

# Specifying a Semantic Wiki Ontology through a Collaborative Reconceptualisation Process

António Lucas Soares<sup>1,2</sup>, Cristovão Sousa<sup>1,3</sup>, and Carla Pereira<sup>1,3</sup>

<sup>1</sup> INESC Porto, Campus da FEUP, Rua Dr. Roberto Frias, 378, 4200-465 Porto, Portugal

<sup>2</sup> DEI, FEUP, University of Porto, Rua Dr. Roberto Frias, sn 4200-465 Porto, Portugal

<sup>3</sup> CIICESI-ESTGF-IPP, Rua do Curral, 4610 – 156 Margaride, Felgueiras, Portugal  
{asoares, cpsousa, csp}@inescporto.pt

**Abstract.** This paper describes an action-research approach to the specification of an ontology to be applied in the information organisation of a community of forest planning experts. Like many others, a community of forest planning experts does not see their technical domains in unison, rather it voices several points of view that need to be shared and understood. This research started by addressing the practical problem of achieving an effective information structure and organisation for a semantic wiki platform. This was supported by a method and platform for the collaborative specification of ontologies: conceptME. Simultaneously, an empirical study was carried out aiming at understanding better how a technical community pragmatically develops conceptual representations of a domain. The results of this research show the benefits of collaboration in the development of conceptual models for knowledge organisation and information retrieval.

**Keywords:** conceptualisation process, knowledge organisation, action-research.

## 1 Introduction

Knowledge management, in the context of a technical community, can be supported by several types of content management systems, semantic wikis being one of them. A semantic wiki provides the tools to describe and organise a community generated information (content) [1] in a way that is meaningful and conceptually related with the scientific and technical domains of work. Nevertheless, to fulfill this potential, the knowledge organisation principles, models and techniques, as well as the governance of the collaborative activities should be shared and agreed by the community. As argued in [2], a common conceptualisation of the domains involved in a project is the cornerstone for an effective and efficient management the project's (i) information organisation, classification and retrieval, (ii) knowledge sharing and (iii) collaboration governance and support. Setting up an information/knowledge organisation system implies that all partners share (even if implicitly) a set of conceptual structures (concepts, their descriptions and their relationships) with which the domain and processes of work are to be understood. This view is in line with a more interpretive view of knowledge organisation in information science: classification work involves some sort of "interpretive flexibility" in which the distance between what is classified (the object) and those who classify (the subject) is not kept at an artificial distance [3, 4].

The more aligned, with the users conceptual vision, the semantic artifacts (classifications, taxonomies, ontologies) are, the easier will be for them to classify (annotate) a piece of content.

Following a socio-semantic vision of the creation of semantic artifacts, in particular ontologies [5], we have been developing a collaborative platform to support the early phases of an ontology specification. We call it the conceptualisation phase. The conceptME collaborative platform [6], is 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. For several applications, these conceptual representations can assume the role of ontology specifications (in some ways also known as informal, lightweight ontology representations). The platform is functionally organised as follows: i) a set of functionalities to manage collaborative modelling projects; ii) 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 concepts, relationships and models; iii) a set of terminological services, supported by a 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 collaborative process; and iv) a negotiation baseline model to ensure simple negotiation mechanisms, leading to agreements for a shared model [2].

This paper reports and discusses the findings resulting from an action-research project aimed at improving the information organisation of a community’s knowledge management system implemented in a semantic wiki platform. This was done through a process of collective reconceptualisation of the meta-data schema (ontology) used to annotate the wiki pages and define its structure.

## 2 Problem Description

The FORSYS<sup>1</sup> knowledge management system is a semantic wiki-based platform for information management and knowledge sharing within a community of practice dedicated to study decision support systems (DSS) for forest management. The main idea of the FORSYS wiki site is to provide a repository on Decision Support in Forest Management continuously evolving over time and serving as a reference for future DSS projects. In spite of the proven usefulness of the platform, the FORSYS community representatives (developers and final users) identified hindrances to the effective achievement of the knowledge management goals. The initial development of the platform’s knowledge organisation structure resulted in a logical structure addressing the established goals. However, two main problems affecting the efficiency of information retrieval were identified.

