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Context Aware E-Learning using Ontology Framework

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Abstract

In web-based e-learning environment every learner has a distinct background, learning style and a specific goal when searching for learning material on the web. The goal of personalization is to tailor search results to a particular user based on that user's contextual information. The effectiveness of accessing learning material involves two important challenges: identifying the user context and modeling the user context as ontological profiles. This work describes the ontology-based framework for context-aware adaptive learning system, with detailed discussions on the categorization contextual information and modeling along with the use of ontology to explicitly specify learner context in an e-learning environment. Finally we conclude by showing the applicability of the proposed ontology with appropriate architectural overview of e-learning system.

Keywords- *Categorization; Context-acquisition; modeling; contextual-diversity; Context-description; ontology-drive;, adaptive e-learning; Interdependence problem*

I. Introduction

The popularity of e-learning applications has created huge amount of educational resources and to locate the suitable learning references based on learner requirement is a big challenge. In recent years, personalized and adaptive search has attracted interest in the e-learning research community, as a means to decrease unwanted return results. Since semantic knowledge is an essential part of the learner context, we use learning environment context-ontology as the fundamental source of semantic knowledge in our framework. In this paper, we propose Ontology for context-aware adaptive e-learning system that delivers learning material based on contextual information of e-learner. Our proposed framework works on the idea of delivering learning Material based on the modeling of learner context as ontological profiles. The paper is organized as follows: after discussing related research work, first, we present the main conceptual points of our approach. Then we detail about ontological representation learner preference context and architectural model of the ontology based adaptive learning system. We end with a conclusion and feature work.

2. Related Research

The related research review presents on ontology-based context model for context–aware e-learning applications where the context model is used to select appropriate learning resources.

Hong M. and Cho D [1] presented a conceptual ubiquitous learning architecture based on a context-aware manger. This ontology-based context model is called CALA-ONT (Context Aware Learning Architecture Ontology) which supports user centric ubiquitous learning services. It consists of four top-level classes and sub-classes, and contains twelve main properties which describe the relations between individuals in top level class and its sub properties.

Schmidt and Winterhalter [2] are using context to retrieve relevant learning object for a given user. The matching service computes a similarity measure between the current user context abstraction and the ontological metadata of each learning object and then can present a ranked list of relevant learning objects. It is a kind of active use of context intending to reconfigure available services (learning objects).

Lee et al. [3] developed a Java Learning Object Ontology for an adaptive learning tool to facilitate different learning strategies/paths for students, which can be chosen dynamically.

Jane Yau and Mike Joy [4] described the architecture of Context-aware and Adaptive Learning Schedule (CALS) tool.

This tool is able to automatically determine the contextual features such as the location and available time. The appropriate learning materials are selected for the students according to, firstly, the learner preferences, and secondly the contextual features. Wang et al [5] introduces an OWL ontology named CONON, which stands for "Context Ontology". CONON is supposed to be used in pervasive computing environments, identifying location, user, activity and computational entities as fundamental context categories to enable context modeling and logic-based context reasoning.

3. Context-Based Adaptive Learning

The context-based adaptive e-learning system basically consists of three important steps as shown in "Fig. 1". It consists of context acquisition, context modeling and context adaptation.
The context-acquisition process collects contextual information of learner through Learner profile, Context detection service and User interface.
Recent approaches to context modeling used very different data structures as their basis. However, here we are proposing an ontological model because it is promising formalism for modeling context. The adaptive behavior in context-based e-learning represents the change in application's normal flow and attitude (e.g. adaptive presentation, recommendation etc.) based on the context of learning environment.

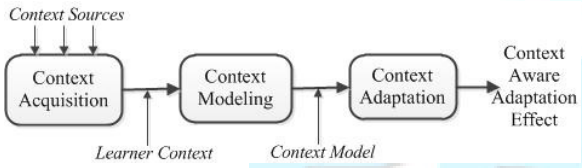

Figure 1. Basic steps in context-based adaption process

4. Categorization of Context

It is possible to categorize context in various ways by considering different characteristics of the context. These categorizations are useful both for application development and for understanding of the user context [6]

4.1 Static

Static information is generally concerned to personal data about users, such as their name, qualification, organization, nationality, location etc. This information is provided by learner during the registering phase and can be modified when user needs to update some data.

