A Negotiation Approach to Support Conceptual Agreements for Ontology Content

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Abstract. Conceptualisation processes are pervasive to most technical and professional activities, but are seldom addressed explicitly due to the lack of theoretical and practical methods and tools. However, it seems not to be a popular research topic in knowledge representation or its sub-areas such as ontology engineering. The approach described in this paper is a contribution to the development of methods and tools to collaborative conceptualisation processes. The particularly challenging problem of conceptual negotiation is here tackled through a combination of ColBlend method and an argumentation-based strategy, creating an innovative method to conceptual negotiation, *argile* method. This method was implemented in to the ConceptME platform as an advanced negotiation mechanism.

Keywords: conceptualisation process, argumentation-based strategy, collaborative networks.

1   Introduction

Collaborative knowledge representation is a research topic of utmost importance for the development of tools supporting collaborative human activities such as knowledge management or ontology content development. Nevertheless, it has not been researched as it would be expected. This is particularly evident in the lack of research literature about the early phases of ontology content development (or ontology specification), when the goal is to achieve a shared conceptualisation of a domain. Knowing more about collaborative conceptualisation processes and proposing new ways to support them is thus a challenging research. We have been researching these topics both by developing new "socio-semantic" methods and collaborative platforms to support the collective construction of conceptual representations. In this paper we will describe a method, based in argumentation techniques, aimed to support what we called "conceptual negotiation". Our context of use are "collaborative networks" involving independent actors (groups, organisations) that established trust, synergistic relationships and develop joint activities in technical domains.

2   Collaborative Conceptualisation and Conceptual Negotiation

An ontology can be viewed as "a specification of a conceptualisation" [10]. Furthermore, an ontology, as a knowledge representation artefact, is deemed to convey some shared conceptualisation of a domain, as perceived and understood by a social group. However, the terms "conceptual" or "conceptualisation" are seldom used in the discourse about the development of ontology content. The term "semantics" is rather preferred. "Conceptualisation" can be defined intuitively as "the relevant informal knowledge one can extract and generalize from experience, observation, or introspection" [18]. We can thus say that a conceptualisation is the result of a "conceptualisation process" (CP) that leads to the extraction and generalisation of relevant information from experience [18]. For an individual, the conceptualisation process of a given reality is a collection of ordered cognitive activities with information and knowledge that is internally or externally accessible to the individual as inputs and an internal or external conceptual representation as the output. Furthermore, a "collaborative conceptualisation process" (CCP) is a conceptualisation process that involves more than one individual producing an agreed conceptual representation. Besides individual CP activities, the collaborative CP involves social activities that include the negotiation of meaning and practical management activities for the collaborative process leading to a "semantic or conceptual agreement". By definition, an "agreement" means that two or more actors reached an understanding about something, approving and accepting it. But why are "conceptual agreements" needed? Simply because different groups, even participating in the same project, can conceptualise (and represent) the same reality in different ways. These differences are not expected to be dramatic, but even so important to hinder the achievement of a shared conceptualisation. Then, a CCP naturally includes understanding, arguing and compromising in order to achieve a conceptual agreement, in what can be called a conceptual negotiation process. Conceptual negotiation is thus a social interaction process leading to an agreement about the conceptual representation of a domain. A conceptual negotiation process establishes a "common ground" of understanding concerning the meaning of the represented conceptual structures and the associated terminology. In spite of considering an ontology as representing "semantic agreements", the research on ontology development didn't give much attention to the process of achieving such (conceptual) agreements. Only a few works acknowledge the importance of supporting the conceptualization phase [17]. Our research in socio-semantics addresses, between others [4], the support to CCP through collaborative conceptual models editing, discussion and negotiation (see figure 2, left). Part of this research resulted in the ColBlend method [1],[2], inspired in the Conceptual Blending Theory [3]. This method proposes a basic negotiation model based on conceptual spaces aimed at integrating ("blending") the conceptual structures contained in the input spaces [3]. In the next sections we present an approach to support conceptual negotiation based in argumentation techniques.

3   The *argile* Approach to Conceptual Negotiation

3.1   Overview of the ColBlend Method

The ColBlend method was designed to support a collaborative conceptualisation process, based on conceptual blending theory (CBT) [3]. In practical terms ColBlend aims to support the co-construction of conceptual representations (we can also call it *conceptual models*) which can serve as a specification for taxonomies, classifications or ontologies [1], [2]. In an overview, the process comprises a set of virtual spaces: a) the input spaces - where each party build models representing their conceptualisation of the domain; b) the blend space - containing the results from the analysis of the input spaces presented for discussion; moreover, it proposes new concepts from a global analysis of the current spaces content and c) the generic space - which contains the common domain model composed by the all parts of the proposals that were accepted by all and "published" to the this shared space. This method led to the development of the conceptME collaborative platform[1] [4], a "conceptual Modelling Environment" where groups of specialists can find tools and resources to collaboratively develop conceptual representations, organise them in libraries, share them with other colleagues and reuse them when needed. Currently, conceptME supports concept maps as representational notation.

