CONTEXT-BASED SEMANTIC ANNOTATIONS IN COPES: AN ONTOLOGICAL AND RULE-BASED APPROACH

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ABSTRACT

Knowledge capitalization is one of many problems facing online communities of practice (CoPs). Knowledge accumulated through the participation in the community must be capitalized for future reuse. Most of proposals are specific and focus on knowledge modeling disregarding the reuse of that knowledge. In this paper, we are particularly interested on CoPs of e-learning (CoPEs) and we propose a knowledge capitalization approach within the framework of a CoPE, based on contextual semantic annotations. The proposed knowledge capitalization process is organized as a five-step cycle: 1) Acquisition and modeling, 2) storage, 3) share and reuse, 4) evaluation and 5) update. To deal with this process we use a contextual semantic annotation model. The annotations aim to model both CoPEs members' tacit and explicit knowledge. The context represents the situation in which the members create or reuse the annotation. A prototype called "CoPEAnnot" has been developed to illustrate our knowledge capitalization process. Ontological and rule-based context reasoning have been used to improve knowledge reuse, by adapting CoPEAnnot features according to the current activity context of members.

KEYWORDS

CoPE, Knowledge Capitalization, Semantic Annotation, Context, Ontological Reasoning, Rule-based Reasoning.

1. INTRODUCTION

Over the last two decades, Communities of practice (CoPs) have been receiving a considerable attention due to their potential application for managing knowledge. CoPs fulfil various functions related to knowledge creation and accumulation. They promote the collaboration, the interaction and the development of people's kills and competencies in a particular area. CoPs of e-learning (CoPEs) represent a virtual environment to build, share, exchange and develop knowledge and techno-pedagogical practices among e-learning actors (Berkani and Chikh, 2010).

Through their participation in the CoPE, the members create a shared repository of pedagogical knowledge, which includes both tacit and explicit knowledge. Therefore, they need to reuse and reap benefit from this repository in order to execute their activities more effectively. According to (Berkani and Chikh, 2010), one of the main questions is how to capitalize this knowledge repository and make it more accessible and reusable.

Most proposals in e-learning and CoPs are semantic-based approaches, whereby the ontological approaches are the commonly used. They are useful to model explicit knowledge and are widely adopted to index resources (Benayach, 2005) (Leblanc and Abel, 2007) (Tifous et al., 2007). However, these approaches are limited in modeling tacit knowledge, which requires the externalization mechanisms. Semantic annotation approaches are more effective for modeling both tacit and explicit knowledge, as shown in (Azouaou, 2006). For instance, the annotation of a document allows the creation of a layer of tacit knowledge. The latter is shared by those who reuse the document. In this case, the annotation is a way to externalize tacit knowledge. Otherwise, the annotation is related to the content of the document, and allows the classification and organization of documents. The effectiveness of semantic approaches in modeling knowledge is appreciated. But, the reuse of that knowledge remains under consideration. On this point, we consider that the preservation of the context of knowledge can overcome this issue. The context of knowledge refers to the parameters describing the situation in which the knowledge is modeled or reused.

Few studies have introduced this notion, the authors in (Azouaou, 2006) (Ouadah et al., 2006) propose knowledge capitalization approaches based on semantic annotation and context. These approaches are specific and they are dedicated to the teacher. Their aim is to capitalize his personal knowledge and they don't take into account the consideration of knowledge sharing. In addition, the notion of context has not been fully exploited and important aspects like context reasoning haven't been considered.

This work aims to propose a knowledge capitalization approach for communities of practice of e-learning. At first, our objective is to organize the knowledge capitalization process in the CoPE, in order to cover the whole life cycle of knowledge. Then, we aim to assemble the two components of semantic annotations and context to model CoPEs members' tacit and explicit knowledge. At the end, our objective is to improve knowledge reusability by benefiting from context reasoning mechanisms such as ontological and rule based reasoning.

2. CONTRIBUTION

In this section, we describe our approach, including a process of knowledge capitalization, a contextual annotation model, context reasoning mechanisms and the architecture of context-aware annotation system.

2.1 Knowledge Capitalization Process

The knowledge capitalization process we propose is based on the knowledge capitalization model proposed by (Grundstein, 1995). The process is organized as a five-step cycle, where each step aims to address a range of co-existing issues in the three facets of Grundstein's model: preservation, exploitation and update.

