An Approach for the Personalization of Exercises based on Contextualized Attention Metadata and Semantic Web technologies

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Abstract: The generation of Contextualized Attention Metadata (CAM) allows to retrieve information about the different actions that users execute over different resources in a specific context. This paper presents how CAM is used within a learning system to personalize help provided to students while working on online exercises. We outline our approach and present two application examples within this framework for the personalization of exercises with hints.

Keywords: Adaptive and Personalized Technology-enhanced Learning; Semantic Web and Ontologies for Learning Systems; Knowledge and Competence Management;

I. INTRODUCTION

Assessment systems with the provision of hints have proven to be very useful in the teaching/learning process and many of such systems exist (e.g. [1] or [2]).

While using assessment systems, students perform many actions in numerous contexts. The information describing the actions is often stored in proprietary formats and is used for personalization, feedback or group pattern. To enable interoperability among various such learning systems, a model to describe the student activity is needed, overcoming the drawbacks of proprietary solutions.

Contextualized Attention Metadata (CAM) specification [3] provides an excellent framework for storing complete and interoperable data about the actions that users execute while interacting with the different exercises and hints. So far, CAM data has been used for simple reflection support, e.g. in the MACE web-based information system and different desktop applications [4]. However, there is no approach for using CAM within an assessment system in the learning domain.

This paper focuses on the discussion on how CAM can be used in learning systems that feature assessment and hints. We use semantic web technologies. Many solutions exist today that make use of these technologies, e.g. for the personalization of contents [5], assessments [6], or hints in problem based learning [7]. But none of the solutions uses CAM, and thereby do not enable contextualized personalization to its full extend. In addition to solve interoperability issues, we overcome the problem of lost information, e.g. on the student's learning process when storing only the average score of students, the number of hints requested, etc. In a changing environment where the different estimators and measures for personalization vary, this flexibility is important to have all the data available.

II. THE LEARNING SYSTEM WITH EXERCISES AND HINTS

The learning system we use for explaining our approach is XTutor (http://icampus.mit.edu/xTutor/) with its hinting module extension [1]. Figure 1 shows a working example with a group hint. Different exercises with hints can be edited with an implemented authoring tool [8].

Figure 1. Example of exercise and hints within XTutor

III. CONTEXTUALIZED ATTENTION METADATA

CAM represents the information about the actions that users execute in systems. Reference [3] describes an approach for monitoring and capturing CAM data in an efficient way, giving a data model and an XML binding.

With this CAM specification, several applications have already been implemented. Some application examples are the Zeitgeist [4] application that generates statistics about the MACE web based information system or the CAMERA tool [4] that processes the actions about users in different applications.
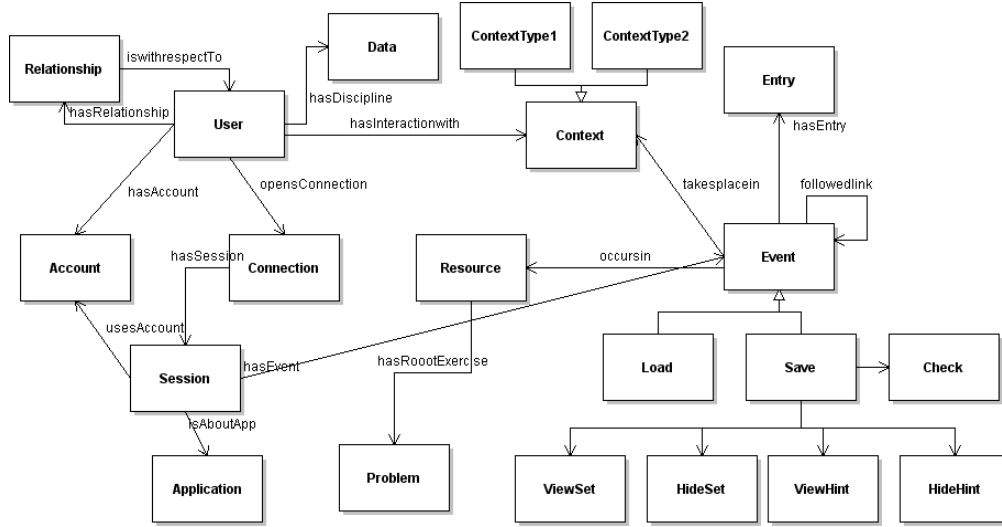
Figure 2.   Integration of hints, exercises, and the different event types with CAM-RDF data.

IV.   COMBINING CAM WITH THE LEARNING SYSTEM

Figure 2 shows a representation of some of the main elements of the RDF binding for CAM, and the CAM-Exercises-Hints RDF schema integration for our approach. Exercises and hints with a defined RDF binding would be located under the *Resource* class. There is a property of the *Resource* which is *hasRootExercise*, which points to the root problem. We cannot directly substitute the resource with the problem (removing the *hasRootExercise*) because the same root problem can have multiple combinations of different hint problems, hinting techniques, etc., so it would not identify the resource univocally.

The possible event types are presented in figure 2 and are used for the *hasEvent* property from *Session* to *Event*. *Load*, which implies that the exercise with hints has been accessed by its URL, and *Save*, which implies that the student has pressed some button: *Check* for checking the correctness of the different solutions to the different problems (root and hints that have been answered), *ViewSet* for viewing directly the hint problems in a sequence hint or the meta-information of a group hint, *HideSet* for hiding the information of a *ViewSet* action, *ViewHint* for selecting a specific hint of a group hint, and *HideHint* for hiding a specific hint of a group hint.

