

A CONCERN-ORIENTED AND ONTOLOGY-BASED APPROACH TO CONSTRUCTING FACETS OF INFORMATION SYSTEMS

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Abstract: A concern-oriented analysis approach for developing information systems is presented. The method uses the concerns of various stakeholders of an information system (IS) for partitioning the system conceptual domain in stakeholder-oriented sub-domains. Mental representations descriptions of stakeholders' beliefs and knowledge related to each concern are identified and on their basis, a domain ontology can be created. Furthermore, facets of the future IS are constructed by an abstraction mechanism applied on the domain ontology.

1 INTRODUCTION

In this paper, we present some results we obtained in our research on information systems analysis. We consider an information system as an informational model of one or more work systems belonging to an enterprise, or in general to an organization. Such a system gives informational support to the represented systems. It provides functionalities of capturing, transmitting, storing, retrieving, manipulating, and supplying data, information, and knowledge.

The conceptual mechanisms we generally use for managing the IS complexity are decomposition and composition, and refining and abstraction. We considered them in order to propose an analysis approach for constructing views on ISs. These mechanisms are based on the fundamental principle of separation of concerns that we present in what that follows.

Separation of concerns is an old decomposing and composing principle which partitions a system into smaller more manageable and comprehensible parts (Parnas, 1972). Each decomposing criterion is derived from a concern or need belonging to a particular area of interest.

The stakeholders of an IS are people who influence the system development and/or use.

Stakeholders are employees, managers, customers, suppliers, etc.

We define the (stakeholder's) concern as a problem-originated care of one or more stakeholders involved in the construction or evolution in its natural environment of an IS. The care of a stakeholder derives from his/her interest or responsibility in the IS' real world, his/her thinking to improve or modify something in this world for better matching his/her expectations, or worrying about something wrong or undesired could occurs.

In our approach, the specification of a concern problem uses a pair composed from two descriptions: a) the initial state description of the current situation, as the stakeholder perceives it, and b) the final state description of the situation that matches expectations, interests, or desires of the stakeholder. These two elements are respectively considered as hypothesis and conclusion of the problem specification. The problem's initial state contains all information and knowledge necessary to obtain the final state of the problem and, thus, to solve it. The high-level specification of a concern that a stakeholder tries to solve is an association of such a pair of states and the role the stakeholder plays in the system.

2 MULTIFACETED INFORMATION SYSTEMS

According to our approach, we can analyze an information system as an aggregation of views that are created by composing facets. These facets can be explicitly constructed based on the stakeholders' beliefs and knowledge.

We consider a belief as a state of mind about a mental representation that symbolizes a mental object that depends on a perception (Ferrario, Oltramari, 2004). In the cognitive psychology, a mental representation is defined as a psychological mechanism that allows the reflection and the knowledge of an entity, phenomenon, or of a state of affairs in its absence. The condition is that, this was previously perceived in the real world (Zlate, 2004).

There is a strong relation between knowledge and beliefs: a credible belief accepted by all people who are interested in, it's a piece of knowledge.

Nevertheless, we do not consider all the beliefs and knowledge of a stakeholder, but only those which belong to the explanations of the cause of problems that are related to their concerns. We called semantic rationale such a motivation of a concern.

We use the semantic rationales of the stakeholders' concerns to firstly identify their vocabularies, and then describe their intended meaning in order to obtain an ontology.

We proposed in (Bogdan, Șerbănați, 2006) and (Bogdan, Luzi, Ricci, Șerbănați, 2007) a concern-oriented approach of IS analysis with the following 11 steps: 1) identification of stakeholders; 2) identification of concerns; 3) concern classification; 4) identification of relations between concerns; 5) priority of concerns solving; 6) identification of semantic rationales; 7) identification of the concepts used in the semantic rationales; 8) ontological analysis of the intension of the concepts; 9) choosing a foundational (top-level) ontology to be extended by the new ontology; 10) classification of the concepts conforming the foundational ontology; 11) definition of the ontology using a formal logical language.

The approach also includes guidelines for the creation of the informational views on the IS under study from the obtained domain ontology. For this, other four steps should be added to the basic method: 12) construction of the UML ontological model of each piece of knowledge or belief; 13) construction of facets for each concern rationale; 14) the analysis of the independence degree of the facets; and 15) construction of the informational view by grouping facets of some related concerns.

This paper is focused on the steps 12)-15) of the method.

2.1 Analysis of Concerns

In order to identify the concerns and their relations in the development process of an IS, our approach firstly recommends to analyze the stakeholders' preoccupations, interests and beliefs, and identify how they generate concerns, in other words how the stakeholders reason.

The analysis of the concerns according to the above four perspectives begins with the construction of their high-level specifications composed from a problem specification and the roles of stakeholders that manifest that concern.

For each concern, the beliefs and pieces of knowledge that constitute their semantic rationales have to be identified. For this we can use the problem specification, the stakeholder's work practice, and his/her explicit and tacit knowledge.

2.2 Building an Ontology

The mental representations of the stakeholders' knowledge and beliefs are formed by concepts that refer instances belonging to three categories: physical entities and their relations in the real world, ad hoc conceptualizations resulted from the stakeholder's experience, and abstract (non-physical or social) entities that were produced by the human mind and are shared by various communities.

The identification of concepts from every semantic rationale represents the activity in which a vocabulary is created. The vocabulary is a set of concepts that we use them in order to refer concrete and abstract entities as well as relationships between them from the domains associated to the problems related to the identified concerns. From each concern rationale the participating concepts are gathered in the vocabulary. In our approach the vocabulary is used for solving the problem associated to the concern. This activity is repeated until the whole conceptual domain of the problems associated to the concerns shared between stakeholders is obtained.

