A SOCIO-SEMANTIC APPROACH TO THE CONCEPTUALISATION OF DOMAINS, PROCESSES AND TASKS IN LARGE PROJECTS

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Abstract: A case study involving a new method to support the collaborative construction of semantic artefacts in an inter-organizational context is described. The method aims at being applied, in particular, in the early phases of ontology development. We share the view that the development of semantic artefacts in collaborative networks of organizations should be based on a continuous construction of meaning, rather than pursuing the delivery of highly formalized accounts of domains. For that, our research is directed to the application of cognitive semantics results, specifically by developing and extending the Conceptual Blending Theory to cope with the socio-cognitive aspects of inter-organizational ontology development. An evaluation experiment for this method is accomplished in the scope of a large European project in the area of industrial engineering. The method evaluation and its results are described.

1 INTRODUCTION

This research work addresses the problems raised by information and knowledge sharing in the context of short life-cycle collaborative networks. Although there is an increasing number of semantic tools and resources available for the companies to use in everyday business activities, problems in establishing a common conceptualisation of a given reality arise in two flavours: (i) notwithstanding the evolution of semantic technologies, it is virtually impossible to establish a priori comprehensive and complete semantic artefacts that account for all the possible variations in business situations and contexts (which are more and more dynamic); (ii) in spite of all the standardization efforts, there is a kind of "social resistance" in accepting semantically oriented standards (viewed as "grand narratives" of a domain).

As clearly argued in (Cahier et al., 2005) about the role of a "socio-semantic web", we need to go beyond of approaches that provide an high level of "automation of the meaning" with formal ontologies built by ontologists and processed by software agents using automated inferences. Instead, we need to address situations where human beings are highly required to stay in the process, interacting during the whole life-cycle of applications, for cognitive and cooperative reasons (Cahier et al., 2005).

In the scientific context, research on ontology engineering addressed poorly the above problems. Current knowledge about the early phases of ontology construction is insufficient to support

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methods and techniques for a collaborative construction of a conceptualisation (Pereira and Soares, 2008). However, the conceptualisation phase is of utmost importance for the success of the ontology. But it is in this phase that a social presence is needed as it requires an actor to predict reliably how other members of the community will interpret the conceptual representation just based on its limited description. By incorporating the notion of semantics into the information architecture, we, thus transform the users of the system themselves into a critical part of the design.

Our view is that ontology engineering needs a "socio-cognitive turn" in order to generate tools that are really effective in copping with the complex, unstructured, and highly situational contexts that characterize a great deal of information and knowledge sharing in businesses collaboration. Our stance is thus a socio-semantic (Cahier et al., 2005) one as we believe that the development of semantic artifacts in collaborative networks of organizations should be based on a continuous construction of meaning, rather than pursuing the delivery of highly formalized accounts of domains.

This line of research is thus directed towards the application of cognitive semantics results in the creation of artifacts acting as socio-technical devices supporting the view that meaning socially constructed through collaboration and negotiation. The first line of this research work deals with the application and extension of the Conceptual Blending Theory (CBT) (Fauconnier and Turner, 1998) to the realm of collaborative semantic tools. The practical application of our approach is to support the co-construction of semantic artifacts by groups of social actors placed in organizational contexts interacting towards a set of common objectives. Simple examples these artifacts are the creation of a common taxonomy (or ontology) for classifying and retrieving content from an inter-organizational portal, the creation of specific terminological accounts to serve as conceptual references in project tasks, or the specification of ontologies for systems interoperability.

2 THE CONCEPTUAL BLENDING THEORY

The relation between cognitive semantics and knowledge representation is better understood by considering the four principles that collectively characterize a cognitive semantics approach (Evans and Green, 2006). According to this view, meaning is constructed at the conceptual level: meaning construction is equated with conceptualisation, a dynamic process where linguistic units serve as prompts for an array of conceptual operations and the recruitment of background knowledge.

Our proposal to support a collaborative process of conceptualisation of a given reality (e.g., a domain in the context of a project) is founded on cognitive semantics, specifically on the Conceptual Blending Theory (Fauconnier and Turner, 1998). CBT accounts for the emergence of meanings by adopting the view that meaning construction involves emergent structure, i.e., conceptual integration is more than the sum of its component parts. An integration network is thus a mechanism for modeling how emergent meaning might come about, accounting for the dynamic aspects of meaning construction.