3.2   The *argile* Method: High-Level Description

Starting from the ColBlend method, we present a new approach to conceptual negotiation that uses an argumentation-based strategy. Inspired in the Toulmin Model of argumentation [12], [13], the work described in [14], [15] and the argument mapping tutorials available in http://rationale.austhink.com/rationale2.0/tutorials/, a method organized in two level of conceptual negotiation is proposed (see figure 1). The first level refers to the creation, description and structural validation of conceptual structures (claims) in an individual level and their negotiation at group level. At the second level, a lightest conceptual negotiation iteration takes place, supporting the integration of the previously agreed conceptual structures (resulting form level 1) into the shared model. The goal is to define, collaboratively, the position of this new input in the global model. An initial proposal of the integrated conceptual model is created based on the blend execution (composition activity). The participant's role is to validate the proposal, if they agree the process is finished, else, they can present a different proposal for integration and a new light cycle of negotiation is started. These two negotiation levels rise from the fact that although all individuals involved in the process have accepted the simple conceptual structure (claim), it does not mean that the integrated model is compliant with all parties views, mainly due to the semantic changes that the integration can made in the global model. At the end, considering the conceptual structure integrated by running the completion and elaboration activities (blend execution) new conceptual structures can be
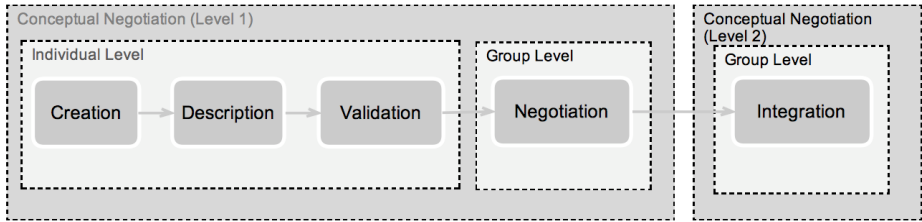
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[1] http://www.conceptME.pt

Fig. 1. The *argile* method activities

suggested to be included in the model. The execution of these activities triggers a new negotiation process.

3.3 The *argile* Method: Activities and Protocol Description

To the particular case of conceptual structures negotiation, the activities of the process are the following (see figure 1):

Conceptual Structure Creation: conceptual structure creation with the minimal degree of granularity (concept-relation-concept). During this activity, if a partner propose a conceptual structure whose concepts already exist in a another structure puts in discussion, the partner is alerted and their action is limited to the following speech-acts (defined according [12] and adjusted to conceptual negotiation (detailed description presented below)): counter-propose, defend, agree or refine.

Conceptual Structure Description: this activity include the introduction of information that support/justify the proposal. This is divided in 3 parameters:

(i) *Evidences* - are "meta-information" provided by the proponent. The "meta-information" can be the definition of the proposed concepts, a global definition of the conceptual structure proposed or documentation to support the proposal. (ii) *Social Value* - When a proposal is submitted, in an initial stage, their social value is directly dependent on proponent credibility. Social value is completed during the activity 4, considering the number of the speech-acts of type *Critique NOT*, *Defend* and *Agree* and the credibility of each participant. (iii) *User Credibility* - The user credibility is a value in the range 0 to 1. Initially, will assume a value according the reputation of the user on the group. This value will be updated according to the following parameters: i) degree of participation; ii) number of proposals made and; iii) their rate of acceptance. In practical terms the value is calculate as follows

$$(\alpha \cdot degreeOfParticipation + \beta \cdot noOfProposals + \delta \cdot accep \tan ceRate)$$
$$i) degreeOfParticipation = \sum UserSpeech - acts / \sum Speech - acts$$
$$ii) acceptanceRate = \sum UserProposals / \sum UserAcceptedProposals \,;$$

where α, β and δ are defined at the beginning of the process, corresponding to a weight between 0 and 1 and the parameters are calculated as follows:

Conceptual Structure Validation: This activity analyses the evidences to validate the presence of the terms constituents of the conceptual structure proposed in the evidences included during the activity 2. Here, some rules two used according argument mapping.

Golden Rule: at least one definition for the conceptual structure proposed must be presented. Rabbit Rule**:** based on the textual corpus-analysis and contexts identification, check the co-occurrence of the terms used in the conceptual structure.

