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Analyzing the Relations between Strategic and Operational Aspects of an Enterprise: Towards an Ontology-based Approach

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Abstract: In this paper, we work towards an approach to establish a connection between the goal domain and the enterprise architecture elements that are responsible for the satisfaction of goals in an enterprise. We observe this connection is far from trivial, requiring us to consider the semantics of goals, the semantics of many other enterprise elements as well as the nature of the relation between goals and these other enterprise elements. This challenge is here addressed by considering several ontological accounts for the enterprise discussed in the literature. Since no single ontological account of the enterprise covers the range of phenomena to analyse the alignment of strategic and operational aspects of the enterprise, we have conducted a survey of enterprise ontology approaches. The semantic layer established through the survey is used in the analysis of the relations between strategic and operational aspects of a healthcare organization in a case study we have conducted. The case study illustrates how ontological theories in the established literature may support enterprise architecture analysis, in particular,

facilitating the alignment between the goals and the operational elements of an organization (such as processes, roles, resources).

Keywords: Enterprise ontologies; organizations; agents; roles; goals; actions/plans; norms/rules.

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1 Introduction

A mature approach to enterprise engineering should enable enterprise architects to address the alignment between strategic and operational aspects of the enterprise as a means of justifying the existence of each operational element in the architecture. A minimum requirement to establishing alignment is the identification of the relations between strategic and operational aspects. Roughly, if we assume that strategic aspects are captured in goal models (such as those employed in goal-oriented approaches (Kavakli, et al., 2003)) and that operational aspects are captured in business process models and other enterprise architecture models, than the identification of the relations between strategic and operational aspects will answer the following questions:

(i) Which goals are satisfied (or not satisfied) in the current enterprise architecture?

(ii) Given a goal or a set of goals in the goal model, which enterprise architecture elements affect the satisfaction (or non-satisfaction) of these goals?

(iii) Conversely in respect to (ii), given enterprise architecture elements, which goal or set of goals these elements address?

By answering these questions, one might realize which obstacles represent risks for the organization's strategic goals' satisfiability, thus being able to mitigate these risks. For instance, one might decide to alter a business process or to give special attention to crucial activities in order to guarantee that the main goals of the enterprise are obtained.

Commonly, this goal-driven orientation is adopted by many proposals in the context of business process management (BPM) works, for example to provide additional support in business process reengineering activities (Nurcan, et al., 2005) (Neiger, et al., 2004b) (Halleux, et al., 2008) (Koliadis, et al., 2006a). Most of these proposals explore the relationship between goal models and business process models (Nurcan, et al., 2005) (Halleux, et al., 2008) (Koliadis, et al., 2006b) (Kueng, et al., 1997) (Koliadis, et al., 2006a) (Neiger, et al., 2004b), with many of these extending business process languages by adopting a notion of goal (Koliadis, et al., 2006b) (Neiger, et al., 2004b) (Soffer, et al., 2005) (Birgit, et al., 2007).

While the alignment between goal models and business processes is particularly important in the alignment of strategic and operational aspects of the enterprise, we have noticed that adopting a purely process-centred view to clarify the alignment is insufficient, since goal achievement is related with a multitude of enterprise elements beyond processes. For instance, organizational policies regarding the remuneration of employees (which are not tied to a specific business process) may affect goal satisfaction. So perhaps these policies and rules are the elements of the enterprise which should be revised, instead of particular processes or activities. Further, goal satisfaction is often partial and only partially defined by certain operational elements. This aspect is neglected in approaches which establish a direct causal relation between the execution of particular processes and goal satisfaction. We conclude that there is an inherent complexity for establishing relationships between goals and the correspondent elements of the enterprise architecture. Establishing these relationships requires us to consider *the semantics of goals and enterprise elements* as well as *the nature of their relations*, a challenge which we address in this paper, considering several ontological accounts for the enterprise discussed in the literature.

Ontology (as a branch of analytic philosophy) is concerned with the nature (kinds of existents) and relations of being (Guizzardi, 2005). The importance of ontology for information systems is largely recognized as a means for providing foundations for conceptual modelling. Ontological foundations have the role of capturing the ontological categories (concepts) which can provide real-world semantics for language constructs (Guizzardi, 2005) as well as clarify the structure of the knowledge (Chandrasekaran, et al., 1999).

According to (Bottazzi, et al., 2005), "an ontological analysis of organizations is the first, fundamental and ineliminable pillar on which to build a precise and rigorous enterprise modelling. An ontological analysis makes explicit the social structure that underlies every organizational setting". In doing so, ontological foundations for enterprise modelling are also an essential instrument for providing a common terminology that captures key distinctions within organizational environments. These distinctions must be generic across many domains as well as provide adequate

specification of the semantics of the terminology of the enterprise (Grüninger, et al., 2000).

Since we have observed that no single ontological account of the enterprise discussed in the literature covers the range of phenomena to analyse the alignment of strategic and operational aspects of the enterprise, we have conducted a survey of enterprise ontology approaches. The results of this survey are presented in section 2, and constitute the *semantic layer* of our approach, defining organizational elements from an ontological point of view. In this survey, we address enterprise ontologies that include an account for the notion of goal (or objective). The *semantic layer* established through the survey is used further in our approach to relate strategic and operational aspects of an enterprise (presented in section 3). A case study conducted in a healthcare organization is presented in section 4, revealing how the semantic layer is used to facilitate the alignment between the goals and the operational elements of an organization (such as processes, roles, resources). Finally, section 5 concludes the paper and sets up an agenda for the future work.

2 Semantic Layer

This section presents our survey in the literature of enterprise ontologies as a means to lay down a common basis for integrating the architectural domains under consideration (the goal domain and the other architectural domains, such as business process domain, organizational domain, rule domain and so forth). The ontologies provide us with relevant concepts in each of these architectural domains and support us in understanding the nature of each of these concepts. Since the various ontological accounts are based on different views and assumptions, our approach here is to carefully select the aspects of each ontology that are relevant to the kind of analysis we intend to carry out (alignment of strategic and operational concerns), while maintaining the coherence of the final set of concepts. In order to scope our investigation, we focus on the concepts which are explicitly related with goals. We start our considerations with the central concept of organization, and proceed to discuss roles, agents (their intentions, goals, capabilities, actions and plans), objects and norms.

2.1 Semantic Layer - Concepts

2.1.1 Organization

Despite the large amount of literature devoted to describing organizations, especially in social sciences such as economics or anthropology, organizations are very difficult to define from an ontological point of view (ISTC-CNR, 2005-2007b). Some proposals argue that organizations can be: (i) social objects (something like a convention or agreement established by humans as an way of coordinate the human behaviour) (ISTC-CNR, 2005-2007b); (ii) artifacts (social objects can be seen as artifacts) which serves to the purpose of orchestrating the collective behaviour (ISTC-CNR, 2005-2007b), or even (iii) intentional agents that emerge from the aggregation of several natural persons (human beings) (ISTC-CNR, 2005-2007b) (Guizzardi, et al., 2007).

In (ISTC-CNR, 2005-2007b), it is argued that, despite the differences in defining the concept of organizations, at least, there is some agreement (in sociology and philosophy) in facing organizations as a collective of individuals who enacts some roles under some constraints (rules and norms) on behalf of some purpose (goals or ends). This proposal adopts the line which considers organizations as designed agents who act in the physical world with a specific mission (in other words, organizations are an abstract social concept, which is separate from the collective body of agents that composes it (Bottazzi, et al., 2005)).

According to this teleological view, organizations are the result of a decision-making process that is necessarily based on goals and on how these goals can be achieved. According to (Dignum, 2004), "an organization can be seen as a set of entities and their interactions, which are regulated by mechanisms of social order and created by more or less autonomous actors to achieve common goals". In turn, this proposal admits that organizations are more than the sum of the agents which compose the organization (in fact, roles describe the organizational perspective on individuals, whereas agents represent the perspective and objectives of the individuals themselves), but it does not recognizes the organization as a social concept.