CBT representation gives rise to complex networks by linking two (or more) input spaces by means of a generic space. The generic space provides information that is abstract enough to be common to all the input spaces. Elements in the generic space are mapped onto counterparts in each of the input spaces, which motivate the identification of cross-space counterparts in the input spaces. A further space in this model of integration network is the blended space or blend. This is the space that contains new or emergent structure: information that is not contained in either of the inputs. The blend takes elements from both inputs, but goes further on providing additional structure that distinguishes the blend from either of its inputs. In CBT, there are three component processes that produce an emergent structure (Fauconnier and Turner, 1998): composition; completion; and elaboration.

3 SUPPORTING THE CONCEPTUALISATION PROCESS

We recognize in the CBT a great potential as the theoretical foundation of a method and associated tools supporting collaborative conceptualisation processes in inter-organizational settings. The following is assumed as the initial state: (1) a collaborative network has been formed and its goals and mission are defined and understood by all members (that we call "strategic frame"); (2) a common ontology with certain goals and to be used in a given time-frame has to be developed; (3) each organization has a representative in a "network team" in charge of developing the ontology. (4) a common conceptualisation (as the first step to the ontology construction) is to be collaboratively created through explanation, discussion and negotiation. This approach is only feasible with the support of a tool that facilitates and manages all the process.

The proposed method establishes the following steps (see figure 1): (1) each organization has assigned one or more input spaces (only one input space is considered here, for the sake of simplicity); (2) each organization represents its conceptualisation proposal through the input space; simultaneously, the organization share the information and other knowledge sources (e.g., URLs, documents and other content) which allow for the correct understanding of its conceptualisation proposal; in the case study we are using conceptual maps as knowledge representation technique; (3) by some manual or automated (or something in between) process, a generic conceptualisation is generated (generic space); the common conceptual structure in the generic space should be generic enough to be accepted by all the team members with minimum negotiation; (4) considering the "counterpart" elements, the process of creating the blend space is started using selective projection; based on the input spaces, strategic frame, generic space and documentation available in the input spaces, the blend is "run" to obtain new conceptualisation proposals; (5) new conceptual structures proposed in the blend space are object of negotiation; the concepts for which consensus exists are represented in ("copied" to) the generic space; situations that justify "backward projection" to the input spaces and their modification are analyzed then the emergent blend structure is validated (confirm or eliminate new concepts that raise in the blend); (6) if input spaces modification takes place, the method should resume at step 4; however, is not necessary the creation of a new blend space; (7) when all participants manifest their agreement with the conceptualisation represented in the generic space, the method instance is finished.

Summarizing, at the end of the process the generic space contains the collective conceptualisation, the blend was used during the negotiation process with the goal to improve, enrich and mainly helping in obtaining consensus. This method may also be used by each organization to support the creation of its input space, which can result in the presence of multiple blendings.

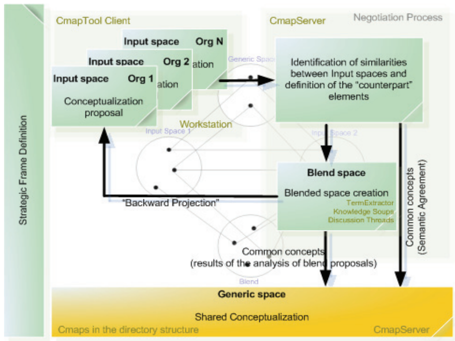

Figure 1: Method to support collaborative conceptualisation process.

4 EMPIRICAL EVALUATION

4.1 Context and Experiment Setup

Several real world experiments were planned aiming to empirically validate and fine-tune the approach. The one described here was carried out within a trans-national (european) project in the area of industrial (automotive) engineering. In this project, a consortium of major European car manufacturers, suppliers, and research institutes develop the "dynamic supply chain collaboration" concept that changes the conventional automotive terms of delivery to a highly reactive "5-Day-capable" system that radically cuts down inventories in the supply network. This is a big and complex project, as it involves 19 partners, from 7 countries and 9 tasks grouped in 3 work packages. One of the work packages aims at building an ontology to be used in several tasks of the project. The general goal of the AC+DC Ontology is to facilitate a common and precise understanding of the concepts used by all partners in the several project activities. The ontology development task started initially without a supporting methodology or even a clear vision of the ontology goals and scope. Within this context, we took the opportunity to set-up an action-research project aiming at, from the one side, to help the project to develop its ontology and, from the other side, to create knowledge about the collaborative construction of ontologies by designing and undertaking a set of experiments. From the preliminary analysis of the problem, jointly with the project team, the following general requirements were derived: (1) the goals and scope of the ontology should be clearly stated, even if not completely detailed; this is of utmost importance to guide the conceptualisation process; (2) there is a clear need for a method and tools supporting the conceptualisation process; only with such a support a collaborative process is feasible.

