

An Ontology for Supporting Communities of Practice

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ABSTRACT

In the context of the Palette project aimed at enhancing individual and organizational learning in Communities of Practice (CoPs), we are developing Knowledge Management (KM) services. Our approach is based on an ontology dedicated to CoPs and built from analysis of information sources about eleven CoPs available in Palette project. This ontology aims both at modeling the members of the CoP and at annotating the CoP's knowledge resources. The paper describes our method for building this ontology, its structure and contents and it analyses our experience feedback from the cooperative building of this ontology.

Categories and Subject Descriptors

H.5.3 [Information Systems]: Group and Organization Interfaces

General Terms

Design, Human Factors.

Keywords

Community of Practice, Ontology, Knowledge Management.

INTRODUCTION

According to [20], CoPs are “groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by

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K-CAP'07, October 28–31, 2007, Whistler, British Columbia, Canada.
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interacting on an ongoing basis”.

The objectives of the Palette IST project (<http://palette.ercim.org/>) are to enhance individual and organizational learning through development of information services, knowledge management (KM) services and mediation services dedicated to CoPs. KM services aim at offering efficient and effective management of the CoP's knowledge resources, so as to improve: (i) the access, sharing, and reuse of this knowledge, which can be tacit or explicit, individual or collective, and (ii) the creation of new knowledge. A CoP's knowledge resource can be not only a document (report, mail, forum, etc.) materializing knowledge acquired and shared through cooperation between the CoP's members, but it can also be a person holding tacit knowledge. Examples of KM services to be developed in Palette are knowledge creation and enrichment, knowledge retrieval or dissemination, knowledge visualization, knowledge evaluation, and knowledge evolution services. We chose a semantic web-based approach: these KM services will rely on an ontology (describing concepts useful about a CoP, its actors and their competencies, its resources such as documents used or produced, its activities, etc.) and on semantic annotations of the CoPs' knowledge resources w.r.t. this ontology. Such semantic annotations (for example, on the profile, role and competencies of a CoP's member, on the semantic contents of a document, on the effective uses of a tool by the CoP, on the collaboration mode preferred by the CoP for a given common activity, on the arguments leading to a decision making), can then be used by KM services such as knowledge search services, knowledge visualization services and they can thus support the learning processes in the CoP.

In [17], we proposed generic models useful for understanding a group activity, collaboration, competencies, learners' profiles, and lessons-learned. A CoP being a specific kind of a group, the CoP-dedicated ontology, called O'CoP, is

based on these generic models. It consists of CoP-relevant concepts and relations, and with which the CoP's resources can be annotated. The CoP-oriented KM services will rely on the O'CoP ontology.

The next section will summarize our ontology development method, and the following sections will successively describe the ontology structure, the main concepts of the ontology, the lessons learnt from its building, the validation of the ontology and our conclusions.

ONTOLOGY DEVELOPMENT METHOD

Our ontology method supported by our tool ECCO relies on the following steps:

- 1) *Information source collection*: (a) corpora mainly constituted of transcriptions, minutes or syntheses of CoPs' interviews; the interviews were performed by Palette members who played the role of *mediators* between some specific CoP and the knowledge engineers) and used to pick out candidate terms; (c) our generic models and existing ontologies or thesaurus (e.g. the structured dictionary WordNet [12]), used as grids to guide the selection of candidate terms within corpora.
- 2) *Contextualized lexicon construction*, by selecting, from the corpora, terms possibly relevant for describing the CoPs, w.r.t. the interpretation grids, and by keeping the trace of the context of use of these terms (i.e. the text surrounding the terms) so as to help understand them.
- 3) *Vocabulary identification* by refining the contextualized lexicon once validated by the CoPs' mediators and by producing, for each term, a definition and some examples of use.
- 4) *Hierarchy building* by first identifying the terminological concepts and relations (i.e. concepts and relations corresponding to terms attested in the textual corpus), and then structuring them, with possible addition of new concepts for structuring purposes.
- 5) *Ontology formalization* in RDF(S), the language agreed by the Palette partners for ontology representation.