4.2Dynamic (Run-time context)

It is called Personalized Semantic Context because it defines the personalized information about the learning material that the user likes and dislikes. This part of the profile must be flexible enough to be updated when the interest of the learner changes. In general the contextual information collected may be input by the user through registration process or implicitly gathered by context detection service agent.

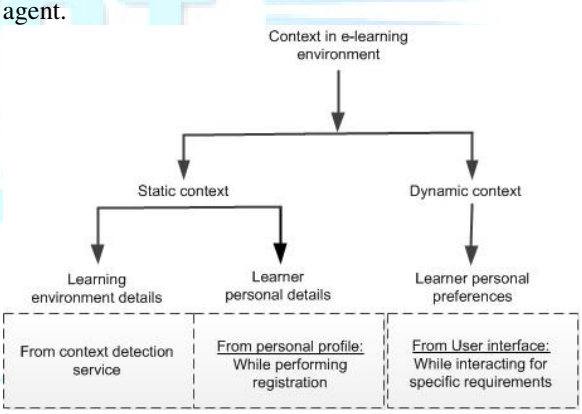

Figure 2. Context categorization in e-learning environment based on information acquisition perspective

5. Context Acquisition And Modeling

According to Slavi Stoyanov [7], an adaptive e-learning system is described as: "An adaptive e-learning system is an interactive system that personalizes and adapts e-learning content, pedagogical models, and interactions between participants in the environment to meet the individual needs and preferences of users if and when they arise." .

Thus, an adaptive e-learning system takes all properties of adaptive systems. To fit the needs for

the application in the field of e-learning, adaptive e-learning systems adapt the learning material by using user models.

According to Brusilovsky [8], an adaptation process consists, the process of collecting data about the user and the process of building up the user model (user modeling). Here in the case of context-aware adaptive learning, we believe adaptation process consists of collecting contextual information about learner and process of building context-aware adaptive learner model as shown in "Fig. 3". Context modeling is conceptually different from modeling of other user features. However, context modeling and user modeling are tightly interconnected.

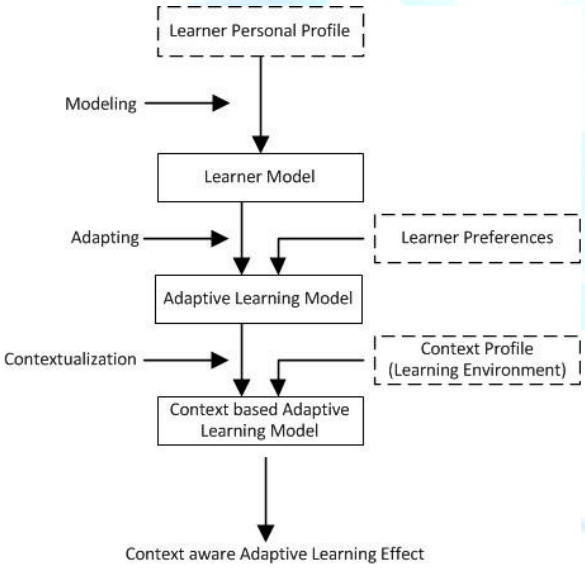

Figure 3. Overview of context-aware adaptive learner model

6. Context in E-Learning Environment

The issue of context arises in many areas of computer applications and is quickly becoming an important topic of research related to e-learning domain. The context in e-learning systems is considered for personalization, adaptation and recommendation of suitable learning material to the user as per the strategies like, in what situation the learner is, what is his learning environment and what is his mode or style of reading. "Contextual factors" can refer to many things. Here, we wish to focus on a restricted sense. In e-learning environment the context can be viewed from the perspective of the learner by considering all the factors that influence learner's learning style. Contextual factors in e-learning environment may be concerned to learning domain, activity or environment.