1) **Acquisition and Modeling:** we propose to annotate the resources after their storage in the repository of CoPE. The resource is annotated based on a contextual annotation model. The latter allows describing the resource, externalizing tacit knowledge and representing the context of members' activity during the annotation process.

2) **Storage:** knowledge that represents resources and annotations are stored in a knowledge base, which includes a repository of resources and ontological knowledge bases of annotation and context.

3) **Share and Reuse:** in this step, the ontological annotation model provides advanced reuse of knowledge. Reasoning capabilities on context ontology permits to adapt research, navigation and recommendation of annotated resources in accordance with members' activity context.

4) **Evaluation:** this step ensures the relevance and the quality of knowledge. Members may assess reused knowledge by means of annotations. These later allow the evaluation and enrichment of the knowledge base.

5) **Update:** it is important to keep up-to-date the knowledge base, in order to ensure that the content still relevant for CoPE members. Resources and annotations can be modified or deleted when it becomes obsolete. The modification of an annotation is considered as the creation of a new annotation, which is translated to the acquisition step.

2.2 Contextual Annotation Model

We propose a contextual annotation model to deal with the knowledge capitalization process. The model represents the important aspects of annotation, which includes the description of the annotated resource, the representation of various elements of annotation and their links to the controlled vocabularies, as well as the description of members' context during the process of creation, evaluation or reuse of annotations. The model is implemented using ontology. It consists of four dimensions: Resource, Annotation, Controlled vocabulary and Context.

2.2.1 Resource

This dimension represents the resource or the part of the annotated resource. It includes the following attributes (figure 1):

- URL: is the Unique Resource Identifier.
- Title: designation distinguishing the resource.
- Authors: creator(s) of the resource.
- Description: represents a summary about the resource content.
- Type: describes the type of resource (e.g. course, exercise, presentation etc.).

2.2.2 Annotation

This dimension represents the externalized knowledge which reflects personal knowledge of the annotator, and also those of recipients of annotation. Thus, those who reuse the annotation may express their judgments and feedback about the annotation via another annotation. This dimension is formalized based on the annotation models in (Azouaou, 2006) and (Mille, 2005). The conceptual model of annotation (figure 1) distinguishes two categories of annotation: personal and shared.

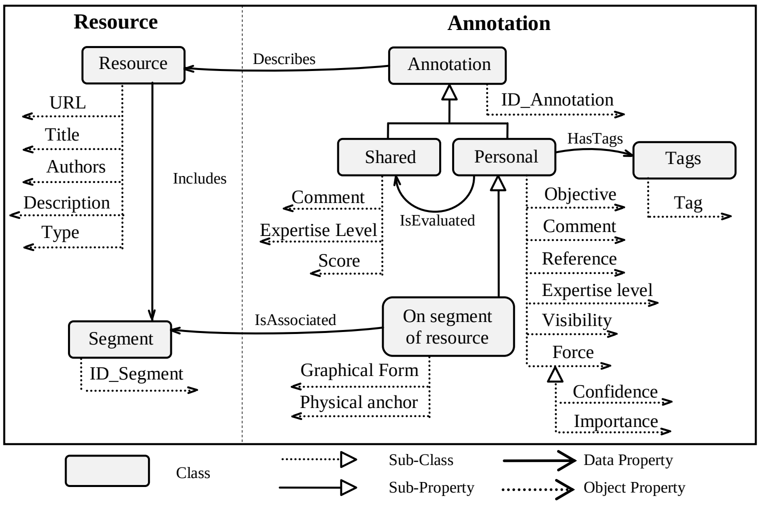

Figure 1. Conceptual Model of Resource and Annotation

1) "Personal" annotation: is associated to the author of the annotation. In the case of annotation on the whole resource, the annotation has the following attributes:

- Tags: this is one or more keywords associated to the resource. It can better organize the annotated resources and provides also a simple and effective browsing technique.
- Objective: represents the reason why the annotation is created. It serves to reuse the annotation, and it is associated with a controlled vocabulary.
- Comment: contains free text, allowing the annotator to freely express his points of views, opinions and expertise about the annotated resource.
- Reference: represents a link to another resource, this element allows the annotator to justify his opinion, argue or enrich his annotations. It may be a reference book, a citation, URL ... etc.
- Expertise level: this attribute is important; people tend to trust an expert over a novice.
- Visibility: refers to access rights to the annotation, we distinguish three types private, public and group.
- Force: represents the value that represents the annotation for the annotator including importance and confidence. Based on this attribute recipients of the annotation can judge the relevance of the annotation.