Conceptual Structure Negotiation: Once validated, the proposal can be shared and the users can negotiate it. The users can act according the following speech-acts: *counter-propose*, *critique NOT*, *defend*, *agree* or *refine*. This activity occurs during a limited time period (time period agreed/defined by group members). At the end of this period, the conceptual structure value is calculated and the conceptual structure with highest value is suggested for integration into the global model. The conceptual structure value (is a value in the range 0 to 1) is calculated as follows (*n* is number of participants in the conceptual structure negotiation activity; A=1 if the participant *Depend* or *Agree* with the proposal; A=0 if the participant *Counter-Propose*, *Critique-Not* or *Refine* the proposal).

Conceptual Structure Integration in the Global (Shared) Conceptual Model: The fact of achieving consensus about the conceptual structure resulting from the first level of negotiation does not mean that the integration into the global model can be automatic (a collaborative activity is desirable). The integration proposal arises of the composition activity execution (blend execution). At this stage, the second level of the argile method initiates according to the description above (see 3.2).

$$\left[ProponentCredibility + \sum_{i=1}^{n} A * UserCredibility_i \right] \Big/ n$$

4   The ConceptME Approach to Support Conceptual Negotiation

4.1   ConceptME Overview

The core of conceptME platform is on supporting collaborative modelling, allowing users to create and share conceptual models, focusing on graphical knowledge representations and terminological methods, accommodated into a service's library. The platform enhances negotiation and discussion capabilities by means of specific extensions, towards consensus reaching.

The platform is organised as follows (see figure 2, left): a) a set of functionalities to manage ongoing and previous collaborative modelling projects (generic project edition, definition and configuration of the enclosing collaborative spaces and related resources); b) a collaborative modelling environment, allowing users to build their models individually or editing them collaboratively (either on their own or through available templates), while discussing around concepts; c) a set of terminological services, based in terminological work methods and techniques, supported by a
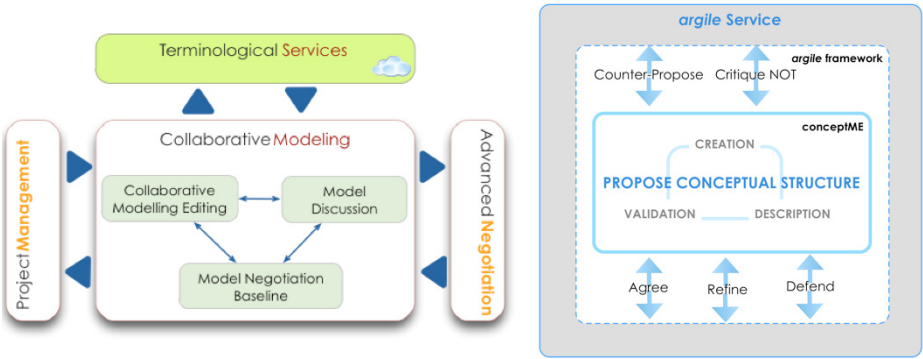
Fig. 2. ConceptME high-level architecture and method service protocol

domain specific textual corpus, allowing users to associate relevant resources to their projects, performing extraction operations to retrieve candidate terms that can be used in their conceptualisation process. At this level, conceptME provides means for corpus organisation and classification and real-time term contexts to detail existing representations; d) a model negotiation baseline enclosing a set of features (merging individual input structures, suggestion mechanism, cross-checking corpus-based validation, auto-complete and categorization, among others) to ensure simple negotiation mechanisms, towards a common shared model. This module provides the interface and environment conditions, allowing to connect other advanced negotiation mechanisms, such as, the argumentation-based conceptual negotiation approach described here.

4.2   Argumentation Service Support: An Illustration Scenario

To support the collaborative argumentation process, a negotiation service based on *argile* protocol was designed and implemented. Following the conceptME high-level architecture, the *argile* method was designed to implement a specific negotiation approach (argumentation based) on top of an existent negotiation baseline. As a service, *argile* main role is to account for decision support tasks taking place at negotiation process thresholds, providing mechanisms for individual proposals evaluation. Figure 2 (right), shows the main interactions (protocol) between the conceptME and the *argile* service. The proposed conceptual structures - developed individually - are published into a shared space within conceptME. At this common space, the claims (published conceptual structures) from each input space are available and the argumentation process starts over a claim on the list. Next, we describe a simple application scenario to illustrate the method. The example is based in a corpus about the domain of urban rehabilitation (http://www.h-know.eu/) used to support the development of the a collaborative platform project ontology. Thus, in the scope of urban rehabilitation, at a certain stage of conceptualisation process, the definition of a conceptual structure around the concept of "construction resource" was

started. The following table shows the assumed status of the negotiation process comprising: i) the users involved; ii) the current user's credibility score - calculated following a weighted sum of the degree of participation (20%), the total amount of proposals and counter-proposals (30%) and the rate of proposals and counter-proposals acceptance (50%); iii) user's domain of expertise; iv) the actions performed so far and; v) the total accepted claims per user. Accepted claims comprises propose and counter-propose speech acts. The table values were dynamic and were updated as the negotiation process run.