In the current work, we adopt the concept of organizations as social agents created by human societies to manage the behaviour of human agents who act on behalf of some goals (the teleological aspect) (Dignum, 2004) (Bottazzi, et al., 2005) (ISTC-CNR, 2005-2007a) (ISTC-CNR, 2005-2007b). Therefore, goals are the drivers for the creation of organizations as the organizational structure which supports the systematic pursuit of goals by autonomous agents.

Since organizations are entities apart from their constituent components, it is important also to highlight that the term "organization" refers to the abstract design of the organization (the relations holding among the units of the organization or the "design layer"), rather than the potential realization of some particular organization (instantiation of some organizational environment, the "realization layer") (ISTC-CNR, 2005-2007a) (ISTC-CNR, 2005-2007b).

Regarding the design of organizations, some proposals (Dignum, 2004) (Fox, et al., 1998) (Uschold, et al., 1998) (Dietz, 2006) conceive roles as the only structural component in the design of organizations (although they can be hierarchically arranged by dependencies or power relations), not making explicit the underling social structure behind these roles (ISTC-CNR, 2005-2007b). However, other proposals (ISTC-CNR, 2005-2007a) describe organizations as being composed by sub-organizations as a mean of explicitly describing the organizational structure. Adopting the concept of sub-organization opens up the opportunity of representing the organizational structure as a set of institutional relationships, i.e., the organization under consideration can be interpreted as being an element of an institutional network of organizations. This kind of representation is useful since internal sub-organizations can interact with external organizations outside the direct influence or control of the organization (ISTC-CNR, 2005-2007a).

Given this, we take the second approach in which organizations are described as structured in terms of sub-organizations as proposed in (ISTC-CNR, 2005-2007a). According to the model presented in this proposal, organizations are a 4-tuple composed by a set of objectives, a set of (direct internal) sub-organizations, a set of institutional relationships and a set of external organizations. The internal sub-

organizations of an organization are the organizations that are linked by a finite chain of direct internal sub-organization relations. The external organizations of an organization are the organizations that have institutional relations with the organization but are not directly controlled by it. Finally, the set of the direct sub-organizations of an organization is the union of the sets of the internal and external sub-organizations.

Regarding goals, since the top organization generally has some strategic goals of its own, these goals must be refined and assigned to its sub-organizations so that these latter jointly become responsible for attaining the goals of the global organization. Observe that in this process of refinement, the top organization refines the organizational high-level goals into more specific goals and assigns them to its sub-organizations. Moreover, this assignment can also include a specific way about how to pursue these goals (ISTC-CNR, 2005-2007a).

The specification of a particular structure for the sub-organizations can be regarded as the mean employed by the designers of the organization to coordinate sub-organizations to achieve the organization's global goals. This specification is imposed by norms that regulate the interaction among these sub-organizations, but the sub-organizations can also decide to autonomously establish some additional relationships.

2.1.2 Roles

When the refinement of the organization reaches its lowest level, sub-organizations with no further decomposition are denominated as roles (Boella, et al., 2006). Roles are social concepts employed for abstracting from specific agents in organizations (ISTC-CNR, 2005-2007b), representing the part of the organizational design which specifies the activities and services necessary to achieve enterprise objectives (Dignum, 2004). Besides being properly defined by abstract design, organizations need to exist in reality through some physical structure (what one could informally call the "translation" from the abstract world to the concrete one). This realization is made by assigning individual agents to roles through an enactment relationship. This assignment of agents to roles is made through the signature of legal contracts (created/regulated through the definition of norms) of the organization with the agents. The signature of this contract represents a conveyance of the goals of the role to the agent which is assuming that role, that is, the goals of a role are expected to be executed by the agent(s) enacting that role.

Observe that, although goals of roles are designed from the organizational point of view, there is the possibility that a same agent assumes different roles with contradictory goals. Alternatively, even if the role's goals do not prevent (or negatively contribute to) the satisfaction of the goals of the other roles assumed by the agent, it is also possible that the operationalization to achieve the roles' goals can have contradictory characteristics. In both cases, the design of goals by the organization must take into account this issue so that to avoid this type of situation.

Besides the assignment of agents to roles (considering the absence of any kind of contradictory characteristic in the goals of roles), the satisfaction of the overall organization's goals requires the joint accomplishment of goals of roles as well as the achievement of goals which do not pertain to any particular individual, but are common to many agents. Again, the design of goals of roles (as well as the

operationalization) by the organization must also ensure the absence of any kind of contradiction along its course.

An obvious problem of goal achievement in organizations is the fact that roles are the design from an organizational point of view, i.e., it is assumed that role playing is predictable, although this is not always true. To regulate the possible deviations from the desired behaviour, organizations rely on norms that fix constraints in the behaviour of agents which enact roles (norms are further explored in section 2.1.6). These regulative norms are applied to agents as they become affiliated to organizations via agreements or contracts (ISTC-CNR, 2005-2007b).

2.1.3 Agents

While roles define how the organization aims at implementing its design through the specification of the behaviour of particular individuals, agents represent the perspective and objectives of the individuals themselves (agents pertain to the "realization layer"). In dealing with goal attainment issues, it is fundamental to regard the characteristics of agents who enact roles in societies in the sense that this can interfere in the adoption of plans to achieve goals.

In this respect, agent-oriented methodologies cope with agents as autonomous and heterogeneous entities that exhibit proactive and flexible behaviour (Ferrario, et al., 2004) as well as mental states (Guizzardi, 2006). In addition, according to Dignum (Dignum, 2004), agents are able to interact and cooperate with other agents, since they are socio-cognitive entities, namely, entities endowed with mental attitudes who assumes that other agents also holds the same characteristic. Dignum also defends that, since agents exhibit autonomous and heterogeneous behaviour, they may be more or less committed with organizational aims and strategies according to the extent to which their own goals are compliant with the organization's goals. In other words, the autonomy of agents may lead to undesirable behaviours from the organizational point of view. Again, as the roles which are assumed by a specific agent can have contradictory goals (as claimed in the previous section), the agents' personal goals can also be contradictory with the goals of their roles. In this case, differently from the previous situation, this does not comprise in a problem of design of goals by the organization, but instead, in a problem of adequacy of the agent with its assumed roles. Differently, in Dietz's work (Dietz, 2006), there is no explicit distinction between agents and roles: this proposal assumes actors (roles) as being autonomous entities whose behaviour is regulated by guidelines, thus avoiding this problem of compliance of agent's goals with the role's goals.

In the sequel, we clarify the concept of goal (from an ontological point of view) and relate it with the components of the BDI cognitive model (Rao, et al., 1991) proposed in the AI literature for describing agents. In this model, agents are characterized by three basic mental components: beliefs, desires and intentions. Further, we also recognize a fourth mental state, namely, capability. We use these mental states to explain how agents which enact roles within organizations impact in the organization's goal achievement. We consider these concepts required to complete the characterization of the notion of agent (which includes here designed agents such as the organization and its organizational units or individuals playing roles in the organization).

Intentions and Beliefs. In addition to defining norms and rules, one may attempt to enforce that organizational roles are met by selecting (human) agents who are fully committed with the organizational goals. In this case, the participation (or admission) of the human agent in the organization is conditioned by the compliance of his/her intentions with respect to the goals of the organization.

Searle (1995) explains that intentionality is the feature of constructing mental representations by which they are about something or directed at something. Intentionality is then the requisite for entertaining intentional mental states (beliefs, desires, fears, or making hypotheses). Therefore, the common characteristic of these mental states is that they refer to possible situations of reality (Bottazzi, et al., 2006a). In (Guizzardi, et al., 2008a), these individualized properties of some individuals are denominated as mental moments and are existentially dependent on these individuals (the bearers) (observe that the term moment does not bear the temporal notion which is associated in the colloquial language).