In the case of annotation on a segment of the resource, the annotation includes also the following attributes:

- Graphical form: it represents the graphical aspect of annotation (highlighting, underlining, etc.). That is used to change the appearance of information to make it more visible (Mille, 2005).
- Physical anchor describing the annotated segment in the resource.

2) "Shared" annotation: this dimension of annotation doesn't exist in the previous models of annotation. It allows members to evaluate and enhance the annotation.It includes the following attributes :

- Comment: a free text provided by the recipient, which allows him to express his points of view, interpretations, judgments about the annotation.
- Expertise level: of the member who evaluates the annotation.
- Score: appreciation of the value (i.e. a relevance measure) given to the annotation.

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2.2.3 Context

By context we mean a set of data characterizing the situation in which the member annotates, evaluates or reuses (view or edit) an annotation. This dimension is inspired from (Azouaou, 2006) and (Ouadah et al., 2006). The conceptual model of context represented in figure 2 includes two levels of context.

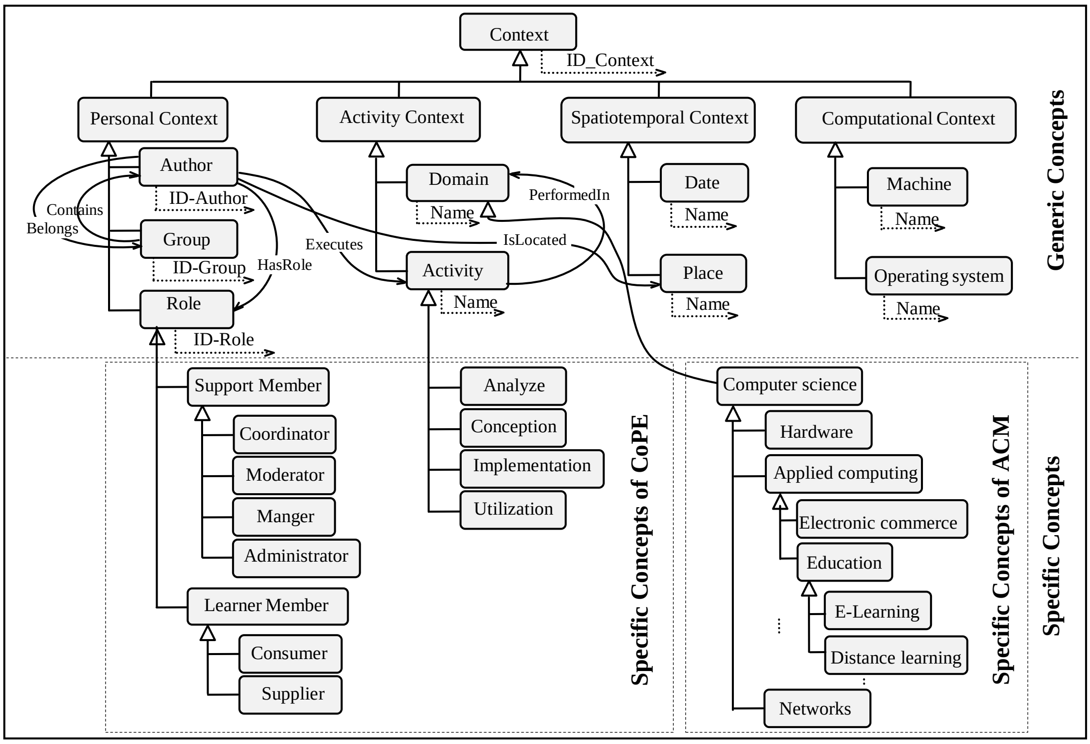

Figure 2. Conceptual Model of Context.

The first level represents the generic concepts of context describing the context of annotation in general and it can be applied to numerous fields. It is composed of four components:

1) Personal Context: includes the "Author" which represents the member of the CoPE, the member's "Role" in the CoPE and the "Group" to which the member belongs to.

2) Activity Context: includes the "Domain" which represents the knowledge domain (e.g. mathematics, physics, computer science etc.) and member's "Activity" in the CoPE.