For cooperative building of the ontology, the different ontologists analyzed the same information sources for performing steps 2) to 5), but each one focusing on his/her generic model so as to build the corresponding subontology. Therefore, an additional step is needed:

- 6) *Integration of the subontologies* by solving the conflicts among them and by integrating them into a single, coherent ontology.

STRUCTURE OF THE O'CoP ONTOLOGY

In the structure of the O'CoP ontology obtained after application of this method, we can distinguish three main layers (see figure 1):

- The *high level ontology*, including the concepts needed to represent the *generic models* presented in [17].

These models served as a grid for analyzing the corpora in order to build the other layers of the ontology.

- A *middle layer* including *concepts common to all CoPs*: in the vocabulary extracted from the corpora, some terms seemed to be relevant to all CoPs and to express common concepts while others were specific to a given CoP (or to a few CoPs). Validation by the CoPs' mediators helped to confirm the terms common to all CoPs. Such terms finally kept as terminological concepts in the O'CoP ontology correspond to concepts of the middle layer, such concepts being specializations of the high-level ontology concepts. Moreover, some concepts stemming from literature on CoPs could be included in this common layer, provided that they were attested by at least the corpora from some CoPs.
- A *specific layer* including the *concepts specific to each CoP*: The concepts of this low layer correspond to terms confirmed by the CoPs' mediators as specific to a given CoP or to very few CoPs.

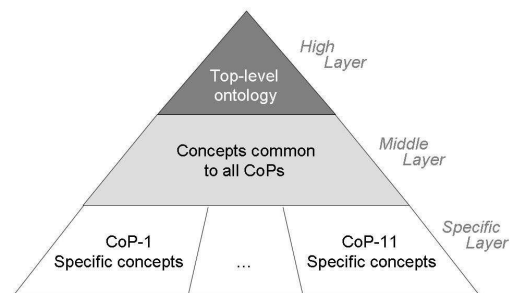


Figure 1. Structure of the O'CoP ontology.

Remark: A model and an ontology have different natures and play different roles, even though concepts and relations evoked in a model can be represented in an ontology. For example, our model for decision making is an abstraction of the elements needed in an actual process of decision-making by several persons. If this model is used for guiding corpus analysis, the ontologist will try to recognize in the text the parts related to the concepts emphasized in this model. If different decision making methods are described in the corpus, the ontologist can represent them through a concept hierarchy of the *Decision-making* subontology.

MAIN CONCEPTS OF THE ONTOLOGY

Community

Figure 2 shows our generic model for a community [17] that was used as a grid of analysis of the corpora and for the conceptualization.

The main concepts related to the community in the O'CoP ontology are:

- *Community*: according to the information collected from Palette CoPs, it can be: a *community of interest*, a

community of learners, a goal-oriented community or a community of practice. Terms used in the interviews stress the common nature of the CoP's members (community of teachers, network of teachers, resource-persons community, association of companies, etc.).

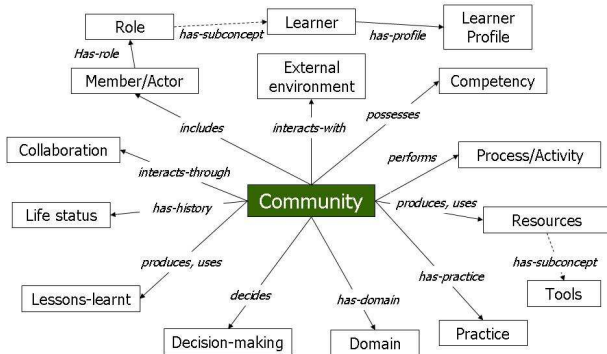


Figure 2. Generic model of Community.