Every mental (intentional) moment has a type (belief, desire or intention) and some propositional content (the propositional content of an intention is a goal as argued in next sub-section). An intention is a goal that the agent commits at pursuing (Guizzardi, et al., 2008a); while desires represent the "will" of an agent towards a specific goal, although it might never actually pursue these goals (Guizzardi, et al., 2007). Actually, the main difference between desires and intentions relies on the association of intentions with the actions, leading agents to be committed in pursuing the goal through the instantiation of some plan (Guizzardi, et al., 2007). The same idea of intentions is explored by (Bottazzi, et al., 2006a) that affirms that "an agent is considered to be intentional when not only it builds a (mental) representation of the goal, but also a representation of the action necessary to its achievement, and of the resulting consequences" (therefore, "intend something" in its ordinary sense is, in fact, a specific type of intentionality termed as intention). Regarding the concept of belief, we analyse two distinct works, namely (Ferrario, et al., 2004) and (Guizzardi, et al., 2008a). In the former, perceptions about the external world may cause the creation of mental objects in the agents. The processing of these perceptions by an agent can lead to the creation of beliefs. From these beliefs, desires can be derived. Finally, desires can lead to the creation of intentions. Therefore, intentions are existentially dependent on beliefs to be created. Goals, in turn, are reliant on beliefs to be pursued. In the latter, beliefs are intentional moments of agents created from the perception of the world. Guizzardi's proposal is different from Ferrario's proposal in the sense that the latter cites a processing step from percepts to beliefs, while the former does not mention the existence of some kind of processing in the agents' mind.

Goals. The concept of goal is widely used in agent-orientation and related fields, ranging from conceptual goal modelling in Agent Organizations and Requirements Engineering to goal execution in AI Planning and Agent Teamwork (Guizzardi, et al., 2007). For example, in the area of Requirements Engineering, the concept of goal is widely used for the definition and analysis of the objectives of the involved stakeholders and the future system. The need of capturing the aspirations of the human stakeholders for the target system leads to the definition of the concept of goal in terms of the desired functionalities of such system, as shown in (Lamsweerde, 2001) (Regev, et al., 2005).

Even with the widespread dissemination of the goal-orientation paradigm in the aforementioned areas, there are few works which define the concept of goal from an ontological point of view. Among of these works, in (Markovic, et al., 2008), "a goal expresses an attainable, measurable and time-bound state of the world that should be achieved or sustained (…)". Similarly, goals are also defined as "the set of desired state of affairs" in (Guizzardi, et al., 2007) and (ISTC-CNR, 2005-2007b) (the definition used in this paper). Another definition of goals states the semantics of such concept on the basis of other ontological concepts: goals are the specialization of a mental moment, i.e., "the propositional content of Intentions" (Guizzardi, et al., 2007). As argued in (Guizzardi, et al., 2007), the external concept regards a state of affairs desired by an agent (here called goal), and the internal one is the desire itself, which is part of the agent's mental state.

Capabilities. In (ISTC-CNR, 2005-2007b), it is argued that agent's capabilities determine the potential states of the world that the agent can hold in executing actions. In other words, while beliefs influence agents in the choice of some particular strategy to achieve some goal, capabilities determines how effectively the agent will execute the chosen strategy.

2.1.4 Actions and Plans

In previous sections, we have discussed how mental states affect agents to adopt actions in the pursuit of goals. Although the distinction between goals and actions is quite important as demonstrated in the BDI model, it is not always clear in the existing works as argued by Guizzardi et. al in (Guizzardi, et al., 2007) which explicitly recognize this separation. Goals are a set of states of affairs (i.e. a set of world states), whereas actions (or action events) are events created by agents with the purpose of attaining goals (Guizzardi, et al., 2007). Therefore, since actions are realized by intentional agents, they are also intentional transformations of reality.

During the process of creation of actions to fulfil goals, agents commonly face different alternative solutions for achieving the same goal. In this decision-making process, there is potential misalignment between the choice of some plan and the satisfaction of the goal associated with this plan. This "misalignment" refers to a possible inadequacy of the plan or due to an intrinsic limitation of the goal to be satisfied in its totality. Therefore, for goals to be achieved, intentions must drive the adoption of "proper" plans.

Concerning this issue, some ontologies (ISTC-CNR, 2005-2007b) (Guizzardi, et al., 2007) distinguish between the planning process (in which agents deliberate about which actions must be executed under some constraints) and the instantiation of actions which actually achieve the goal. Planning comprises in decision-making process with the purpose of choosing which actions are better applied to achieve some situation, considering the current constraints to which the agent is subjected. Therefore, in these frameworks, "a plan is an action type that an agent intends to execute (more correctly the agent intends to execute an instance of that action type) to achieve a goal" (Guizzardi, et al., 2008a). We consider the execution of some business process to be the execution of a plan, which entails the execution of one or more ordered atomic actions, targeting a particular outcome. In other words, the

execution of a business process is the performance of a complex action (using the terminology in (Guizzardi, et al., 2007)).

2.1.5 Objects

In several ontologies, objects are endurants, i.e., entities that "are in time", like a ball, a pen, or a flower. Endurants are the opposite of perdurants (or events) that correspond to entities that "happen in time", like a business process, a wedding, etc. (Guizzardi, 2005) (Bottazzi, et al., 2006b).

In (Guizzardi, 2006), the concept of physical object is specialized into physical agent and non-agentive object. The classification in relation to the agentivity refers to the ability of the object of holding intentionality. Physical agents and their relation with goal achievement have already been explored in previous topics. Therefore, here, we refer to non-agentive objects to explain their relation with goal achievement.

Objects can be physical (e.g., an equipment, a device) or social (e.g., money, language and normative descriptions (Bottazzi, et al., 2006b) (Guizzardi, et al., 2008a). Normative descriptions are further explored in next section.

Objects are denominated as resources when they are used by an agent with a specific purpose. In this case, how the resource participates in the action affects how goals are achieved. With that respect, in (Guizzardi, et al., 2008a), authors define that there are four different modes of resource to participate in actions, namely, creation, termination, change and usage.

Informally speaking, a resource creation and termination correspond respectively to the creation and termination of some resource in the organizational environment. A resource change means that some property (moment) of the resource has been altered by an action and finally, a resource usage is a kind of participation which is not any of the three aforementioned modes. Sometimes, the way how the resource participates in the action is determinant for goals to be achieved. An example of how a resource participation impacts some goal to be fulfilled is when some agent has to access to the resource to achieve a goal or the way that some agent manipulates a resource previously accessed to achieve a goal (in this latter, highlighting the role of agent's capabilities in manipulating certain resources to attain organizational goals).

2.1.6 Rules and Norms

Organizations are entities that strongly depend on norms; i.e., they are completely made up of norms (ISTC-CNR, 2005-2007b). The proposals in (Boella, et al., 2006) (Bottazzi, et al., 2006b) (Guizzardi, et al., 2008a) view rules and norms as a collectively recognized descriptions which act as enforcement mechanisms to restrain the individual behaviour of agents, regulating all sort of organizational interactions among them, including delegations, relationships with internal/external organizational entities as well as defining concepts within the organizational setting.

Botazzi (Bottazzi, et al., 2006b) and Searle (Searle, 1995) suggest three different kinds of norms based on the different functions they have; constitutive norms, deontic norms and technical norms. Searle in its construction of social reality (Searle, 1995) explains that constitutive norms have the function of creating concepts, whereas deontic norms constrain the existence of pre-existing concepts. Technical norms describe the correct procedure to do something, i.e., they specify how a plan should

be executed (Bottazzi, et al., 2006b). For a detailed description of these distinctions, please refer to (Cardoso, 2009) (Almeida, et al., 2011).

2.2 Summary of Concepts

Table 1 summarizes the elements that compose our semantic layer, extracted from the various ontologies surveyed. The various definitions that have been investigated for the same element are presented, and, in the cases in which there has been significant convergence, a single merged definition is provided.