3) Spatiotemporal Context: describes the following information: the "Date" and "Place" in which the member creates, evaluates or reuses the annotation.

4) Computing Context: includes the "Operating system" installed on the host (Windows, Linux, etc.) and the "Machine" on which turns the annotation tool.

The second level represents ontologies describing specific concepts of context. The ontology of CoPE (Berkani and Chikh, 2009) describes the concepts related to CoPE, such as: member, role, activity. ACM Computer Classification System (ACM CCS) (ACM, 2012) is used to describe computer science domain. But, other ontologies of location and time for instance can be also considered.

2.2.4 Controlled Vocabulary

This dimension represents the ontologies associated with the different elements of annotation like tags and attributes (e.g. graphical form, objective of annotation, etc.). We opt for the ontology proposed in (Mille, 2005), which presents a rather comprehensive list of annotation graphical forms. As far as vocabulary associated to the objective of annotation, we reuse the ontologies proposed in (Azouaou, 2006), describing teachers' annotation objectives. Thereafter, other controlled vocabularies can be developed.

2.3 Context Reasoning

Formal approaches for context modeling such as ontology, offer many advantages. The foremost advantage is the inference capabilities. Context Reasoning aims to check consistency of the model as well as to infer new information about context and to derive high level of context. Indeed, the contextual information provided by the environment (system, user, sensors, etc.) leads to elementary data about context, whereas some contextual information is useful only if it is combined with other elementary or composite contexts. The reasoning tasks in this work are grouped into two categories, ontological and rule based reasoning.

1) Ontological reasoning: context ontology is represented using OWL-DL language. The standard reasoning rules supported by this language are, in particular, subClasseOf, subPropertyOf, TransitiveProperty, disjointWith, inverseOf, etc.

Ontological reasoning rules

```
subClassOf:(?A rdfs:subClassOf ?B),(?B rdfs:subClassOf ?C) -> (?A rdfs:subClassOf ?C)
disjointWith:(?A owl:disjointWith ?B),(?X rdf:type ?A),(?Y rdf:type ?B)->
(?X owl:differentFrom ?Y)
inverseOf:(?P owl:inverseOf ?Q), (?X ?P ?Y) -> (?Y ?Q ?X)
```

Explicit context

```
<owl:Class rdf:ID="ActivityContext">
   <rdfs:subClassOf>
      <owl:Class rdf:ID="Context"/>
   </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Activity">
   <rdfs:subClassOf>
      <owl:Class rdf:ID="ActivityContext"/>
   </rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="Analyze">
   <owl:disjointWith>
      <owl:Class rdf:ID="Conception"/>
   </owl:disjointWith>
</owl:Class>
<owl:ObjectProperty rdf:ID="Belongs">
   <owl:inverseOf>
      <owl:ObjectProperty rdf:ID="Contains"/>
   </owl:inverseOf>
   <rdfs:range rdf:resource="#Group"/>
   <rdfs:domain rdf:resource="#Author"/>
</owl:ObjectProperty>
<Author rdf:ID="Author1">
   <Belongs rdf:resource="#Group1"/>
</Author>
```

Implicit context

```
<owl:Class rdf:ID="Activity">
   <rdfs:subClassOf>
      <owl:Class rdf:ID="Context"/>
   </rdfs:subClassOf>
</owl:Class>
<Conception rdf:ID="ScenarioConception">
<Analyze rdf:ID="ScenarioConception">
--- Error
<Group rdf:ID="Group1">
   <Contains rdf:resource="#Author1"/>
</Group>
```

Figure 3. Ontological Reasoning.

The figure 3 shows a part of ontological reasoning rules represented in first order logic, this with some examples illustrating the use of these rules. According to the context ontology, we can define the concept “Activity” as subclass of the concept “Context” using “subClassOf” rule. Furthermore, we can use ontological reasoning via the rule “disjointWith” to infer a contradiction when the instance “ScenarioConception” is defined as instance of both classes at the same time. Also, a new context that “Group1” “Contains” “Author1” can be implicitly deduced based on “inverseOf” rule.

2) Rule-based reasoning: some contextual information cannot be easily inferred using ontological reasoning. Accordingly, we propose to use a flexible reasoning mechanism based on predefined rules. These latter are described with Generic Rule Language specified by Jena API and based on first order logic, aiming to deal with the third step in the knowledge capitalization process. It allows deducing additional information about the current context of members and consequently adapting the reuse of annotated resources.