- **Domain:** as stressed in [21], it is the area of knowledge that brings the community together, gives it its identity and defines the key issues that the CoP's members need to address. It is the "focus" of the CoP and it evolves over its life span in response to new, emerging challenges and issues [9]. For instance, the *Domain* of ePrep¹ is the *Educative use of Information and Communication Technologies (ICT)*.
- **Field:** it corresponds to the "discipline" or the "branch of knowledge" of the CoP's members (e.g. the *Field* of ePrep includes Mathematics, Physics, Chemistry, etc.).
- **Objective:** related to the CoP as a whole, or to a part of it (a group, a project, a team, etc. depending on the CoP's organization), it can be *Permanent* (e.g. "sharing knowledge and experience") or *Temporary* (e.g. to answer a specific temporary need).
- **Organizational structure:** CoPs' organizations vary from formal and structured ones (e.g. based on a "board of governors" for the CoP ADIRA²) to informal ones (e.g. based on "informal subgroups" for DL³).
- **CoP's characteristics:** besides the fact that CoPs can be different according to their internal organization, they can also be different at a lower level, which defines the CoP's identity, characterized by:
 - The *Membership:* is the CoP open to any person interested in it (based on a voluntary participa-

tion")? Or are there some conditions/criteria for entering the CoP (e.g. competency, cooptation)?

- The *Cultural Diversity* of the members: the CoP can be either homogeneous or heterogeneous w.r.t. nationality, organizational culture... [11].

Figure 3 shows some relations concerning communities.

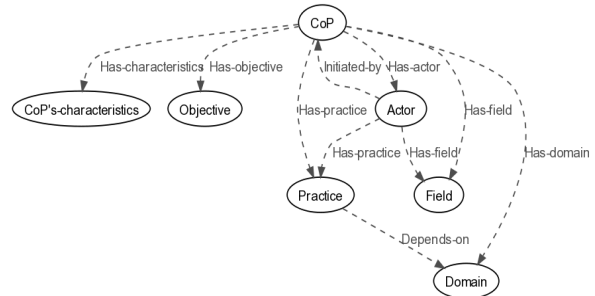


Figure 3. Relations concerning a community.

Actors

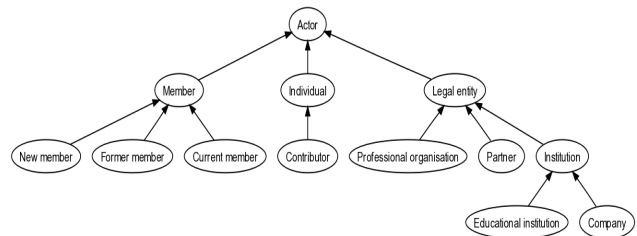


Figure 4. Concepts describing Actors in a CoP.

The analysis of the corpora related to Palette CoPs led us to define an *Actor* as "an Individual or a Legal entity intervening in the CoP". Indeed, the *Actors* of a CoP are not only its members, but also the entities which interact with the CoP, and constitute its environment. We categorized the *Legal entities* met in the CoPs' corpora, by relying on Wordnet [12] as well as on the discussions and exchanges with CoPs' mediators. We thus obtained two subconcepts: *Professional organization* and *Institution* (*Companies* and *Educational institutions*).

These *Actors* can be involved in the CoP as: *Members*, *Contributors* (*Individuals* participating in particular activities or during some specific periods of the CoP's life) or *Partners* (*Legal entities* supporting the CoP).

The *Actors* of a CoP can also be defined according to their:

- **Personal Characteristics,** which have an implication on their being *Actors* of the CoP, but still can identify them outside the CoP: e.g. in the case of an *Individual*, this includes the *Occupation*, *Competencies*, etc.
- **Role in the CoP:** It refers to the Involvement of the *Actors* in the CoP, which is defined by their engagement degree (*Member*, *Partner*, *Contributor*) as well as their position in the CoP. The *Actor's Role* can be of two types (see Figure 5):

¹ A CoP gathering teachers of French "Classes préparatoires aux Grandes Ecoles" interested in ICT (cf. http://www.eprep.org/Presentation_GB.htm#CoP).