The first step was to look for existing ontologies in the supply chain management area in order to reuse them. There are some specialized ontologies such as (Ureten and Ilter, 2006) and (Fayez et al., 2005) that present a models based on the SCOR model; (Maier et al. 2003) that study the information integration inside an enterprise and not between supply chain members; and The United Nations Standard Products and Services Code (UNSPSC) provides an open, global multi-sector standard for efficient, accurate classification of products and services. These ontologies cover very specific sub-domains being hard to reuse. There are also several upper-level ontologies which are too abstract to be applied in particular situations. Since collaboration concepts behind supply chains and their requirements could be fundamentally different, there is no standard ontology, which would be detailed enough to be applicable in every practical case.

In this experimental phase two tools are used to support all the process. For the joint construction of a conceptual representation, Concept Maps supported by CmapTools (http://CMAP.ihmc.us/conceptmap.html) were used. With CmapTools it is possible to endow the conceptual representation with some collaborative mechanisms which support a partial implementation of the method. CmapTools has a client-server architecture allowing users to build their own personal CMAPS and publishing them, later on for discussion in the form of "claims". To support the blend space creation, together with CmapTools features, the text mining tool, TermExtractor (http://lcl2.uniroma1.it/TermExtractor), capable to extract relevant terms in the interest domain, by submitting an archive of domain-related documents in any format was used.

The experiment context was the following: Four teams from four different organizations (geographically dispersed) participated in the domain conceptualisation. Two of those teams (Team1 and Team2), from two different organizations (Org1 and Org2), were domain experts from academic and professional areas respectively; another team (Team3) from another organization (Org3) were experts in information and knowledge management and in collaborative networks; the fourth team (Team4) from another organization (Org4), beyond their academic expertise in the specific domain, they have a reasonable understanding about ontologies.

The experiment was setup firstly by establishing the roles of each actor: 1) Contributor: all team members should play this role contributing for the improvement and enlargement of the current version of the AC+DC conceptualisation. The contributor responsibilities are to make inputs to the shared conceptualisation by proposing and discussing concepts and relationships (claims); 2) Facilitator: responsible by facilitating the discussion/negotiation around the conceptualisation and by maintaining the CMAPS updated and consistent. Teams 2, 3 and 4 where assigned the role of contributor; team 1 was assigned the role of facilitator.

4.2 Experiment Procedure

As mentioned before, the use of CmapTools would allow untrained users, that cannot be expected to conform to the constraints of a formal semantics, to concentrate on the task at hand in an unrestrictive environment. Our goal is to allow users could start informally, without having to translate their know-how into any knowledge representation (heavy) formalism (Eskridge et al., 2006).

The first step, the strategic frame definition, helped to define the context, goal and mission of the ontology development task, as well as, the scope and boundaries of the conceptualisation. With the main focus in the dynamic supply chain collaboration concept, more precisely in the Dynamic Supply Loops (DSL) concepts, the team created an initial shared conceptualisation guided by the following focus question: "what processes, activities and information are involved in the DSL network planning model, allowing collaboration in entire supply chain in feedback loops?" The resulting conceptualisation was presented in a concept map, defining the scope and boundaries of the conceptualisation process, i.e., this result together with the goals initially defined for the ontology constituted the "strategic frame". Afterwards, the conceptualisation of the several process and activities was initiated, which means detailing the DSL.

After the construction of the first CMAP, a "knowledge soup" (Canas et al., 2004) object was created in order to aggregate ideas and propositions about the Production Planning Process. The input spaces, by their turn, were connected to the "knowledge soup", contributing for the implementation of the blend space. Thus, all the teams in the project were able to extend the first shared domain conceptualisation about the DSL, contributing with their own claims - changes that were made in the input spaces and which were published in the server. All members could see the other member's claims. Claims come from each team's domain expertise, from the results of the TermExtractor tool document analysis, other documents produced by the several project workpackages, the logistics area of SAP dictionary (http://help.sap.com/saphelp_46c/helpdata/En/35/2c d77bd7705394e10000009b387c12/frameset.htm), the terms and glossary about supply chain management proposed by (Vitasek, 2008) and the most important of all, by the conceptual structures identification in the experts mind when they interact with the other member's claims.