Table 1. Context Tuples

ID_Context	ID_Author	ID_Group	Role_Name	Activity_Name	Domain_Name
C1	Author1	Group1	Manager	Conception	E-learning
C2	Author2	Group2	Coordinator	Conception	E-learning
C3	Author3	Group1	Moderator	Conception	Distance Learning

The tuples in table 1 correspond to individuals of Context. The first tuple represents the current context of annotation "C1". Context reasoning basis on the other context tuples and the rule "R5" (Figure 4) infers a new context that the context "C1" has the same group and the same activity as the context "C3". More precisely, the rule R5 defines the relationship "SameGAc" between two instances of "context" concept, when their authors belong to the same group and execute the same activity. This rule is based on the relationships defined in the other inference rules ("Sameidc", "InC", "SamePerson", "SameGroup" and "SameActivity").

```
[R1: (?c1 prefix:ID_Context ?id_c1)(?c2 prefix:ID_Context ?id_c2)equal(?id_c1,?id_c2) -> (?c1
prefix:Sameidc ?c2)]
[R2: (?c rdf:type prefix:Context)(?a rdf:type prefix:Author)(?c prefix:Sameidc ?a)-> (?a prefix:InC
?c)]
[R2: (?a1 rdf:type prefix:Author)(?a2 rdf:type prefix:Author)(?a1 prefix:ID_Author ?ida1)(?a2
prefix:ID_Author ?ida2) equal(?ida1,?ida2)-> (?a1 prefix:SamePerson ?a2)]
[R3: (?g1 rdf:type prefix:Group)(?g2 rdf:type prefix:Group)(?g1 prefix:ID_Group ?idg1)(?g2
prefix:ID_Group ?idg2)equal(?idg1,?idg2) -> (?g1 prefix:SameGroup ?g2)]
[R4: (?ac1 rdf:type prefix:Activity)(?ac2 rdf:type prefix:Activity)(?ac1 prefix:activity ?idac1)(?ac2
prefix:activity ?idac2)equal(?idac1,?idac2)-> (?ac1 prefix:SameActivity ?ac2)]
[R5:(?c1 rdf:type prefix:Context)(?c2 rdf:type prefix:Context)noValue(?c1 prefix:Sameidc ?c2)(?a1
rdf:type prefix:Author)(?a2 rdf:type prefix:Author)(?a1 prefix:InC ?c1)(?a2 prefix:InC
?c2)noValue(?a1 prefix:SamePerson ?a2)(?g1 rdf:type prefix:Group)(?g2 rdf:type prefix:Group)(?a1
prefix:Belongs ?g1)(?a2 prefix:Belongs ?g2)(?g1 prefix:SameGroup ?g2)(?ac1 rdf:type
prefix:Activity)(?ac2 rdf:type prefix:Activity)(?a1 prefix:Executes ?ac1)(?a2 prefix:Executes
?ac2)(?ac1 prefix:SameActivity ?ac2) -> (?c1 prefix:SameGAc ?c2)]
```

Figure 4. Reasoning Rules

2.4 Context-aware Architecture for CoPEAnnot

Here, we propose a context-aware architecture for our annotation system called CoPEAnnot. Many researchers have proposed several context-aware architectures and most of them are proposed in pervasive and mobile computing domain. The works in (Azouaou and Desmoulins, 2006) and (Ouadah et al., 2009) proposed architectures for context-aware annotation systems. As most available architectures, they don't permit context reasoning and inference. The latter becomes a vital requirement for context-aware systems in order to facilitate the adaptation task. Our architecture (see figure 5) differs from the previous ones at the reasoning support that provides. It consists of two main components: context management and annotation management. This separation is inspired from (Chaari and Laforest, 2005). The authors suggest that the body of application must be designed in isolation from contextual data.