7. Contextual Diversity in E-Learning Environment

The e-learner produces heterogeneous needs under various contexts, so besides learner's characteristics, adaptation to learner's contextual environment is a new kind of adaptation that was brought by e-Learning systems [8]. Although the e- Learning has evolved from one-size-fits-all system to adaptive and personalized learning system, the adaptive learning contents are not suitable to study because e-Learning system does not take into account their various contextual diversities of learning environment and learning style of learner. The contextual diversity in e-learning environment is as shown in"Table-1".The content-based adaption in on-line news sites is concerned particularly to the navigational activity of the user, but in the case of e learning systems it could exploit the learner specific supplementary information such as learner educational details, learning environment, preferences and learning style illustrated by the navigational activity.

Category Type and Features

Personal details
Organization: Research-group, University
Role: Professor, Researcher, Student
Qualification: Bachelor-degree, Master-degree
General Preferences
Language: English, Chinese, etc
Subject: Database, Artificial-inelegance, etc
Learning-media: Video, Audio, Animated, etc
Learning-style: Example-oriented, Case-study, Survey, etc
Learning environment
Preferences
Device: PC, Cell phone, PDA
Device support: Audio, Video, Image, Text
Network-connectivity: Wired, Wireless
Location: Nation, City
Time: Fixed Time

8. Ontology and Context Description

In the knowledge representation domain, the term "ontology" refers to the formal and explicit description of domain concepts, which are often conceived as a set of entities, relations, instances, functions, and axioms T. Strang [8], analyses several approaches in the literature according to data scheme used and concludes that ontologies are promising for context modeling. They represent explicit, formal (i.e. machine understandable) and shared conceptualization of real world aspects.

X.H. Wang [5], refers to several reasons in order to use ontologies for context modeling: (1) knowledge sharing, (2) logic inference, (3) knowledge re-use. In the context of e-learning, the adaptive process is concerned to the adaptation of learning content and the presentation of this content to the learner specific requirements and environment.

A context model is also a system of concepts (entities) and relations, so that the ontology is a possible mean for context modeling to specify the representation of contextual knowledge. Here, we used an ontology-based context model for context representation. This model adopts Web Ontology Language (OWL) as the representation language to enable expressive context description and data interoperability with third-party services and applications.

"Fig 4" shows general categorization of context information in e-learning domain (from learner perspective) as *Situation-context*, *Domain context* and *Activity-context* and the concerned partial context ontology, representing the learner's context is as shown in "Fig. 5" . The Context information has the form of subject, predicate, and value. The subject is a subject of context, e.g. a Location, Learning-Media, a computing entity or an activity.

The predicate represents a property of subject, e.g., *Is Located In*, *has Learning Media,* etc. The value represents all values of subject or subjects, e.g., city name, text etc.

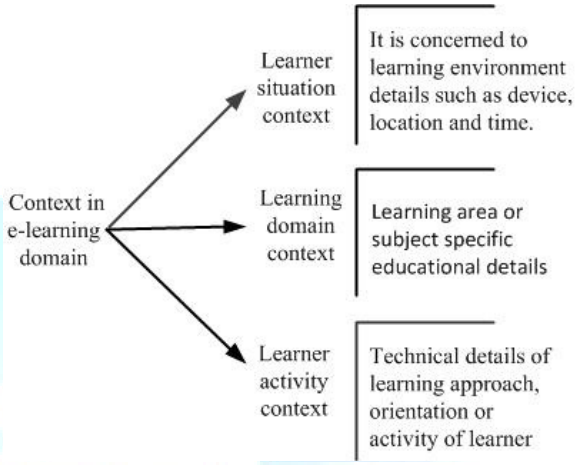

Figure 4. Context categorization in e-learning environment based on learner perspect

The ontology of learner-context must be able to capture all the characteristics of learner and learning environment information, but here, our proposed context ontology is an abstract representation with only three categories of contextual information.