Table 1 A Summary of Definitions for the Elements of the Semantic Layer

<table>
<tr><th>Semantic Layer</th><th colspan="2">Surveyed Definitions</th><th>Definition Adopted for the Semantic Layer</th></tr>
<tr><td rowspan="4">Organization</td><td rowspan="3">Organization</td><td>Social objects (ISTC-CNR, 2005-2007b)</td><td rowspan="3">Designed social agents who act in the physical world with a specific mission (ISTC-CNR, 2005-2007b) (Guizzardi, et al., 2007)</td></tr>
<tr><td>Artifacts (ISTC-CNR, 2005-2007b)</td></tr>
<tr><td>Designed social agents (ISTC-CNR, 2005-2007b) (Guizzardi, et al., 2007)</td></tr>
<tr><td rowspan="2">Organizational structure</td><td>Roles are the only structural component in the design of organizations (Dignum, 2004) (Fox, et al., 1998) (Uschold, et al., 1998) (Dietz, 2006)</td><td rowspan="2">Sub-organizations and roles describe the organizational structure. Organizations are a 4-tuple composed by a set of objectives, a set of (direct internal) sub-organizations, a set of institutional relationships and a set of external organizations (ISTC-CNR, 2005-2007a).</td></tr>
<tr><td>Sub-organizations and roles describe the organizational structure (ISTC-CNR, 2005-2007a)</td></tr>
<tr><td colspan="2">Role</td><td colspan="2">Roles are social concepts employed for abstracting from specific agents in organizations (ISTC-CNR, 2005-2007b), representing the part of the organizational design which specifies the activities and services necessary to achieve enterprise objectives (Dignum, 2004). Roles are specific type of sub-organizations that have no further decomposition (Boella, et al., 2006).</td></tr>
<tr><td rowspan="4">Agent</td><td>Agent</td><td colspan="2">Autonomous and heterogeneous entities that exhibit proactive and flexible behaviour (Ferrario, et al., 2004) as well as mental states (Guizzardi, 2006).</td></tr>
<tr><td>Intention</td><td colspan="2">A goal that the agent commits at pursuing (Guizzardi, et al., 2008a) (Bottazzi, et al., 2006a)</td></tr>
<tr><td>Desire</td><td colspan="2">Represents the “will” of an agent towards a specific goal, although it might never actually pursue this goal (Guizzardi, et al., 2007) (Bottazzi, et al., 2006a)</td></tr>
<tr><td>Belief</td><td>Correspond to perceptions about the external world may cause the creation of mental objects in agents. The processing of these</td><td>Intentional moments of agents created from the</td></tr>
</table>

		perceptions by an agent can lead to the creation of beliefs (Ferrario, et al., 2004).	perception of the world (with a pre-processing step) (Ferrario, et al., 2004) (Guizzardi, et al., 2008a).
		Intentional moments of agents created from the perception of the world (does not mention the existence of some kind of processing in the agents' mind) (Guizzardi, et al., 2008a)	
	Goal	Expresses an attainable, measurable and time-bound state of the world that should be achieved or sustained (…)" (Markovic, et al., 2008)	The set of desired state of affairs (Guizzardi, et al., 2007) (ISTC-CNR, 2005-2007b)
		The set of desired state of affairs (Guizzardi, et al., 2007) (ISTC-CNR, 2005-2007b)	
		The propositional content of intentions (specialization of a mental moment) (Guizzardi, et al., 2007)	
	Capability	Determine the potential states of the world that the agent can hold in executing actions (ISTC-CNR, 2005-2007b)	
Actions and Plans	Actions	Actions (or action events) are events created by agents with the purpose of attaining goals (intentional transformations of reality) (Guizzardi, et al., 2007) (ISTC-CNR, 2005-2007b)	
	Plans	In the planning process, the agents deliberate about which actions must be executed under some constraints. Therefore, a plan corresponds to an action type that an agent intends to execute (more correctly the agent intends to execute an instance of that action type) to achieve a goal (Guizzardi, et al., 2008a) (ISTC-CNR, 2005-2007b)	
Objects		Objects are endurants, i.e., entities that "are in time", like a ball, a pen, or a flower. Endurants are the opposite of perdurants (or events) that correspond to entities that "happen in time", like a business process, a wedding, etc. Objects are denominated as resources when they are used by an agent with a specific purpose (Guizzardi, 2005) (Bottazzi, et al., 2006b)	
Norms and Rules		Collectively recognized descriptions which act as enforcement mechanisms to restrain the individual behaviour of agents, regulating all sort of organizational interactions among them, including delegations, relationships with internal/external organizational entities as well as defining concepts within the organizational setting (Boella, et al., 2006) (Bottazzi, et al., 2006b) (Guizzardi, et al., 2008a)	

3 Relating Strategic and Operational Aspects Using the Semantic Layer

3.1 Background

Our investigation on the semantic layer (described in section 2) was motivated by the difficulties encountered in establishing the relation between strategic and operational aspects of the organization in the scope of a case study we have conducted in a healthcare organization.

Our initial hypothesis for the study was that goal models and business process models would allow us to establish the links between the strategic and operational aspects of the enterprise. Thus, we have designed the case study as a series of iterative interview, modelling and validation rounds, resulting in goal models and business process models in Tropos and ARIS EPCs respectively. Our decision to represent goal models and business processes models using different modelling languages can be accounted by our expressiveness requirements and the support provided by the modelling languages: while ARIS supports business process modelling and detailed organizational structures, it offers an overly simplistic set of goal-related concepts; in its turn, Tropos offers a rich set of goal-related concepts (and associated goal analysis methods), while refraining from addressing business process modelling in detail.

After separately elaborating goal models and business process models, we have attempted to address the issue of the alignment between the goals captured in the goal models and the organizational behaviour captured in business process models.

We have asked domain experts the following questions (using the goal models as a guide): (i) what is necessary for this goal to be achieved? (ii) is this goal currently achieved? (iii) if not, why?, and (iv) what would be the necessary change(s) in the organizational environment for this goal to be achieved? The responses of these questions pointed not solely to activities and business processes, but also prominently to organizational norms, agent's beliefs and capabilities, conflicts in agent's goals, availability of resources (such as equipment and information systems), definitions of roles in the organization, etc. As a consequence, it became clear the initial hypothesis was not valid in the organizational setting and that the alignment between strategic and operational aspects could not be established solely through goal models and business process models. This has justified the investigation into the semantic layer, and prompted us to adjust our study to incorporate the various semantic relations between goals and other elements of an enterprise architecture beyond organizational behaviour captured in business process models. In section 3.2, we report on the approach that resulted from this investigation. Later, in section 4, we discuss the application of the approach in a case study in a specific enterprise setting.

3.2 Approach

The following steps are performed for each goal in a goal model:

1) Apply the aforementioned questions to identify which enterprise architecture element is responsible for the achievement of the goal, hence mapping this element to the concepts in the *semantic layer*;
2) Examine the nature of the relation between goals and the identified elements (including other goals), considering the relations in the semantic layer;

3) Check the completeness of the concepts and relations identified spontaneously in the responses of domain experts (step 1). This step involves using the concepts and relations in the semantic layer to verify the elements that were not elicited in the responses, but which may also contribute or pose a threat to goal satisfaction.
4) Map the semantic layer concept to the correspondent architectural element in the process model (if possible given the limited expressiveness of the process model when compared with the semantic layer). This is required to maintain the relations between goal models and processes models,