The first conceptual model implemented was composed by a small number of classes, each with a long list of properties. Although usable, this model had evident drawbacks for the users: long wiki pages made difficult to locate the needed information, need to repeat the same information in several pages, and the need to scroll up

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<sup>1</sup> COST Action FP0804 - Forest Management Decision Support Systems.

and down instead of navigating between pages through hyperlinking. Another consequence of the implemented conceptual model was the rather simplistic way the domain was apprehended by the users. A domain modelled by few classes characterised by long property lists only enables a superficial understanding as it is difficult to grasp the details from the property lists. A more detailed conceptual account of a domain increases the user's capabilities for undertaking successfully domain related tasks such as searching, retrieving and organising information.

The community managers decided to improve the platform's knowledge organisation structure involving as much as possible the community members. This called for an approach effectively supportive of building a shared understanding of the domain, resulting in a specification of a conceptualisation socially accepted by the community [2]. An approach focused on content, context and addressing social factors in the construction of basic structures of knowledge that would inform the problem solving process, whereas, semantic theories should underlie the development of artefacts to share the information [7].

### 3 Research Methodology

The redesign of the community knowledge management platform was taken as an opportunity to research the practices of knowledge organisation and representation of a specific scientific and technical community. Therefore, given the dual objective of the project - (i) to improve the knowledge organisation of the platform (problem solving) and (ii) to know more about about the practices of knowledge organisation and representation in technical communities (creation of scientific knowledge) - the principles of Action Research (AR) were applied. AR consists in a holistic approach of problem-solving where knowledge is learned by working in a context of action and where people try to work together to address key problems in their organisations. Typically an AR based project involves more or less systematic cycles of action and reflection: in action phases co-researchers test practices and gather evidence; in reflection stages they make sense together and plan further actions [8]. Often, research approaches in this category are also referred as participatory AR [9]. What separates this type of research from general professional practices is the emphasis on the scientific study, which is to say the researcher studies the problem systematically and ensures the intervention is informed by theoretical considerations. Therefore, much of the researcher's time is spent on refining the methodological tools to suit the exigencies of the situation, and on collecting, analysing, and presenting data on an ongoing, cyclical basis [10].

The problem characterised in the previous section fostered the following research question: "does the collaborative development of conceptual domain models, by representatives of a technical community, lead to better quality specifications of a knowledge organisation system?". This question addresses two dimensions: the semantic process and the semantic artefact. The later is the result of a set of related activities (process) undertaken in collaboration and represents a (semantic) agreement within the technical community. The former includes the collaborative activities structured by the method and mediated by the conceptME platform. These were characterised in the previous section.

The research method adopted was qualitative. Questionnaires and interviews were used to collect preliminary data while the main data collection technique was participatory observation [11]. Content analysis was made by text interpretation (from interviews transcriptions, observation notes), without codification. The findings were collectively interpreted regarding the suitability of the results according to the users expectations. The validity of the results depends on (1) the degree to which the developed artefacts provide a common understanding about the context in which the research was conducted; and (2) to which extent it provides the essential rational not only about how semantic categories are related, but how the achieved models provide the gateways for the semantic wiki structure.

Two expert groups were formed, and a third group of non-domain experts participated with the role of observer and facilitator. The planned actions were developed based on the principles and assumptions of the ColBlend method [2]. Basically, this method proposes three steps: (i) the development of the individual proposals, (ii) publishing of the proposals and (iii) discussion/negotiation/merging of the proposals.

## 4 Results

From the analysis of the answers of the first questionnaire we become aware that, unsurprisingly, the participants were comfortable with the forest management DSS concept, but not so much with the current conceptualisation of it. Additionally, we verified that all participants had information and knowledge management concerns in their daily activities and they revealed their preferences for graphical knowledge representations, despite of being aware of the difficulties of building such representations. The boundaries of the domain being conceptualised were specified by formulating a set of focus questions to which the models should provide answers. Meetings took place at the end of each step where the results were discussed, based on the data collected from interviews and observation, as well as from the conceptME platform. The first iteration of the AR cycle happened in two moments.

In the moment a) a group composed of FORSYS representatives and KR specialists paved the way for the rest of the project and produced a first conceptual representation of the Decision Support System domain area. Recommendations on how to address the optimisation of conceptual models aimed at specifying a knowledge organisation system were outlined. The moment b) involved two independent FORSYS expert groups debating the two other main domain areas: Lessons Learned and Case Study. It resulted in two models that were the inputs for creating a merged, agreed model in the second iteration. At the end of this moment, we were able to know more about the implicit conceptual relations structures used by the domain experts. The second iteration corresponds to the negotiation and agreement regarding the conceptual models developed by the several groups in the first iteration.