² <http://www.adira.org/>

³ Doctoral Group Lancaster : <http://domino.lancs.ac.uk/>

- *Governance role*: in order to interact, learn and share knowledge effectively, the CoP's *Members* need a support, which can be provided by: (1) a *Facilitator*: s/he encourages the participation of the *Members*, facilitates their interactions; (2) a *Coordinator*: s/he organizes and coordinates the activities and events of the CoP. We distinguish *Individual coordination* (ensured by one main coordinator) and *Collective coordination* (in the case of a CoP organized per groups or teams, where individual "local" coordinators belong to a coordination group or team), (3) an *Animator*: s/he guides and manages the *Community*, ensures its development, relevance and effectiveness, thus playing both roles of *Facilitator* and *Coordinator*.
- *Peripheral role*: represents knowledge providers and receivers. They are more or less involved or active in the CoP, their participation depends on the *Actors* who play these roles (motivation, etc.).

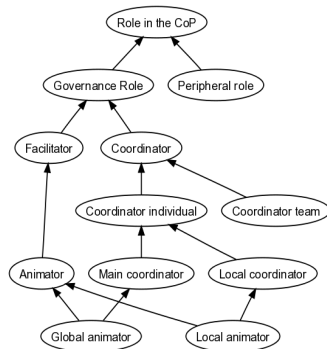


Figure 5. Concepts Hierarchy for Actor's role in the CoP.

- *Practice*: CoPs' *Members* are practitioners in an *Institution*, outside the CoP. They meet physically or virtually, through the CoP, that is their channel to exchange about their shared *Practice* (e.g. teaching practice).
- *Behavior*: the *Attitude* of a *Member* towards the CoP gives additional information about his/her degree of engagement in the CoP.

Competency

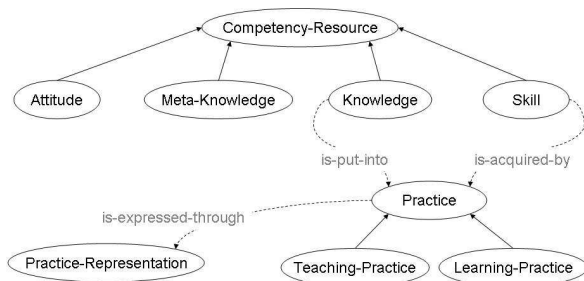


Figure 6. Some relations between Competency Resources and Practice.

A *Competency* is defined as a set of *Resources* provided or to be acquired by an *Actor* (who plays a particular *Role* in some *Environment* or *Situation*) so that the *Actor* can perform, or can help some other *Actor* to perform some *Activity*. *Competency Resources* are a major component of the *Competency* subontology (as detailed in [15]). Figure 6 illustrates some relations between *Competency Resources* and *Practice* identified in the corpora.

Collaboration

The generic model of collaboration proposed in [17] is composed of four concepts: (1) *Objective*: the specific aim of the collaboration and the goal to reach; (2) *Activity*: tasks realized during collaboration, such as discussions, exchanges of knowledge, of experience in order to achieve the objective of the collaboration; (3) *Actor*: CoP's members taking part in the collaboration; (4) *Resource*: all that supports the collaboration or is created during collaboration.

In addition, collaboration can be defined according to some dimensions related to [4]:

- The *geographical dimension*: it indicates if the participants belong to the same company or if the collaboration has an international dimension, if the collaboration occurs in face-to-face or at distance;
- The *temporal dimension* of the collaboration: short term (hours), medium term (days), long term (months-years), synchronous or asynchronous collaboration;
- The *media* used to support collaboration: audio/visual, oral/written ...
- The *type of interactions* occurring: number of participants (provider and recipient) such as 1-1, 1-many, many-many, with possible hierarchical relations among the participants.

Thus the high-level layer of the O'CoP ontology comprises the concepts: *Geographical situation*, *Temporal situation*, *Media* and *Interaction*.