Negotiation is initiated, supported by discussion threads over each claim. Following the end of a discussion, the approved (consensual) claims, can be imported directly to the CmapTools Client instance of each organization, updating the personal map in focus. This last step is the "Backward Projection" of the method. Technically, all this process is supported by the CmapTools "knowledge soups" feature, which aggregates in the server all the claims from all input spaces, therefore users are able to see the claims and who published them. Accordingly, knowledge soups jointly with discussion threads contribute to shape the blend space in the CmapServer. With TermExtractor the enrichment of the current conceptualisation by the discovery of new terms and the supported validation of the existing ones was achieved. All the input spaces have the same conceptual structure and the person in charge for coordinating the process perform the upload of the final (consensual) map into the server. The CMAPS present in the CmapServer, comprise the generic space.

4.3 Analysis of the Results

This experiment dealt fundamentally with the first three steps of our method, i.e., the creation of the strategic frame, input spaces and the generic space of departure. Consequently, the focus was directed to empirically understand how the inter-organizational team uses and appropriates the visual concept map building tool and it interacts and organizes the work.

There was a high receptiveness of the concept maps as visual representation technique. This experience showed that conceptual maps are a suitable tool to be used during the collaborative conceptualisation process, because in this phase "completeness is more important neatness and rigor" (Kremer, 1994). We can conclude that this approach is a good way to overcome the problem that untrained users cannot be expected to conform to the constraints of a formal semantics, for they can become frustrated and distracted if they must change their thinking to conform to the structures of a formal system (Eskridge et al., 2006). From our observation and from the interviews we concluded that by discussing the problem using a domain-specific vocabulary supported by a visually oriented, easy to use, informal tool, effective results are achieved in a relatively short time.

Our goal is to allow that the users could start informally, the construction of a (non-computational) "knowledge base" without having to commit to a particular knowledge representation, and without having to translate their know-how into any particular knowledge representation format. After the informal knowledge is built up, its structure may become more obvious. Then, users could then begin to gradually coerce the concept maps to conform to the formal semantic system.

In the following paragraph we share some lessons learnt with this experiment.

1. Appropriate definition of the strategic frame and road map: The starting point of this case study shows clearly the importance of these tasks. After the initial definition of the strategic frame and road map, is equally important that in the previous specified time periods, go backwards and review the following questions: What do we have? What do we want? and How to get there? These questions allow the team to evaluate the forces and weaknesses of current situation. 2. Rules to organise the process and motivate the participation: The evaluation showed that the majority of users were passive in their participation. Automatic notifications of all teams whenever changes exist, version control and definition of a time frame in which the proposals can be discussed are fundamental to better organise the process, and motivate the participants. Therefore, if no one present suggestions during the time period defined, it means that agreement exists. Every time there's a change in any discussion item within the process, users should be informed and invited to comment the new proposals. The collaborative process of conceptualisation is really complex because of the high number of areas, processes and activities, among others. One way to deal with this is to follow some rules such as (Gómez-Gauchía et al., 2004a): to create many small CMAPS with few concepts and relations in each; to organize them in an orthogonal manner: horizontally by levels of abstraction and vertically by sub areas of the ontology; and use a code based on colours. 3. Project

generated documentation as an enabler: The continuous production of project documentation is a way to validate and improve the conceptualisation. On the other hand, the consensual conceptual structure, agreed so far, should be used in the production of new deliverables in order to standardize the contents of each deliverable. By this reason it's easy to share and understand the meaning of the concepts in the domain. 4. First version of the conceptualisation: Somehow in contradiction with 3., the need to anticipate as much as possible the first version of the conceptualisation was identified. The existence of a blend space provided more reliability, collaboration and agility to the process of conceptualisation. This was due to the fact that the inputs for blend were based on project produced documentation, as well as other important resources selected by the domain experts. This resulted in an high level of acceptance of the proposals. However, it would be advantageous if the conceptualisation was created even before the elaboration of the first deliverable. Equally, the blend should be created based on resources other than those produced within the project. A good example is the use of the SAP dictionary and ILIPT project documentation. 5. Carefully selection of the information resources used as inputs in the blend space: The results obtained in the blend depend directly on the information sources used. The blend results can be accepted with more or less support, according to the provided inputs during its creation.

5 CONCLUSIONS

The results presented and discussed here allowed us to identify some of the weaknesses of the adopted procedure as well as the foremost drives for the improvement of the method and supporting tools. During this experiment, some of the method steps were well covered by the existing tools while others were partial or not covered at all. Nonetheless we were able to represent all steps outputs using CmapTools. The blend creation became an important mechanism within our case study, increasing trust during the conceptualisation process. However, considering the knowledge acquired during the experiment, we are convinced that the support of a semantic wiki enabling versioning besides the discussion on the visual conceptual structures will be very advantageous.

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