Furthermore, the concepts are ontologically analyzed according to the OntoClean methodology in order to obtain a backbone taxonomy based on a combination of some properties, like rigidity, identity, and dependence (Guarino, Welty, 2004). Then the foundational ontology is chosen. Subsequently a new taxonomy is created by subsuming the existing categories in the foundational ontology taxonomy. In addition, on the basis of the conceptualization of foundational

ontology, the domain ontology is created by formally describing the intension of each concept and their intentional relations.

During our research, we used the top-level ontology DOLCE (Masolo, Borgo, Gangemi, Guarino, Oltramari, 2003) and one of its modules D&S (Gangemi, Mika, 2003). Other top-level ontologies might be used.

2.3 Views and Facets

In our approach a view is a model of an IS related to a particular, homogeneous from a logical point of view, set of concerns. We consider that the concerns emerge from a particular perspective of the IS developing process: social, functional, informational, or technological perspective. Therefore, depending on the perspective applied, we obtain social, functional, informational, or technological views. The views are models of a future or existing IS resulting from a projection of the system in a large area of concerns belonging to more stakeholder roles. In this paper, we consider only the informational views.

An informational view is a structural model of the system to be modelled, basically a UML class diagram (UML, 2003). It contains categories in the system's conceptual domain, their relations, as well as constraints regarding the model interpretation.

We also consider an informational view as a cluster of facets. Each facet is a simplified model of the informational view and conceptually represents a concern-driven abstraction of the informational view according to a stakeholder's paradigm. This paradigm is shaped in time by stakeholders playing the same role or having the same responsibilities. Confronted with similar situations the stakeholders manifest similar concerns and build similar solutions for solving these concerns. We can say that a facet describes the semantic rationale of a concern.

Technically, a facet is constructed according to a template that contains the following fields: the codes of the facet and concern, the dependency graph of the beliefs and knowledge for a semantic rationale of the concern and the facet semantics represented as a UML class diagram that contains the participating concepts and their ontological relations extracted from the domain ontology.

The template associates the semantic rationale of the concern to the concern semantics as it is derived the knowledge and beliefs of a concern's semantic rationale. In the next subsection, the UML ontological model is defined.

2.3.1 UML Ontological Models

An UML ontological model is a class diagram that semi-formally describes the semantic of a piece of knowledge or belief of a concern's rationale. Such model is constructed from the domain ontology of an IS trying to preserve its semantic. It uses concepts of the UML metamodel like class, data type, association, and dependence (UML, 2003). In our research, we found that the correspondence between these concepts and the categories and conceptual relations of the domain ontology (constructed using the top-level ontology DOLCE+D&S) is expressed in the following rules:

1. All categories of the domain ontology, excepting the abstracts and formal roles, are mapped to classes.
2. The material roles are mapped to association classes and the formal ones are mapped to association roles.
3. Categories subsumed by abstract category are mapped to the data type UML concept. A data type is a type whose values have no identity (UML, 2003).
4. All ontological relations, excepting parthood, constitution, and subsumption are mapped in associations in UML ontological models. An association is a relation that describes semantic connections between individuals that are instances of the given classes (UML, 2003).
5. Temporal and temporary parthood, also constitution relations are mapped in UML aggregation relations (UML, 2003).
6. The subsumption relation is mapped to the UML generalization/specialization relation. As it is known, the subsumption relation holds between two categories A and B (and we say, "A subsumes B") of an ontology if and only if, for all possible states of affairs, all the instances of B are also instances of A. Using UML language we express the same semantic saying that B is a subclass of A.

In order to construct an UML ontological model of a piece of knowledge or belief, our approach proposes the applying of the abstraction mechanism and the following rules on its mental representation description in the natural language:

1. If a concept from the mental representation corresponds to a category from the domain ontology, we map this category and the category or categories from the foundational ontology that subsume it into classes or data types.
2. If a concept corresponds to a quality from foundational or domain ontology, the model will contain the corresponding class and, in addition,

the class or classes that map the category or categories in which the quality inheres in. We inferred this rule from the fact of, according to DOLCE, each quality is specifically, and constantly dependent on the entity it inheres in (Masolo, Borgo, Gangemi, Guarino, Oltramari, 2003).

3. In the case of a relation between two concepts, we check if it is an ontological relation. If so, we transform the relation into an UML one, according to the rules 3-6 above enumerated.
4. If the relation between two concepts, excepting the causality one, is not an ontological one, the domain ontology is traversed on the basis of the subsumption relation of the corresponding categories and, on the basis of the reasoning supplied by the ontology, we search the ontological relation that has the same meaning with the initial relation.
5. The causal relation between two concepts is described in the model by the dependence relation.

After we constructed the UML ontological models of beliefs and knowledge of a concern rationale, we can construct its facet. In order to construct the facet structure, we apply again the abstraction mechanism on the UML ontological models and we only take the classes that will be part of the future informational system and their ontological relations.

3 CONCLUSIONS

In this paper, we have presented an approach based on a concern-oriented analysis aimed to construct an information system as a composition of multi-facetted views. A view is an aggregation of the facets of related concerns of the stakeholders.

The facets are constructed on the basis of domain ontology by composing UML ontological models of the beliefs and pieces of knowledge's mental representation descriptions of a stakeholder's concern.

The approach has been applied on a sub-process of the clinical trial, namely the identification of the subject selection criteria, but from the limited space reason, we don't present the example as a case study in this paper.

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