According to these different criteria, we can determine which type(s) of collaboration occur(s) within a given CoP: e.g., collaboration through the media of an audio-conference is an audio synchronous way of collaborating that implies at least two members situated in different places.

Other dimensions, inspired by [3] [18], related to other aspects of the collaboration, are:

- (1) The *engagement towards the community*: it represents the emotional and psychological disposition of the actors; it results in their involvement and their participation to reach the goal of the collaboration. The engagement could be decomposed around three axes: the *belonging to the community* (availability and involvement of the participants), the *cohesion* (behavior of the participants and will to know each other) and the *productivity* (progression of the attack of the common goal and personal objectives).

(2) The *communication*: it is related to the process of exchange and sharing of ideas that lead to emergence of new knowledge. The communication could be classified around three processes: express one's ideas in order to share them, establish links between ideas in order to make emerge new ideas and finally structure the ideas.

(3) The *coordination* aims to optimize the work and result of collaboration, via the effective agency of the activities, the resources and participants to reach the goal. The coordination can be divided into three categories: (a) the task to accomplish (negotiate - inform, argue and conclude - about the project, realize the project and manage the realization of the project), (b) the composition and constitution of the team (size of the group, homogeneity or heterogeneity on competencies or experience of the members) and (c) the animation (via forum, discussions...).

The concepts representing these three dimensions are strongly related to the *Actor* concept.

Figure 7 shows our new generic model for collaboration.

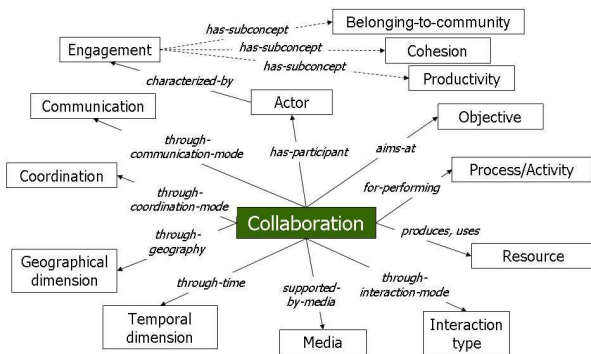


Figure 7. Generic model of Collaboration.

After analysis of the information sources, the terms considered as common to all CoPs are: (a) *Objective*: aim, need, goal, wish, expectation, will, waiting, reason; (b) *Activity*: communication, exchange, sharing, learning; (c) *Actor*; (d) *Resource*: information, knowledge, experience, practice, document; (e) *Outcome*: result.

Process/Activity

The model of *Process* [17] involves four concepts: (1) *Activity*: transformation of an input into an output object; (2) *Role*: the responsibilities ensured by a function; (3) *Resource*: all that supports the process realization; (4) *Outcome*: the product of the process, it can be injected in the resources.

Activities occurring in a CoP can be classified in four categories: (1) *Communication* (transmission of information); (2) *Interaction* (exchange and sharing); (3) *Negotiation* (agree on ideas, make consensus - can concern the task to accomplish, the communication or the management of the interactions); (4) *Learning* (acquisition of new knowledge).

Moreover, we can also apply the following dimensions in order to classify an activity: (1) *geographical dimension* (same company, international, face-to-face, at distance); (2) *temporal dimension* (short term, middle term or long term); (3) *media used to support the activity* (audio, visual).

All the dimensions identified above are common to all CoPs: different types of collaboration can occur in a CoP.

Decision Making

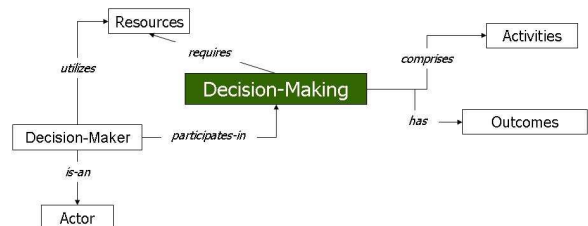


Figure 8. Generic model of Decision Making.