To illustrate the application of the procedure, consider that the questions associated with a given goal G_A revealed that the satisfaction of the goal is somehow related to an action or a process that is modelled in the process model (we call this process as plan P_1 in the *semantic layer*). The subsequent step (2) requires us to consider the nature of the relation between G_A and P_1 by employing the semantic layer. The semantic layer reveals various alternative interpretations for the relation between a goal and a plan. One of these is that achievement of the goal depends on the planning process that ultimately selects P_1. During the planning process, in order to consider the satisfaction of the goal G_A, one has to select between two alternative activities/processes P_1 and P_2 to achieve the goal. In this case, there are several *alternative* activities/processes, and one has to decide the most suitable alternative. The goal is best achieved depending on the activity/process chosen during this phase. A second admissible interpretation is that the activity/process P_1 is the only alternative to achieve the goal G_A and the activity/process has to execute to achieve the goal (the achievement of the goal is not related with the planning process). In this case, what matters for the goal G_A to be achieved is not the selection among alternatives, but rather the *instantiation* of the activity/process. In that respect, we have also to settle: (i) whether the process P_1 has to execute *one* time (one instantiation) to achieve the goal G_A or; (ii) whether the process P_1 has to execute *several* times (several instantiations) to achieve the goal G_A. The correct semantics for the relation between G_A and P_1 must be settled through interviews with domain experts. Having settled the semantics for the relation between G_A and P_1, we may investigate other possible relations for G_A not uncovered by the questionnaire (step 3), with the purpose of leveraging the relations in the semantic layer to lead to a more complete identification of the alignment. One may ask in this example: Do the goals of the agents who perform the process P_1 interfere in the achievement of the goal?; Do the capabilities of the agents affect goal satisfaction?; Do the objects (resources) employed in P_1 contribute to the achievement of the goal?; etc. Finally, we record the correspondences identified between the semantic layer concept and the elements in the process model (e.g., the correspondence between P_1 and specific processes or activities in the process model).

4 Case Study Goal Alignment in a Rheumatology Department

The case study was performed in the Rheumatology Department of the Cassiano de Moraes University Hospital (HUCAM) in Vitória, Brazil. We have elicited 8 sets of validated AS-IS goal and business process models, concerning 8 of the 15 business processes performed by the organization and one extra goal model to capture strategic aspects that are relevant for many business processes at once. We then applied the approach described in section 3.2. We explore here some examples found in the context of the study. We emphasize the role of the semantic layer in the application of the approach and thus we have selected examples which are representative enough to show the various relationships captured in the *semantic layer*. Due to space constraints, we select here a relatively small number of examples and omit most of the models; for a complete set of results please refer to (Cardoso, 2009).

4.1 Example 1: The involvement of Goals, Plans and Capabilities

Figure 1 depicts a fragment of the Physician's goal model. This fragment shows the refinement of the *Confirm Clinical Suspicion of Sjögren Syndrome* goal, which is central to our first example. The goal is a refinement of the overarching *Diagnose Patient's Health State* (not depicted in Figure 1).

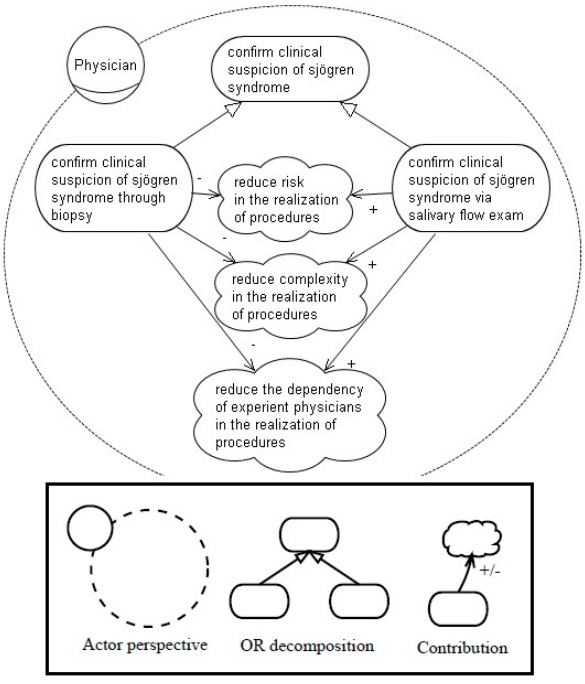

Figure 1 The physician's goals (fragment of the goal model)

Step 1 of the approach reveals that the goal can be satisfied through two alternatives procedures (actions), namely, via *biopsy* or *salivary flux exam* (for this reason, the goal has been refined into two goals, namely *Confirm Clinical Suspicion of Sjögren*

Syndrome through Biopsy and *Confirm Clinical Suspicion of Sjögren Syndrome via Salivary Flow Exam*). Therefore, the *Confirm Clinical Suspicion of Sjögren Syndrome* goal (G_A) is related to the ontological category of Actions in the *Semantic Layer* (Figure 2).

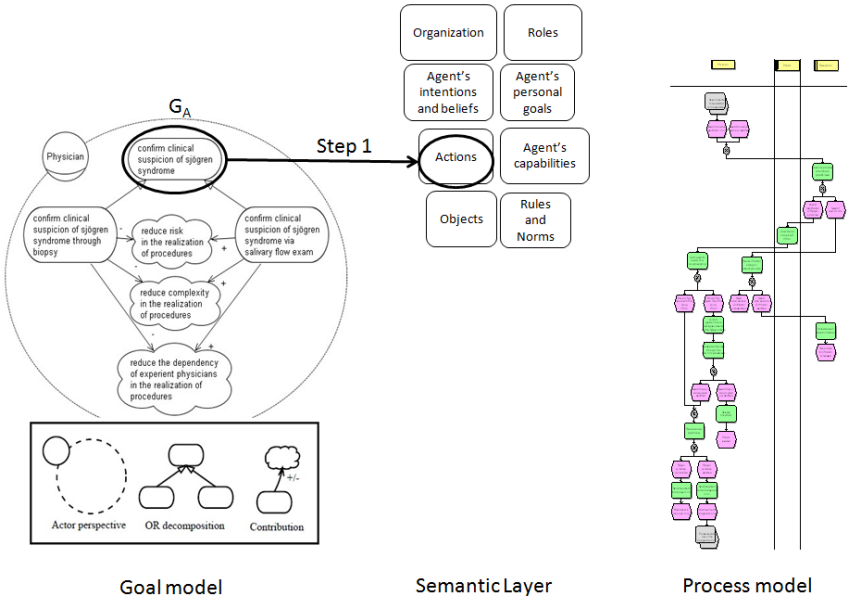

Figure 2 Example: Step 1 - Initial identification of relations

In step 2, the relations between the goal and the two identified actions are analysed. The *biopsy* of the salivary gland (P_1) is the most effective exam which can be chosen to achieve the goal since it confirms the clinical suspicion of the condition (Sjögren syndrome) with one hundred percent certainty. In contrast, the *salivary flow exam* only provides some insights for the physician. Nevertheless, the first exam applied for diagnosis is always the *salivary flux exam* (an inferior method to achieve the goal). In other words, the *biopsy* exam is the best plan to be applied since it (completely) satisfies the goal (in opposition to the salivary flow exam which satisfies the goal within certain limits), but it is only applied when the first solution has failed in achieving its goal (confirm clinical suspicion of the condition). The prioritization of the *salivary flux exam* is accounted by the complexity, risk and knowledge required in a *biopsy* exam. If we perform a contribution analysis in Tropos (Bresciani, et al., 2003), it is said that while the *salivary flow exam* positively contributes to *Reduce the dependency of experient physicians in the realization of procedures, Reduce risk in the realization of procedures* and *Reduce complexity in the realization of procedures* goals, the *biopsy procedure* contributes negatively to the same goals. Therefore, due to its positive contribution to other goals, the *salivary exam* is prioritized to confirm the condition. Observe that in the first case, there is a plan which better achieves the goal, but another plan (which satisfies the goal within acceptable limits) is chosen. After this analysis and by applying the *semantic layer*, we may conclude that the achievement of the *Confirm Clinical Suspicion of Sjögren Syndrome* goal depends on

the planning process (first interpretation for the nature of the relation). In Figure 3, our interpretation of the relation led us to identify two actions P_1 (refers to the activities that correspond to the *biopsy*) or P_2 (refers to the activities that correspond to the *salivary flow exam*) to satisfy the goal during the planning process.

