribute to raising the level of generality of the standard.

The analysis has also supported us in identifying certain ambiguities of the RM-ODP specification regarding the properties of the different composition relations that are defined to hold between different types of entities. In fact, what we have been able to observe is that by using general notions of "collection" and "refinement", the specification conflates a number of relations of very different nature. For instance, the relation between *objectives* and *sub-objectives* is a formal relation which itself subsumes different kinds of patterns of logical relations (such as AND-decomposition and OR-decomposition). In contrast, the relation between *communities* and their parts is a material mereological relation (componentOf) that denotes a: (non-classical) mereological relation, and a relation of functional dependence which is itself materialized via a relation of delegation. Our treatment of whole-part relations enables us to account for "role binding" and "establishing behaviour", as well as is the basis for our treatment of hierarchical decomposition of communities.

The treatment of whole-part relations combined with the notions of intentionality is what has enabled us to account for the distinction between interface roles and other roles played in the scope of a community, in an account that captures precisely the intuition on the distinction between community roles and interface roles that was put forward in [46]. We believe that the interpretation provided here can serve to provide methodological guidance for a modeller to decide which concepts to use in particular settings, thus further strengthening the RM-ODP as a useful conceptual framework in system specification and analysis.

In our long-term research efforts, we have been analysing several enterprise modelling and conceptual modelling approaches employing UFO (ArchiMate and its extensions [4], DODAF/MODAF [3], ARIS [56, 57], i*/Tropos [11, 31]). This has given us some insight into the applicability of the current versions of the UFO social and intentional concepts to address a wide range of concepts such as those discussed in the enterprise language. Nevertheless, we regard the efforts to interpret the enterprise language as an opportunity to validate the usefulness and generality of the foundations we employ here. We have been able to identify the need for further investigation to strengthen the foundations with respect to *accountability* and *policy* concepts. The extension of the foundation and an interpretation of the accountability and policy concepts will be the subject of our future work. The extension would allow us to elaborate on the structure of normative descriptions, which would be applicable to account for the structure of contracts in terms of *policies* and *rules*. Further, treatment of accountability should address the notion of *accountable actions* present in the enterprise language, which have interesting relations with some of the notions we have discussed here such as communicative acts, commitments and delegation. [6]

We do not intend to suggest that the terminology used in this paper should replace the terminology currently used in the specification, and we do not intend to imply that the UFO conceptualization should be exposed directly to users of the standard. The main role of the ontological analysis has been to provide us with a rigorous framework to analyse the RM-ODP conceptualization. In this sense, ontological analysis can be seen as a tool for hypothesis formulation, and the recommendations that we have identified here using ontological analysis should be considered as hypothesis subject to further examination. In particular, one should consider the pragmatic impact of amendments on the set of standards and its users. We believe that some of the recommendations raised by the ontological analysis performed here can have direct application in the revision of the reference model, and would

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[6] Please note that the *agent* concept in RM-ODP is included in the accountability concepts and does not correspond directly to the notion of UFO Agent. Similarly, the notions of commitment and delegation we have discussed do not correspond directly the RM-ODP accountable actions of *commitment* and *delegation*.

subsequently impact on the tools that enable users to design and analyse enterprises using RM-ODP. For example, our analysis shows that (in the reference model "as is") users are limited in their ability to refer to objectives of enterprise objects that are not community-objects. This limitation hampers the use of the reference model in situations which require considering the roles of individuals in the enterprise (for example to analyse goal conformance and goal conflicts). Further, our analysis shows that users cannot specify the delegation of goals without being required to prescribe how these goals are to be achieved. This may hamper the use of the reference model in realistic knowledge-intensive organizations, in which open delegation prevails and, thus, cannot be ignored.

It is important to add that, despite the fact that we have been able to uncover issues is the ontological analysis, the Enterprise Language RM-ODP has, in general terms, performed better than many of the other languages and frameworks we have investigated, whose intended semantics have been harder to uncover, and which presented many cases of construct excess, deficit, and semantic overload (see, e.g., [3, 4, 11, 28, 56, 57]).

Finally, in [29] the core of the UFO ontology is defined formally in order to allow for unambiguous interpretation of the intended semantics for concepts. Nevertheless, the intentional and social aspects introduced in [30] and used here still require full formal treatment. This is part of our current research agenda.

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Highlights

We analyze the enterprise language based on a foundational ontology

We propose well-founded recommendations for clarifications to the standard with respect to the notion of community

The account provided in the paper strengthens the foundations of the enterprise language