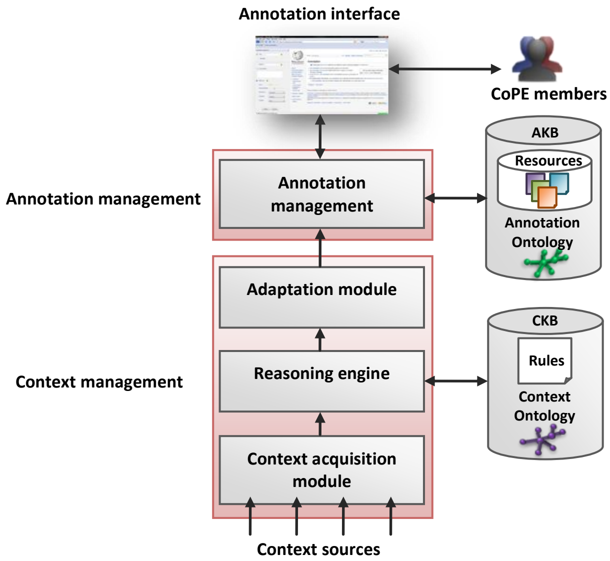

Figure 5. CoPEAnnot Architecture.

1) Context management: is responsible for context acquisition, reasoning and adaptation:

a) Context acquisition: this module is responsible for collecting contextual information from different sources (operating system, learning environment, user, user model, physical sensors, etc.), for interpreting contextual information (transform them into more useful and meaningful contextual information) and for their storage in accordance to the ontological model of context.

b) Reasoning engine: is the brain of our architecture. It is in charge of reasoning about contextual information acquired by the acquisition module. Based on ontological reasoning and rule-based reasoning, the reasoning engine infers information about annotations' context which is semantically closest to the current context of annotation.

c) Adaptation module: This module adapts the functionalities of context-aware system according to contextual information provided by the reasoning engine.

2) Annotation management: is in charge to manage annotations, it includes the following major steps:

a) Annotation management module: is in charge to insert, store and update, research, navigation and recommendation of annotations. These last three features are adapted according to the current context of the annotation.

b) Annotation interface: represents the graphical interface that allows the exchange and the interaction between the CoPE members and the annotation tool.

The context knowledge base (CKB) contains the OWL ontology defining the context. It contains also a set of inference rules which is processed by the reasoning engine. The annotation knowledge base (AKB) includes the repository of resources and the OWL ontology defining the annotation model and their controlled vocabularies.

3. IMPLEMENTATION

A prototype system has been developed based on the above architecture and annotation model. Here we give a brief description about the implementation of CoPEAnnot and their functionalities. Ontological models are developed using Protégé ontology editor. The system is implemented in client-server architecture. The client is the user who has as browser Mozilla Firefox, in which the annotation tool constitutes a browser extension (plug-in). Graphical interface was built using XUL, DOM, JavaScrip and CSS. AJAX technology is used to insure the communication between the client and the server which is sort of http request/response. On the server side, we used Tomcat as a Servlet container as well as a web server. Servlet are java programs that used to handle http requests/responses. Jena frame work provides a programming environment for RDF, RDFS, OWL and SPARQL and it also includes several internal reasoners, where the rules engine supports generic inference based rules.

(A) (B) (C)

Figure 6. Screenshots of CoPEAnnot.

The annotation extension is constitutes of tow toolbars, the first one provides the following main features: CoPEAnnot (Home), Resource, Annotation, Navigate, Search and Help. The second one provides a graphical form palette. Home sidebar shows the tag cloud and the recommended annotations adapted to the current context of the member (see figure 6 part B). Members can annotate (see figure 6 part A) any resource already exists in the knowledge base. The tool enables annotation of different types of resources and the annotation on segment is considered for only html resources. Thereafter, members can also edit, share, and evaluate annotation. In addition to the standard features of navigation, the tag cloud facilitates access to knowledge and it enables faster discovering of knowledge. The tool provides also contextual semantic search based on controlled vocabularies (see figure 6 part C).

4. CONCLUSION

In this paper, we have investigated how context-based semantic annotations can be used in a knowledge capitalization process, dedicated to a community of practice of e-learning. We have proposed an approach which first aims to organize the knowledge capitalization process in the CoPE, and to cover the whole life cycle of knowledge. Then, the proposed contextual annotation model serves for modeling tacit and explicit knowledge of CoPE, and it favour knowledge sharing. Ontological and rule-based reasoning represent the brain of the proposed context-ware architecture of CoPEAnnot. They have been used to adapt the annotation tool features according to the current activity context of members. Our future work will focus on the tool validation. To achieve this goal, some experiments are to be performed within a community of learners. We also plan to improve CoPEAnnot by extending reasoning capabilities on other elements of context and developing controlled vocabularies.

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