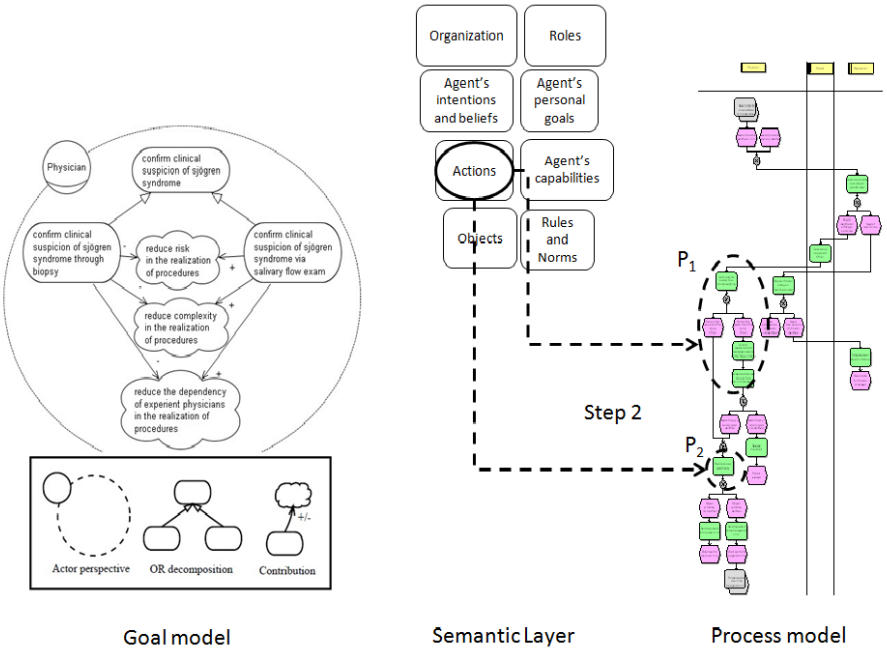

Figure 3 Example: Step 2 – Analysis of relations

In step 3, we consider the completeness of the concepts and relations identified spontaneously in step 1. In this case, we discover that although the satisfaction of the goal is associated with the realization of some exams, this is not the central aspect for the satisfaction of the goal. Instead, what indeed makes the difference is the capability of the involved physicians to select the best plan based on constraints (or priorities) imposed on them during the planning process. In this case, since the achievement of the goal relies not only on the planning process, but also on the *capabilities* of the physicians who perform the planning process. Consequently, the achievement of the goal (which can be accounted by the procedures, physicians and physicians' capabilities) has been mapped to the concepts of Plans (section 2.1.4), Roles (section 2.1.2) and Capabilities (section 2.1.3) in our *semantic layer* (Figure 4). This first example illustrates that although activities are necessary to achieve some goals, solely considering these activities in isolation is not sufficient to analyse the goal satisfaction.

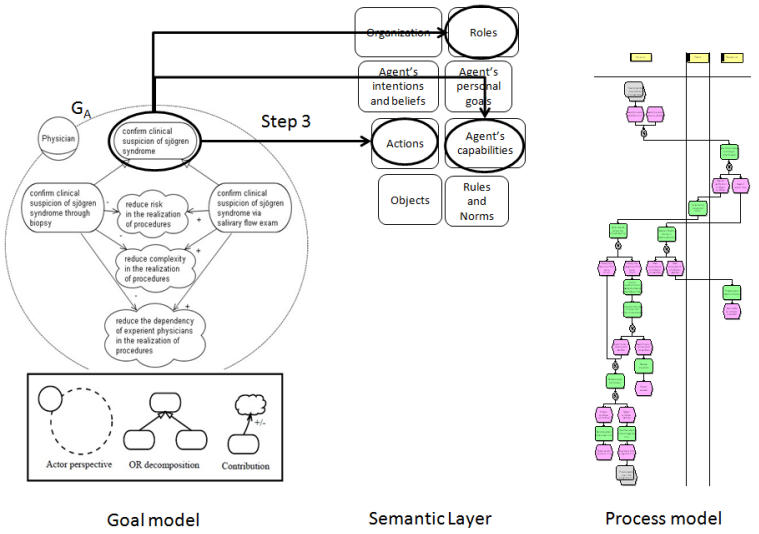

Figure 4 Example: Step 3 – Identification of relations using the semantic layer

Since the achievement of the goal is related to three ontological categories (that may be modelled in the process models), we mapped the ontological categories to their respective elements in the process model (step 4). In this case, Plans, Roles and Capabilities are respectively mapped to *biopsy* (P_1) or *salivary flux exam* (P_2), physician and physicians' capabilities in the process model. Observe that in this example, the model is able to capture the plans (activities) and roles, but lacks a more expressive notation to express roles' capabilities and for this reason in Figure 5, physician and physicians' capabilities are mapped to the same element in the process model.

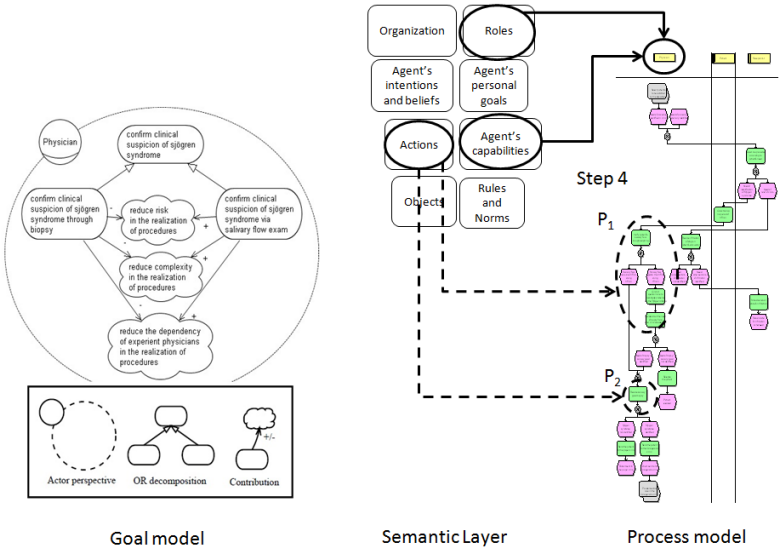

Figure 5 Example: Step 4 – Identification of traceability correspondences

4.2 Example 2: The involvement of Goals, Capabilities and Objects

In our second example, we demonstrate how (social or physical) objects are used as mechanisms for improving the satisfaction of goals in the context of the domain. Following the steps of our approach:

1) Concerning the physician's goal to *Reduce Patient Suffering through Infiltration*, the question/response indicated that the achievement of the goal is impacted by the ability/experience of the physician in manipulating the resources (the better the physician can guide the injection of the drugs within the affected areas, the higher is the relief felt by the patient). The mapping for the *semantic layer* revealed that the achievement of the goal is associated with the ability of the physician (Capability) in manipulating some resource (Object Usage).
2) Regarding the examination of the nature of the relations, the only possible interpretation is that the agent's capabilities to inject the drug will determine how well the goal is going to be achieved. Additionally, considering the resource involved, the *semantic layer* also revealed that the way how the resource participates (how it is manipulated) in the action is determinant for goals to be achieved.
3) The addition of a device for guiding the infiltration (an ultrasound or radioscopy) significantly improves the level of the achievement of this goal. Therefore, besides the relations identified in the previous step, we also add resources (Objects) that can significantly improve or even completely satisfy the goal to account for the goal satisfaction. Regarding the semantics of the relation, we interpret that access to the device for guiding the infiltration increases the level of satisfaction of the goal.
4) In this example, the expressiveness of the process models does not cover the elements associated with the satisfaction of the goal and therefore, this step is not performed here.