In order to build a CoP's specific *Decision Making* subontology, the Decision Making generic model presented in Figure 8 was employed as a backbone. This model comprises the following main concepts. *Decision making* refers to the cognitive process leading to the selection of a course of action among alternatives. This concept was the root concept of the proposed ontology. The *Resources* concept enables to represent all the input used for making a decision. The *Outcome* concept helps to represent the result(s) of a decision making activity. Primary outcomes of decision making activities are decisions. Consensus or conflicts sharing of knowledge, lessons learnt, etc. may also be decision making outcomes of activities. Another concept used for structuring the *Decision Making* ontology is the concept of *Actors* involved in the decision making activity. The *Activity* concept refers to a set of tasks related either by topic, dependencies, data, common skills, or deliverables: e.g. some typical decision making activities are collaboration, discussion and coordination.

Resources

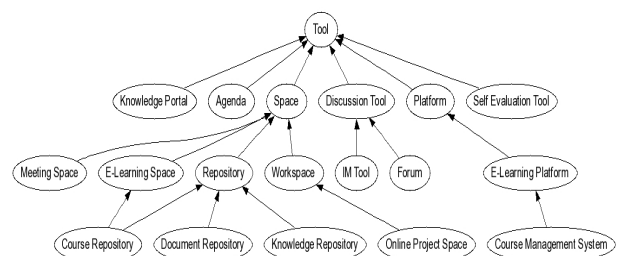


Figure 9. Excerpt of hierarchy of tools.

The analysis of corpora on the CoPs led us to subdivide the Resources manipulated by a CoP into:

- *Tools* which are defined according to the needs of community and the functionalities they offer. Figure 9 shows an excerpt of the hierarchy describing the categorization of these tools answering recurrent needs of a CoP [22] including knowledge capturing (Knowledge portal), knowledge storage and sharing (Repository), collaboration (Workspace, Agenda, ...)
- *Materialized resources* including documents, discussion. Almost all Palette CoPs are interested in easy access to interaction traces constituted by (synchronous or asynchronous) discussions and in archiving them. Figure 10 gives a view of the hierarchy of concepts describing such discussions.

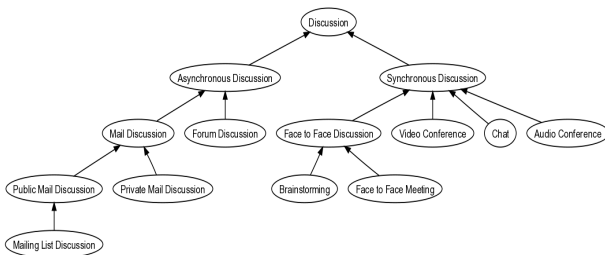


Figure 10. Concept hierarchy describing discussions.

EXPERIENCE FEEDBACK

This section sums up lessons learnt from O’CoP building.

Terminological Analysis

During the terminological analysis, we found several terms common to some CoPs but used to evoke different concepts: for example, depending on the CoP, the term “*platform*” was used to evoke either a website, or a workspace for the CoP, that may contain its documents and where the discussions of members are hosted, or a dedicated software such as a e-learning platform. Some terms were also used ambiguously to refer to concepts. For instance, CoPs use different terms to evoke the persons in charge of particular tasks in the CoPs (“*coordinator of the project*”, “*local coordinator*”, “*manager*”; “*facilitator*”, “*educator*”, “*trainer*”), whereas these tasks were not well described and identified.

Finally, some CoPs use different terms to refer to the same concepts, these synonyms must be associated to the same concept in their ontologies in order to avoid redundancy. For example, the terms “*Journal*” and “*Logbook*” are used to designate the record of activities or practices of a CoP’s member.

The resolution of terminological conflicts (such as several concepts expressed by the same term or several terms designating the same concept) requires:

- Precise information on the *context of use of the terms*: this is the role of the contextualized lexicon emphasized in our ontology development method and that enabled to

keep the link between the terms extracted and the part of text they stem from.