Table 1. *Argile* Illustration Scenario - (**a**: initial assumed score)

User name	#User credibility value	#Performed actions (speech acts)		#Accepted claims
User1	0.50 + a	9	3 propose	4
			3 agree	
			3 counter-propose	
User2	0.56 + a	10	5 propose	4
			2 critique NOT	
			2 defend	
			1 agree	
User3	0.33 + a	15	3 propose	2
			1 counter-propose	
			3 agree	
			5 agree	
			1 defend	
			2 refine	

Going forward with the example, *user1* submitted the following conceptual structure to the common shared space as a new claim (claim #1): "*Construction agent is a type of construction resource*". On publishing, *argile* service has returned a golden rule warning exception, which means that no definition has been provided. Meanwhile, *user1* has decided to add a proper definition and resubmitted it for publication. *User2*, by his turn, has built the following structure (claim #2): "*Construction product is a type of construction resource*". The structure was validated, regarding the golden and rabbit rule and was appended to the claim list at the shared space. Afterwards, the discussion takes place around claim 1 and claim 2, from which two more claims arises: claim #3, counter proposing claim #2, stating that – "*Construction material is a type of construction resource*", and; claim #4, on defending claim #2 adding a warrant by specifying the original source documentation (ISO 12006-2 standard classes). The next table summarises the speech acts performed by each user and the conceptual structures to be integrated into the shared model (claim #1 and claim #3).

Table 2. Negotiation speech-acts - (Caption: * the proponent)

Claim thread	Claim ID	User1	User2	User3	Conceptual structure value	Selected claim
#1	#1	*	---	Agree	0,28	YES
#2	#2		*	Counter-propose		
#2	#3	Agree		*	0,28	YES
#2	#4	---	Defend	---	0,19	NO

5   Related Work

Researchers that study the collaborative creation of semantic artifacts have already pointed out the need for conceptual negotiation [5, 6, 7]. They state that many problems stem from the fact that various stakeholders with partially conflicting interests need to simultaneous collaborate on joint objectives. The incompatibilities are due the fact that these multidisciplinary teams have specific insight into certain sub-domains and use it to reach unrelated goals. [5] Presents an approach that models the members' commitments, interests and responsibilities using communicative workflow that allows for meaning negotiation. Ontology is used as a means of disambiguating communication. The meaning negotiation process used to attain consensus uses the DOGMA-MESS methodology [16]. [6] Also uses meaning negotiation in order to reach consensus via ontology integration. [7] Is similar to [5, 6] in that it deals with meaning negotiation; negotiation is based on the merging and alignment of local ontologies and; the resulting global ontology represents the shared agreement. The negotiation process is based on the extend DOGMA-MESS methodology resulting in an iterated four phase negotiation process. Unlike previous work however, [7] attempts to semi-automated the meaning negotiation process by providing an algorithm that tallies the changes that were made to the local ontologies and uses those values to make changes to the merged ontology. In essence this article presents a voting protocol, which according to [8], is not particularly flexible, efficient and effective. Although much work exists in the general area of agent based negotiation [9] to the best of our knowledge none deals with the specific problem of conceptual negotiation. The work that most closely resembles what we are attempting is described in [11]. It describes a general negotiation model and protocol based on speech-acts and argumentation in a knowledge intensive context (as opposed to the normal e-commerce setting such as supply chain management); the system does not use automated agent negotiation per se but provides support for designers to discuss issues based on CAD drawings; it deals with multi-issue negotiation, which is referred to as multiple interrelated negotiation and, as is required in any knowledge intensive negotiation process, the agent system promotes problem solving by generating alternatives. Our aim to provide a similar solution in the context of conceptual negotiation where the shared agreement is a conceptual model represented by concept maps.

6   Conclusions and Future Work

This paper brings into discussion the problems and requirements related to supporting collaborative conceptualisation processes, more specifically how to conduct the conceptual negotiation process. In this perspective, an innovative approach to conceptual negotiation, *argile* method, was presented. *Argile* method combines the principles of ColBlend method [2] with an argumentation-based strategy, and appears as the pilot proposal that deal with the specific problem of conceptual negotiation during the process of conceptual models construction. Together with other services (extraction services, templates, ontological guidance, and so on), this method was implemented in to the ConceptME platform as an advanced negotiation mechanism. Preliminary experiments were already run and the results showed that this approach improved the collaborative conceptualisation process in concepts elicitation and negotiation.

Future work will be focused on the running of experiments aimed at obtaining further feedback from specialists, in several domains, to improve and fine-tune the methods and tools developed so far. In what concerns to conceptual modelling this research is surely proposing a refreshing view on this subject.

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