8.1 Situation-context

Adaptation to the context of the user's current situation is a relatively new research direction within Adaptive E-learning Systems, which was also expanded into the area of mobile adaptive systems. Dimensions of the context consist of user platform (hardware, software, network bandwidth etc) and user location (country, state, city etc)

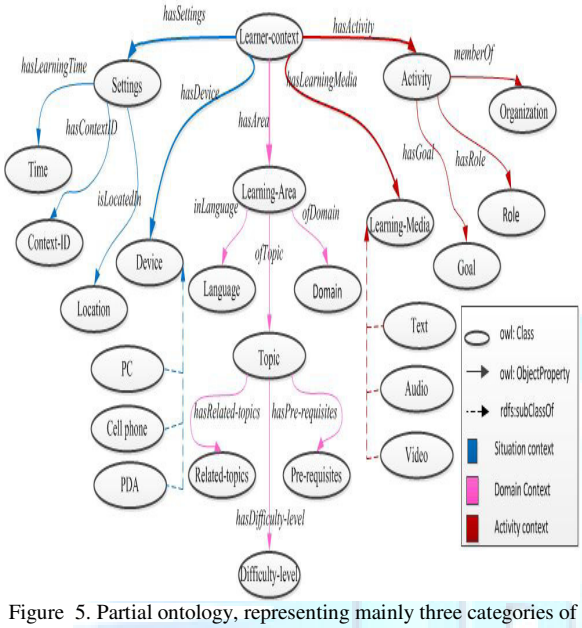

Figure 5. Partial ontology, representing mainly three categories of contextual information in learning environment

8.2 Domain-context

The domain context is used both for user ontology model and document models, for providing the required and related document specific facilities. Generally it consist the elements such as topic, language, related topics etc.

8.3 Activity-context

Context adaptation process is to adapt the context parameters to the activity needs of e-learner. This adaptation aims to create suitable learning environment to the learner, that helps learner to concentrate better on their on their learning activity so as to get better and suitable learning material. Context parameters such as the user interests, user goals and any particular interests encountered into the current moment and expressed through concepts illustrated by the accessed documents can be considered as Activity context elements. We considered here the OWL language for our context modeling due to the reason; it is a W3C recommendation that consists of web standards such as RDF, RDFS and XML Schema for context information representation. The OWL and RDFS allows the necessary semantic interoperability between context-aware systems. The OWL has been developed most recently as an ontology language which defines classes and properties and also their relationships more clearly. Figure.6" shows OWL program with XML-syntax as a part of the context model and it is a simple and partial program of the proposed context-model, it represents the contextual details like:, a learner with professor role is using learning device cellphone of Nokia model with medium screen size, Symbian operating system and 128 MB RAM.

```
<rdf:RDF
xmlns:owl ="http://www.w3.org/2002/07/owl#"
xmlns:rdf ="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
xmlns:xsd
="http://www.w3.org/2001/XLMSchema#">
<owl:Ontology rdf:about="">
<rdfs:label>Learner Context Ontology</rdfs:label>
</owl:Ontology>
<owl:Class rdf:ID=" Professor ">
<rdfs:subClassOf>
<owl:Class rdf:ID=" Role "/></rdfs:subClassOf>
</owl:Class>
<owl:Class rdf:ID="City">
<rdfs:subClassOf>
<owl:Class rdf:about="#Location"/>
</rdfs:subClassOf>
</owl:Class>
<owl:ObjectProperty rdf:ID=" usingDevice ">
<rdfs:domain rdf:resource="# Professor "/>
<rdfs:range rdf:resource="# Device "/>
<rdf:typerdf:resource="http://www.w3.org/.../owl#FunctionalProperty"/>
</owl:ObjectProperty> <usingDevice>
<Mobile-Phone rdf:ID=" Nokia-C5-03 ">
<hasScreenSize rdf:datatype=" &xsd;string ">Medium </hasScreenSize>
<hasOS rdf:datatype=" &xsd;string ">Symbian OS v9.4 </hasOS>
<hasMemory rdf:datatype=" &xsd;string ">128 MB RAM</hasMemory>
</ Mobile-Phone > </usingDevice >
</ Professor >
</rdf:RDF>
```

Partial program of proposed ontology with contextual details

9. Proposed Architectural Model

In this section we proposed the possible architecture-model for e-learning system which includes several contextual dimensions from the learner context perspective as shown in "Figure 7". This architecture consists of three databases- Learner profile database, Learning-activities database and knowledge base. Learner profile database contents are collected through learner registration process that contains the personal details of learner such as qualification, position, learner preferences etc. The learner's scheduled events and the learning activities are stored in learning -activities database. Knowledge base consists of aggregated contextual information, collected from different sources and this information being represented and organized using ontologies.
Learning style adaption module performs filtering of learning material based on learner's learning activity and personal preferences. Finally, the context adaption module delivers learning-material as per the learner's context.