- *Validation by persons knowing the domain*, such as, in our case, the CoPs’ mediators. For example, the synonym terms (either in the same CoP or in several CoPs) were recognized by the CoPs’ mediators during the phase of vocabulary identification and term validation. The synonym terms corresponding to a given concept were formalized through the RDFS label of this concept.

Conceptualization and Structuring

The conceptualization and structuring phase relied on the collaboration between the ontologists, each contributor first achieving it for his/her subontology. Then, the identification of relations that connect concepts from different subontologies lead us to introduce new concepts that were not considered important at first: e.g., the notion of *Former member* did not exist in the first hierarchy of Actor concepts, but it was introduced to characterize *Orphan resource*.

Palette CoPs vs CoPs in Literature

The different Palette CoPs adopted different terminologies, sometimes quite specific to the CoP and rather different from the terminology usually found in literature on CoPs. Therefore, we did not include in the common layer of the ontology the concepts offered by literature if they were not attested by the Palette CoPs’ corpora. For example, the various kinds of leaders stressed in [19] or the taxonomy of facilitation tasks for CoPs proposed by [14] did not appear in the corpora and therefore were not included in O’CoP.

Implementation

The use of RDF/S to formalize the ontology was suggested by the guidelines of the Palette project [16] and motivated by the fact the expressive power needed for O’CoP was expected to be fulfilled by RDF/S: O’CoP will mainly be used to annotate CoPs’ resources and will only need simple but efficient reasoning for retrieving them. The arguments in favor of using RDF/S [5] correspond to the needs of the Palette project. We chose to start by using the simplest representation language for our ontology, and to use extensions to pure RDF/S only to answer specific issues. For instance, during the structuring stage, we were confronted to the issue of representing properties having domains or ranges requiring to be expressed through class conjunction or disjunction. O’CoP is formally an OWL-Lite ontology, but in the early stages of its development we took benefit from the simplicity of RDF/S.

Cooperative Building of the Ontology

The O’CoP ontology building was a distributed, cooperative process between: (a) six ontologists focusing on different parts of the ontology since each one was guided by one generic model, (b) eleven CoP mediators playing the role of validation from the CoPs viewpoints.

This led to the need of integration of different viewpoints. The different ontologists had various ways of modeling knowledge: e.g. the concept of *Activity* was needed for modeling *Collaboration*, *Competency*, *Decision-making* and *Resource*, such modeling being performed by four different ontologists. According to the needs and modeling choices of the four ontologists, the concepts related to *Activity* were thus modeled with various detail grains and various perspectives, requiring later more integration work.

Let us cite two examples of integration conflicts:

- The same concept may appear in different subontologies, but with different subhierarchies stemming from this concept: either the subhierarchies can be merged if they correspond to the same viewpoint, or intermediate structuring concepts can be introduced in order to make explicit the different viewpoints adopted by the different ontologists for modeling the concept.
- Relations with the same label but with incompatible domains or ranges may appear in different subontologies, requiring their renaming.

To conclude, our approach was both bottom-up (it relied on a deep analysis of the corpora on the CoPs) and top-down (this analysis was guided by our generic models).

VALIDATION

The Palette project being a user-centered design project, besides a classical validation/evaluation of the ontology from the technical point of view, we planned a validation/evaluation from the use(r) point of view.