4.3 Example 3: The involvement of Goals and Norms

Our third example is related to (deontic) norms for enforcing the satisfaction of goals. Following the steps of our approach:

1) The questions/responses indicated that the patient's goal to *Obtain high cost drug with no monetary charge* is regulated by a state law which addresses the financing of some high cost drugs by the state government. In this case, a rule from the state is responsible for regulating who can access the resource (high cost drug) within the organizational environment, even though this affects other resource saving directives in the organization (the law states that some high cost drugs must be covered with public money unconditionally for special types of conditions). Concerning the mapping to ontological categories, high cost drug is a classified as a Physical Object (section 2.1.5) and the implementation of the goal is made through a Deontic Norm (section 2.1.6), i.e. a state law for the regulation of drugs access.

2) With the support of the *semantic layer*, we interpreted that the access to the high cost drug (resource) satisfies the goal (which in its turn positively contributes to the satisfaction of higher-level goals such as *Minimize patient's physical suffering* and *Promote quality of life*), whereas the deontic norms regulate who is able to access it (constrain the behaviour of the agents that do not have the right to access it).
3) No additional elements were revealed in the completeness verification for this goal.
4) The expressiveness of the process models is not able to capture the ontological categories responsible for the satisfaction of this goal.

An important comment refers to the notion of partial/total satisfaction of goals. A recurrent characteristic of the satisfaction relationships within the case study is that even if the necessary elements for the satisfaction of some goal are provided, it does not entail the total satisfaction of this goal, but instead the goal may be satisfied within partial limits. For instance, achieving the *Avoid the occurrence of complications during drug administration* goal depends on the physician's technical knowledge to perform some pre-emptive actions, e.g. to administrate a drug for controlling the blood pressure. Nevertheless, the successful achievement of the goal is related not only with the physician's technical knowledge or with the pre-emptive actions, but primarily with the response of the patient to this treatment (observe that even if the physician adopts all the relevant solutions for achieving the goal, it may not be attained or may be partially attained). In this case, satisfaction of the goal is outside the control of those who set up the organizational environment.

4 Conclusions and Future Work

In this work, we contributed to the identification of the relations between the strategic and operational aspects of the enterprise architecture applying an ontology-based approach. This approach has required a survey of the literature on enterprise ontologies, focusing on the basic social components which form organizations (i.e., an enterprise's basic building blocks) and on how these blocks are related with the achievement of the enterprise's goals.

Our work advances the state-of-the art in Enterprise Architecture Management and by relating goals and other elements in the enterprise architecture, as opposed to considering business processes as the sole operational component of the enterprise. We employ enterprise ontologies to account for the selection of a broad spectrum of enterprise elements that covers different aspects of the enterprise in a real-world setting. We consider that these points represent important differences from our proposal with respect to existing *goal-oriented business process modelling* approaches. The use of enterprise ontologies brings about two benefits: first, this teleological discussion can be considered complementary to the theoretical literature of enterprise architecture in the sense that it has provided some important relationships among goals and the other enterprise elements which have not been covered by the previous proposals, such as the relationships among the agents' personal goals and roles' goals. Second, exploring the literature in ontologies has

opened the possibility for us to apply a theoretical basis in a practical scenario, helping in clarifying the structure and relationships of the organization.

Concerning the proposed approach to relate goals and enterprise elements, we have observed that identifying the elements which impact on the satisfaction of certain goals is in some cases straightforward, e.g., consider the fact that in the current enterprise setting a *Rheumatologist* is required to perform the actions to satisfy the *Diagnose Patient's Health State* goal. In other cases, however, knowledge about specificities of the domain under consideration is required. For instance, in order to satisfy a "safety" goal in the context of drug infusion in a particular rheumatologic treatment, devices for measuring the patient's blood pressure are required as well as procedures to employ these devices continuously during treatment. For this reason, we believe that ethnographic observation of an enterprise's daily operation should be complemented with interviews with highly skilled personnel, which can provide guidance in case domain-specific knowledge is required. In our case study, interviews with hospital administrator and medical doctors were a valuable instrument in uncovering motivations for operational aspects of the organization.

The case study has revealed that: (i) goal satisfaction often requires multiple enterprise elements simultaneously (from different architectural domains, such as procedures/actions, norms, agents, their capabilities, and resources) and (ii) relations between enterprise elements and goals are not "causal" in the sense that even if the necessary enterprise elements have been provided, goals may not be satisfied.

Our survey has revealed the need to align ontological theories from several different sources, as these sources emphasize different aspects of the enterprise that have shown to be relevant in the analysis of goal satisfaction. We are aware that the integration of several ontologies can bring about semantic inconsistencies, since each ontology defines its concepts based on different assumptions and foundations. We recognize that this semantic interoperability is an issue that cannot be neglected in this integration. Nevertheless, we argue that enterprise modelling covers a broad scope of the social domain which is currently not addressed by a sole enterprise ontology. Certainly, a systematization of the concepts presented here in the definition of a coherent formal ontology is a natural direction for future work and remains a significant challenge. This enterprise ontology must not be developed as a unique artefact aiming at representing the entire complexity of organizations; instead, it should be composed by several ontologies which (explicitly) commit to different philosophical choices, i.e. each of these ontologies concerns a different paradigm or way of conceptualizing organizations. The value of each ontology would depend on its usage scenario and purpose. In this particular work, we have focused on the explanatory power of the ontological theories to reveal issues in the alignment between the strategic and the operational aspects of an enterprise architecture.

As future work, we envision the use of enterprise models with well-defined ontology-based semantics to represent organizations. A rich ontology-based semantic foundation can be considered the first requirement to build rigorous representations of the organizational setting, capturing ontological distinctions which are relevant to pursue enterprise analysis and design. We also believe that such rigorous representation of the organization can be used to support formal reasoning during the selection of the strategies which will be adopted to attain a set of goals or strategic directives. This should be fruitful in the systematization of business process

reengineering efforts. Nevertheless, we can not disregard the fact that these reengineering efforts have to consider the domain knowledge specificities, which limits the automated applicability in producing the results with the same quality than the techniques developed by human specialists of the domain.

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References

Almeida, J. P. and Cardoso, E. (2011) 'On the Elements of an Enterprise: Towards an Ontology-Based Account', *ACM Symposium on Applied Computing (SAC'11)*, TaiChung, Taiwan: ACM, 2011. 978-1-4503-0113-8.

Birgit, K. and List, B. (2007) 'Extending the EPC and the BPMN with Business Process Goals and Performance Measures', *Proceedings of the 9th International Conference on Enterprise Information Systems, ICEIS 2007*.

Boella, G. and Van der Torre, L. (2006) 'A Foundational Ontology of Organizations and Roles'. *4th International Workshop of Declarative Agent Languages and Technologies (DALT'06)*. Hakodate, Japan: Springer, 2006. Vol. 4327. 3-540-68959-1.

Bottazzi, E. and Ferrario, R. (2005) 'A Path to an Ontology of Organizations', *EDOC International Workshop on Vocabularies, Ontologies and Rules for The Enterprise (VORTE 2005)*. Enschede, the Netherlands.

Bottazzi, E., et al. (2006a). From Collective Intentionality to Intentional Collectives. *Journal of Cognitive Systems Research*,Vols. 7(2-3).

Bottazzi, E. and Ferrario, R. (2006b) 'Preliminaries to a DOLCE Ontology of Organizations', *International Journal of Business Process Integration and Management, Special Issue on Vocabularies, Ontologies and Business Rules for Enterprise Modelling*. Vols. 1, Nos. 1/2/3, pp. 64–74.

Bresciani, P. and Sannicolò, F. (2003) 'Requirement Analysis in TROPOS: a Self Referencing Example', *in Agent Technologies, Infrastructures, Tools, and Applications for e-Services, LNAI 2592*, Springer-Verlag, Berlin, Germany.

Bresciani, P., et al. (2004) 'Tropos: An Agent-Oriented Software Development Methodology', *Journal of Autonomous Agents and Multi-Agent Systems*, pp. 203–236.