The main result was a complete conceptual model of the FORSYS domain, agreed by the stakeholders and optimised for implementing the knowledge organisation system of the wiki platform. At the end of this iteration, the recommendation process for conceptual relations elicitation in conceptual modelling was completed. Table 1 details the goals and expected results of each AR iteration.

**Table 1.** Action and research goals and expected results

	action goals	action results	research goals	research results
<b>1st iteration moment a)</b>	<ul style="list-style-type: none"> <li>to define the requirements for the metamodel improvement</li> <li>to elaborate a “proof of concept” for the DSS conceptual model</li> </ul>	<ul style="list-style-type: none"> <li>a strategy for the improvement of the metamodel</li> <li>a DSS conceptual model</li> <li>the DSS meta-model part and the wiki template structure</li> </ul>	<ul style="list-style-type: none"> <li>to characterise a process of re-conceptualisation by the domain experts in knowledge representation oriented to information organisation and retrieval</li> </ul>	<ul style="list-style-type: none"> <li>recommendations on how to address the optimisation of conceptual models aimed at specifying knowledge organisation systems</li> </ul>
<b>1st iteration moment b)</b>	<ul style="list-style-type: none"> <li>to debate and learn, individually, about the <i>lessons learned</i> and <i>case study</i> conceptualisation</li> </ul>	<ul style="list-style-type: none"> <li>conceptual representations of the <i>lessons learned</i> and <i>case study</i> areas of FORSYS (one for each group)</li> <li>a better and shared understanding of the domain (partial)</li> </ul>	<ul style="list-style-type: none"> <li>to characterise the use of conceptual relations by the domain experts</li> <li>to assess the value of using <i>focus questions</i> to assist the collaborative development of the models</li> </ul>	<ul style="list-style-type: none"> <li>knowledge of the implicit conceptual relations structures used by the domain experts</li> </ul>
<b>2nd iteration</b>	<ul style="list-style-type: none"> <li>to debate, learn and agree about the conceptualisation of the main areas of FORSYS: <i>DSS</i>, <i>lessons learned</i> and <i>case study</i></li> <li>to complete the conceptual specification of the knowledge organisation system for the wiki platform</li> <li>to specify the semi-automated linking between conceptME and the FORSYS wiki</li> </ul>	<ul style="list-style-type: none"> <li>a complete conceptual model of the domain, agreed by the stakeholders and optimised for implementing the knowledge organisation system of the wiki platform</li> <li>validated specification of the semi-automated linking between conceptME and the wiki</li> </ul>	<ul style="list-style-type: none"> <li>to further characterise the use of conceptual relations by the domain experts</li> <li>to improve the conceptual negotiation process centred around the discussion of conceptual structures</li> </ul>	<ul style="list-style-type: none"> <li>optimisation of the recommendation process for conceptual relations elicitation in conceptual modelling</li> </ul>