Moreover, the CAM data stores the student solutions to the different problems using the *Entry* class, which has a name (*hasEntryName*) and a value (*hasEntryContent*). Each solution attempt of a student is registered with these two fields. This model allows us to identify which problems are opened for a student in a specific exercise (following the sequence of hints viewed, hidden, etc.).

Figure 3 shows the partly implemented architecture, inspired by the one presented in [7]. The MACE system is a web portal where users perform different actions. Different format transformation modules are required.
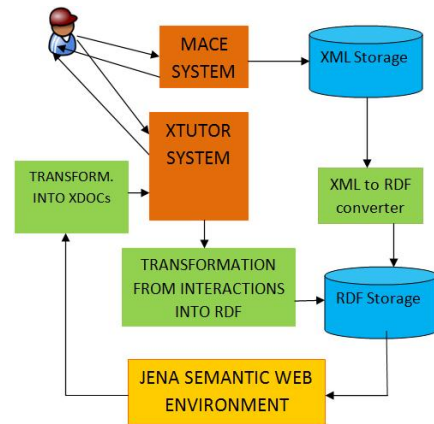

Figure 3.   Architecture for combining the hinting learning system and MACE with CAM

V.   APPLICATION EXAMPLES

A.   Adaptation of the Hint Contents

A hint can be obtained from the external MACE web based system (e.g. the one with the closest difficulty to the student level in the considered topic). We have composed the following SPARQL sentence in Java for this purpose:

```
"PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>"
+"PREFIX
cam:<http://www.fit.fraunhofer.de/ontologies/cam#
>"+"PREFIX dc:
<http://purl.org/dc/elements/1.1/>"
+"SELECT ?webpage ?title (COUNT (?y) AS
?countweb) " + "WHERE {" +
  "?x cam:hasgoToPage  ?y . " +
  "?y cam:occursin ?webpage . " +
  "?webpage dc:subject \"" + subject +
  "\"^^xsd:string ." + "?webpage dc:title ?title
. " + "}"
+"GROUP BY ?webpage ?title "+
"ORDER BY ?countweb";
```

The SPARQL sentence returns a classification of all the MACE resources that cover a certain topic (given by *dc:subject*) depending on the total number of *goToPage* actions performed by all the students. Among the many actions of the MACE system, *goToPage* was selected because it implies to go directly to the complete resource, so we consider it to be a good estimator to determine how useful a resource is. According to the order of the resources of this SPARQL sentence, resources can be classified with a quality level. When the hinting system needs a hint content of a specific topic for some student, this SPARQL sentence would be executed and the student knowledge level in that topic would be retrieved and classified in a scale. The opposite quality level of a resource from the MACE system would be assigned to the student as hint according to the SPARQL classification.

B. Adaptation of the Hinting Techniques Applied

We can take advantage from other systems like MACE in order to make the hinting techniques adaptation decisions. Here, the challenge is how to connect and interpret the MACE actions that are stored as CAM data, with the information that can improve some hinting technique. For example, if a user always generates a *goToPage* action (opens the resource) after a *getMetaDataforContent* for that resource (which shows some meta-information of the resource but not the complete resource), this could indicate that the student does not consider the meta-information carefully, but instead opens the resource directly. Consequently, this behavior might indicate that the student uses hints without thinking carefully about the root problem first. For this type of students, hinting techniques that could prevent viewing hints can be useful in some situations rather than for students that hardly ever look for the complete MACE contents. Regarding this example, we have the following SPARQL sentence in our environment:

```
"PREFIX
cam:<http://www.fit.fraunhofer.de/ontologies/cam#
>"+
"SELECT (COUNT (DISTINCT ?webpage) as ?number) "
+ "WHERE {" +
  " ? c1 cam:hasSession  ?s1 . " +
  " ?s1 cam:hasgetMetadataForContent ?y . " +
  " ?s1 cam:hasgoToPage  ?z . " +
  " ?y cam:occursin  ?webpage . " +
   " ?z cam:occursin" + "> ?webpage . " +
"}" ;
```

This SPARQL sentence returns the number of times that a specific user accessed the same web page, performing both, a *getMetadataForContent* and a *goToPage* action. With a similar query, we can retrieve the number of times that a user accessed a web page performing only one of such actions. Next, we can classify the proportion of times in which a user selected both compared to the total. This classification can serve as a clustering of users, and it can be used for personalization of the hinting techniques applied as outlined above.

VI. CONCLUSIONS

This paper outlines how we use contextualized attention metadata (CAM) to drive an exercise system that also provides help to learners in the form of hints. We focus on personalizing the content of hints as well as the rule-based on which hints are given. We describe the technology that is needed to enable a CAM-supported hinting system, relying basically on semantic web technology.

In two applications, we show how RDF-based CAM is used to personalize the help system of an online exercise tool. In particular, we demonstrate the use of CAM to adapt the content of hints as well as how CAM is used to select the appropriate hint-giving approach. Both use cases are presented together with the respective SPARQL sentences.

Finally, the use of CAM for assessment learning systems implies a lot of benefits such as the integration with information from other systems (e.g. with our MACE example). In addition, the inclusion of semantic web technologies in the approach provides additional benefits.

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