Cardoso, E. (2009) 'On the Alignment between Goals Models and Enterprise Models with an Ontological Account', *Master Thesis*, Federal University of Espírito Santo (UFES), Vitória, Brazil.

Cardoso, E., et al. (2011) 'A Method for Eliciting Goals for Business Process Models based on Non-Functional Requirements Catalogues', *International Journal of Information System Modelling and Design (IJISMD)*. IGI Global, Vol. 2, 2.

Cardoso, E., et al. (2009) 'Eliciting Goals for Business Process Models with Non-Functional Requirements Catalogues', *10th International Workshop on Business Process Modelling, Development and Support (BPMDS 2009)*. Amsterdam, The Netherlands, Springer-Verlag.

Cardoso, E., Guizzardi, R. and Almeida, J. P. (2010a) 'Aligning Goal Analysis and Business Process Modelling: A Case Study in Health Care', *International Journal of Business Process Integration and Management (IJBPIM)*.

Chandrasekaran, B., Josephson, J. R. and Benjamins, R. (1999) 'What Are Ontologies, and Why Do We Need Them?' *IEEE Intelligent Systems.* Vol. 14, 1, pp. 20-26.

Chung, L. et al. (2000) 'Non-Functional Requirements in Software Engineering', *Kluwer Academic Publishers.*

Dietz, J. (2006) 'Enterprise Ontology: Theory and Methodology', New York, USA, *Springer-Verlag.*

Dignum, V. (2004) 'A Model for Organizational Interaction: Based on Agents, Founded in Logic'. *PhD thesis.* Utrecht University, The Netherlands.

Ferrario, R. and Oltramari, A. (2004) 'Towards a Computational Ontology of Mind' *Proceedings of the International Conference FOIS (Formal Ontology in Information Systems).* IOS Press, pp. 287-297.

Fox, M. et al. (1998) 'An Organizational Ontology for Enterprise Modelling. Simulating Organizations: Computational Models of Institutions and Groups'. *Menlo Park*, CA, USA, MIT Press, pp. 131--152.

Grüninger, M., Atefi, K. and Fox, M. (2000) 'Ontologies to Support Process Integration in Enterprise Enginnering', *Computational and Mathematical Organization Theory,* Kluwer Academic Publishers, pp. 381–394.

Guizzardi, G. (2007) 'On Ontology, Ontologies, Conceptualizations, Modelling Languages, and (Meta)Models', *In Frontiers in Artificial Intelligence and Applications, Databases and Information Systems IV*. Amsterdam, The Netherlands, IOS Press, 978-1-58603-640-8.

Guizzardi, G. (2007) 'Ontological Foundations for Structural Conceptual Models'. *PhD thesis.* University of Twentee, The Netherlands.

Guizzardi, G., Falbo, R. and Guizzardi, R. (2008a) 'Grounding Software Domain Ontologies in the Unified Foundational Ontology (UFO): The case of the ODE Software Process Ontology', *XI Iberoamerican Workshop on Requirements Engineering and Software Environments (IDEAS'2008),* Recife, Brazil.

Guizzardi, R. (2006) 'Agent-Oriented Constructivist Knowledge Management', *PhD Thesis.* Twentee University, the Netherlands.

Guizzardi, R. et al. (2007) 'Towards an Ontological Account of Agent Oriented Goals', *Software Engineering for Multi-Agent Systems V: Research Issues and Practical Applications,* Springer-Verlag, Vol. 5, pp. 148--164. 978-3-540-73130-6.

Halleux, P., Mathieu, L. and Andersson, B. (2008) 'A Method to Support the Alignment of Business Models and Goal Models', *Proceedings of 3rd International Workshop on Business/IT-Aligment and Interoperability (BUSITAL'08) CEUR Workshop Proceedings*. Montpellier, France, CEUR Workshop Proceedings, pp. 120-134. 1613-0073.

ISTC-CNR (2005-2007a) 'Mostro, deliverable 2 - Designing Organizations: Towards a Model'. Autonomous Province of Trento. http://www.loa.istc.cnr.it/Publications.html

ISTC-CNR (2005-2007a) 'Mostro, deliverable 3 - Ontology of Organizations and Security - An Ontology of the Teleological Dimension in Organizations'. Autonomous Province of Trento. http://www.loa.istc.cnr.it/Publications.html

Kavakli, E. and Loucopoulos, P. (2003) 'Goal Driven Requirements Engineering: Evaluation of Current Methods', *In Proceedings of the 8th CAiSE/IFIP8.1 Workshop on Evaluation of Modeling Methods in Systems Analysis and Design, EMMSAD*. Velden, Austria.

Koliadis, G. and Ghose, A. (2006) 'Relating Business Process Models to Goal-Oriented Requirements Models in KAOS', *Advances in knowledge acquisition and management (Pacific Knowledge Acquisition Workshop)*. Vol. 4303. 3-540-68955-9.

Koliadis, G. et al. (2006) 'A Combined Approach for Supporting the Business Process Model Lifecycle' *in Proceedings of the 10th Pacific Asia Conference on Information Systems (PACIS).* Kuala Lumpur, Malaysia.

Kueng, P. and Kawalek, P. (1997) 'Goal-based business process models: creation and evaluation' *In Business Process Management Journal* 3.pp. 17-38.

Lamsweerde, A. (2001) 'Goal-Oriented Requirements Engineering: A Guided Tour'. *In Proceedings of 5th International Symposium on Requirements Engineering (RE 2001)*. Toronto, Canada : IEEE Computer Society Press.

Lin, Y. (2008) 'Semantic Annotation for Process Models: Facilitating Process Knowledge Management via Semantic Interoperability'. *PhD Thesis*. Trondheim, Norway, Vol. 2008.239. 978-82-471-5157-0.

Markovic, I. and Kowalkiewicz, M. (2008) 'Linking Business Goals to Process Models in Semantic Business Process Modelling.' *In Proceedings of the 12th International IEEE Enterprise Distributed Object Computing Conference (EDOC '08)*, Munich, Germany, pp. 332-338. 978-0-7695-3373-5.

Mylopoulos, J. et al. (1992) 'Representing and Using Non-Functional Requirements: A Process-Oriented Approach', *IEEE Transactions on Software Engineering*, Vol. 18, pp. 483-497. 0098-5589.

Neiger, D. and Churilov, L. (2004) 'Goal-Oriented Business Process Modeling with EPCs and Value-Focused Thinking'. Business Process Management. pp. 98-115.

Nurcan, S. et al. (2005) 'A Strategy-Driven Business Process Modelling Approach'. 6 Journal of Business Process Management. Vol. 11, pp. 628-649. 1463-7154. 2008.

Rao, A. and Georgeff, M. (1991) 'Modelling Rational Agents within a BDI-Architecture', *Proceedings of the Second International Conference on Principles of Knowledge Representation and Reasoning (KR'91)*, Cambridge, MA, USA, Morgan Kaufmann Publishers, pp. 473–484.

Regev, G. and Wegmann, A. (2005) 'Where do Goals Come from: the Underlying Principles of Goal-Oriented Requirements Engineering', *Proceedings of the 13th IEEE International Requirements Engineering Conference*. Paris, France.

Searle, J. (1995) 'The Construction of Social Reality'. *Information Technology and People*, Vol. 12, 4, pp. 157-160.

Shoham, Y. (1993) 'Agent-Oriented Programming', *Artificial Intelligence, Elsevier Science*, vol. 60, 1, pp. 51-92.

Simon, H. (1996) 'The Sciences of the Artificial', *3rd Edition, Cambridge*, UK, MIT Press, 0262691914.

Soffer, P. and Wand, Y. (2005) 'On the Notion of Softgoals in Business Process Modeling'. *Business Process Management Journal. Emerald Group Publishing Limited,* Vol. 11, 6, pp. 663– 679. 1463-7154.

Uschold, M. et al. (1998) 'The Enterprise Ontology', *The Knowledge Engineering Review*. 13, Vol. 1, pp. 31-89.