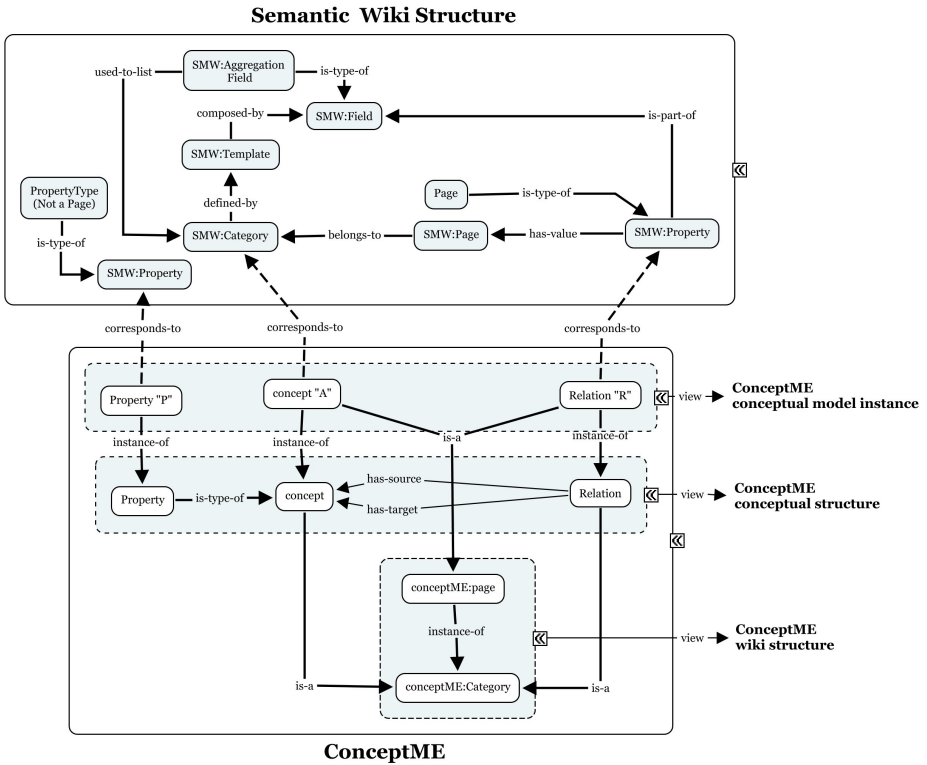


Fig. 1. ConceptME to SMW meta-model mapping

One of the action goals of this project was to determine to what extent conceptME could serve as a modelling front-end to specify the meta-model of the FORSYS wikiplatform, replacing the spreadsheet currently specifying the FORSYS properties model. Figure 1 depicts the meta-model which matches the structure of concepts developed in conceptME with Semantic MediaWiki (SMW).

ConceptME runs itself on top of an instance of SMW which means that every content such as a specific instance of concept, relation or property, added to the platform, is a wiki page belonging to a specific category, namely, a concept, a relation or property. The mapping between the developed models in conceptME and the SMW follow a simple set of basic rules: r1) a concept within a conceptME model (represented as Concept "A" in the above picture), corresponds to a specific category in SMW; r2) a relation connecting two concepts within a conceptME model (represented as Relation "R" in the above picture), corresponds to a specific property in SMW; r2.1) a property (in SMW) resulting from a relation between two concepts (from conceptME) must be of the Page type and its value should be a wiki page. r3) a concept within a conceptME property model (represented as Property "P" in the above picture), corresponds to a specific property in SMW; r3.1) a property (in SMW) resulting from a concept in a property model (from conceptME) can be of any type but Page; r4) a template to define new categories in SMW should be defined to cope with these rules and its member fields types should correspond to the properties translated from

conceptME model. r4.1) special fields, such as aggregated fields, should be used in the definition of SMW categories that correspond to the target concept in a typical conceptME conceptual structure. That means, the direction of the link among concepts must be taken into account. The aggregated fields will list all the “source pages” where a specific “target page” is used by means of a property page.

## 5 Discussion

The results were analysed according to the followed process and the developed models. Given the AR approach, this discussion is based on the data collected by the researchers through participatory observation and joint reflection with the domain experts (acting as co-researchers) [10].

**The Process.** As described above, the process designed to improve the knowledge organisation structure of the FORSYS platform (the problem solving part of the AR) followed the method devised in [2], which is supported by the conceptME modelling environment. Two groups of specialists addressed the same focus questions and independently developed a concept map for it. Then, the groups debated the similarities and differences of the respective outcomes and, supported by the model merging facilities of conceptME, negotiated a common model (concept map). From our observation, and from the reflection made with the experts, it was evident there was an initial difficulty in understanding entirely the concept maps produced by the other group due to the lack of textual definitions for the concepts. This was overcome by the debate and discussion between the two groups, albeit at the expense of more time to reach an agreement [12]. In fact, an extra effort to sustain and argue in favour of the proposed conceptual structures was observed. The definition of focus questions was very useful as a pragmatic way to define the domain boundaries as well as to assist in the validation of the completeness of the developed concept maps. The roles and composition of the teams developing the models revealed to be important both for the process and the quality of the results. The expert role was fulfilled with people with different backgrounds, differences that contributed positively for debating the different points of view when merging the concept maps. The facilitator role also revealed a major importance. As in every social process involving collaboration, facilitation and leadership are fundamental for the efficiency and effectiveness of the results. From the observations during the project, we conclude that it was beneficial that facilitation encompassed both the knowledge representation and the technical domains.