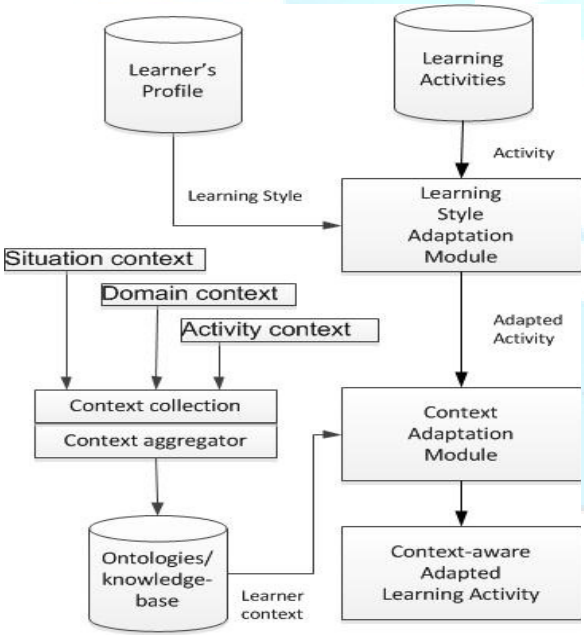

Figure 7. Proposed architectural overview of e-learning system

10. Advantages of Ontology for Context Modeling

When dealing with context information it is always a challenge to describe contextual facts and interrelationships in a precise and traceable manner. Ontologies seem to be well suited to represent the knowledge concerned to context in elearning domain. Some of the advantages of ontology for context modeling are as mentioned below.

- Amount of information to be delivered to user can be reduced based on learner preferences and context ontology.
- The user needs and expectations can be predicted to recommend suitable material based on ontological inference mechanism.
- It enables formal analysis of domain knowledge for context reasoning from explicitly defining context ontology.
- The main purpose of ontology-based context model is to enable semantic interoperability and to provide common understanding of the structure of context information among users.

11. Inter dependence Problem among Context Elements

The contextual parameters of e-learner are acquired from different sources such as registration process, context detection service etc., as we referred in "Section- 4". The adaption process is able to deliver learning material by considering the entire context parameters group together based on semantic, ontological and conceptual relation among them. In practical implementation, to some-extent there may be interdependence, ambiguity and contradiction problems among some of the context elements. "Table-2" shows few context-elements of such category

.

Time and Location: In web based learning the global date-time format is to be considered because the time depends on geographical location of learner.

Learning-media and Device: The context parameter, device (such as PC, Cell-phone etc) must be able to support the type of learning-media format

(such as Audio, Video, text formats) selected by the learner.

Learning-topic and domain: The learning-topic and learning domain cannot be considered as independent contextual
elements.

Context-element Depending on Explanation

Time Location Learning time is location dependent
Learning-media Device Learning material
format is device dependent Topic Domain
Learning topic isdomain dependent

12. Conclusion

In this paper we introduced the context-aware adaptive learner model along with its ontology-based framework for context-aware delivery of learning material by adapting learner context. Here, we introduced the possible categorization approaches to categorize contextual information in e-learning domain based on context acquisition and learner perspective. Finally we proposed a possible architecture model for context aware e-learning system and interdependence problem among the context parameters. The future work will concentrate on detailed study on interdependence problem among the context parameters and implementation of the proposed model. We believe that the primary advantages of our ontology based context model, contains semantic relationships between concepts and It can provide semantic based context information for searching learning material in context-based e-learning environment.

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