(1) Validation/evaluation of the ontology for use

It was performed by user representatives, the CoPs' mediators, having in mind the future use of the ontology by CoP members, a use transcribed in the different usage scenarios defined in the Palette project. It was planned to be performed at the level of the terminology, and at the level of the hierarchies of concepts and relations. The *terminology validation* was done successfully: the mediators assessed, for each term, if it was relevant (i.e. representative of a CoP, or useful for becoming a concept or a relation of a CoP-dedicated ontology, or useful for annotating CoP resources or persons). The *hierarchy validation* is under progress. In addition to these planned validations, we noticed two "spontaneous" validations from the CoPs' mediators, showing the importance of the evaluation of "the pre-processed material an ontologist has at his/her disposal for building the actual ontology" [8]. They were related to our information sources (corpora and grids):

(a) *Validation of the corpora.* – By using transcriptions of interviews of the CoPs, we supposed implicitly that they were representative of the terms used by the CoPs. But the CoPs' mediators judged afterwards that these transcriptions were appropriate only for extracting terms related to the

organization of CoPs: they had scarcely asked questions about CoPs' practices, which leads to an ontology with very few concepts related to practices. They suggested using complementary corpora (e.g., forum discussions, exchanged documents) to find terms related to practices. Some ontologists also noticed a lack of documents describing the CoPs' collaboration or decision making activities.

(b) *Validation of the grids.* – Some mediators also brought a critical glance to the generic models used as interpretation grids.

(2) Validation/evaluation of the ontology in use

It will be performed (a) through the testing, by usability specialists, of competency questions related to the Palette scenarios, (b) through usability evaluations of the Palette ontology-based services by usability specialists unrolling the Palette scenarios, and (c) through CoP members' direct testing of the Palette ontology-based services.

CONCLUSIONS

Our Contributions

This paper presented O'CoP, an original ontology composed of more than 800 concepts and 80 relations, dedicated to CoPs, and more precisely aimed at enabling to annotate the CoP's members and the CoP's resources. The three-layered structure of this ontology is generic and should be useful for other researchers, as well as the content of the ontology itself. The high-level ontology and the middle-layer aim to be reusable for any CoP. The specific layer is typical to Palette CoPs but any external CoP having similar characteristics to a given Palette CoP could take inspiration of the corresponding subontology. Moreover, if an external CoP is interested in extending the O'CoP ontology specific layer with the concepts relevant for this CoP, it can reuse our ontology development method provided that it relies on relevant information sources. The main challenge is to enable a CoP to evolve itself its own ontology (without needing to rely on an external ontologist).

Related Work

We can compare our work with recent work linking CoPs and ontologies. In [13], the authors present a method based on analysis of the relationships between instances of a given ontology in order to identify potential CoPs in an organization. In [2], the authors develop an ontology aimed at enabling services among a civil servant CoP; in [7], design of situated ontologies for knowledge sharing in a CoP is studied; in [1], a semantic web system for open source software communities relies on specific ontologies (Code, Bugs, Interactions, Community). In comparison to this related work, the O'CoP ontology is original through: (a) the method used to build it cooperatively from analysis of several real CoPs, b) its objective of enabling to annotate CoP's resources in addition to modeling of the notion of CoP, and (c) its three-layered structure, with a generic

layer, a middle layer gathering concepts common to all CoPs and a low layer specific to a given CoP. Our work can also be partially compared to the typology of virtual CoPs (i.e. CoPs interacting through ICT) proposed by [6] or to the typology of CoPs based on their knowledge characteristics [10] but these typologies are not materialized through ontologies.

Further Work

After a final validation of the integrated O'CoP ontology by the CoPs' mediators, we will make it available to all the Palette CoPs and support them in case of need of extension of their specific subontology. Indeed, for some Palette CoPs, in addition to the specific concepts already modeled in the specific layer of O'CoP ontology, some specific domain concepts can be useful for annotating the CoP's resources: for example, @pretic is a CoP constituted of resource-persons supporting the use of ICT in Belgian schools and exchanging mails and discussions in forums: we are helping them to build the specific subontology for annotating such mails and forums not only by concepts offered by O'CoP ontology about the actors, their competencies, their activities, but also by concepts about ICT. Last, we will develop several of the O'CoP-ontology-based KM services evoked in the introduction.

ACKNOWLEDGMENTS

We thank very much the CoPs' mediators for their fruitful work of validation, P. Durville, the ECCO tool developer and F. Gandon for his methodological support, and, the European Commission for funding the Palette project.

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