**The Developed Models.** Several aspects of the resulting conceptual models were analysed: the set of elicited concepts, the differences between those and the set of concepts (categories and properties) extracted from the existing meta-model, the differences between the elicited concept sets from the two groups, the set of elicited relationships, the meaning of the basic conceptual structures (a concept and directly related concepts). Due to limited space in this paper, we will look at the aspects related to relationships. Conceptual relationships elicitation is difficult in practice leading to oversimplified and imprecise conceptual models. In fact, one of the most difficult problems in a conceptualisation process is the elicitation of conceptual relations [13,14]. While the elicitation of

concepts is close to the basic cognitive process of categorisation the same is not true for the relationships as, for their elicitation, additional ontological knowledge is necessary. In the particular case of the FORSYS project the relationships elicitation was of great importance because of the need to transform part of the relatively big sets of concept properties into conceptual structures. As explained before, this would lead to a better organised, less monolithic content organisation in the wiki platform. A great part of the conceptual structures represented in the models were not precise enough due to the use of the “has” relationship. In fact, this relationship had already been amply used in the starting conceptual models proposed to the groups after the 1st iteration (moment a). Although the participants have been invited to use a catalog of predefined types of relations provided by conceptME, and despite of reporting its usefulness, in most cases the groups tended to accept the proposed conceptual structures as final and stable. Observing in detail those structures reveals that the intention of their creators seem to have been to represent: i) a chain of entities and their member fields; ii) a compound structure, in which an entity is composed or made up of other entities; iii) a containment structure, in which an entity belongs to another entity. These results were expected as [15] concludes that the “has” relation is a too generic conceptual relation and most of the times is used to represent a physical relation between entities. In the same line, [16] concludes that “has” is used generally as meaning some kind of contiguity engagement.

During the analysis of the shared model (2nd iteration) a new proposal, derived from the merged one, was developed trying to focus on the mentioned gap. The intention was, on the one hand, to clarify the use of the “has” conceptual relation and, on other hand to re-build the conceptual structures considering a set of primitive relation types [17]. The facilitators helped the groups to debate the meaning of “has” by posing simple questions. Table 2 presents examples of the results.

**Table 2.** Examples of the transformation of “has” conceptual relations

Conceptual structure (CS)	Posed question	New CS according to the answer
“Lesson learned <i>has</i> DSS”	<b>has</b> Lesson learned a DSS <b>as</b> Scope?	Lesson learned <i>has-scope</i> DSS
“Lesson learned <i>has</i> Source” and “Case study <i>is-type-of</i> Source”	<b>has</b> Lesson learned, a Case study <b>as</b> Source?	Lesson learned <i>has-source</i> Case study

At the beginning, the experts showed themselves some reluctance regarding the new proposal. This is explained due to the fact that they were already committed to a monolithic view of the DSS concept structure, regarding the construction of the FORSYS wiki. Moreover, we found that maintaining the concepts but changing the relations could result in a substantially different perspective over the subject. The relationships are, indeed, the dynamic part of the structures of knowledge. It is important to point out that this kind of conceptual modelling will work the better, the earlier it starts. It is a good practice not to start from what we want to achieve but from what we want to know. Finally, the developed conceptual models were subjected to an assessment against the competency questions. The conclusion was that the models already answered all the questions except one: How lessons learned should be

applied? This implies to define the processes on how to apply a lesson, which was out of the scope of FORSYS project.

## 6 Conclusions and Further Work

The research described in this paper makes a contribution to the scarce literature on domain conceptualisation processes in the context of communities of experts. First, it helped a community of forest planning experts to create a shared conceptualisation of the decision support systems for forest management domain by debating and learning from the joint construction of conceptual models. At the end of this process, the participants acknowledged, both individually and in group, the achievement of a higher level of ontological understanding of the domain. Second, the empirical findings achieved during the action-research cycles will shed more light on the characterisation of socio-semantic processes involved in knowledge representation. This knowledge will be also valuable for improving the conceptME platform in a way that supports more effectively the collaborative conceptualisation processes. In particular, the conclusions about the identification and use of conceptual relations by the experts were of utmost importance. These findings will be reflected in future releases of the conceptME platform. Similar action-research projects need to be done in different expert communities to enable cross-case analysis, enabling more sound generalisation of the research results.

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