# Semantic Based Approach for Adaptive E-Learning System: An Architectural Model

Nehru Veerabatheran, Kalla. Madhusudhana

**Abstract**— E-learning systems are expected to provide the suitable learning materials for learners. However, they cannot meet this expectation due to the similarity of learning material. This problem is caused due to lack of personalization and the current solutions are not sufficiently aware of the context of the learner. This paper aims to develop the ontology based learner model for context-aware adaptive e-learning system to provide context-aware delivery of learning material. Furthermore, this study discusses about the approaches for acquiring contextual information of e-learner along with the appropriate architectural overview of e-learning system.

**Index Terms**— Ontology, Context Model, Architecture, Adaptive Learning, Context detection, Learner profile, context Acquisition

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## 1 INTRODUCTION

The explosion of learning material in educational domain is leading to develop context aware personalized e-learning applications that help learners with a more accurate learning. The development of context-aware e-learning applications should be supported by adequate context modeling and reasoning techniques [1].

Modeling context knowledge is a crucial task to support the delivery of the right information at each moment. The context of the learner profile, preferences and learning environment should be extracted for adaptation, personalization and anticipation of learning material that is suitable for learner.

The traditional e-learning systems provide adaption based only on user preference, to improve performance, it is required to incorporate learning environment context information such as the device or network context to determine the appropriate presentation method and the context of the learner profile such as organization and role to determine the learner type or standard along with the learner preferences.

Here, we discuss about the three different sources for acquiring contextual information of e-learner and ontology-based context model to provide context aware adaptive delivery of learning material along with the architecture of context-aware adaptive e-learning system.

The remainder of this paper is organized as follows. In the second section we study the background concepts related to this paper. In section three, the sources for acquiring contextual information in e-learning environment is described. In section four, we proposed the ontology for modeling contextual knowledge of the learning environment to use them during the context aware adaption process. In section five, the architecture of context-aware adaptive e-learning system is proposed.

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## 2 RELATED WORK

Our literature 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 [2] 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 [3] 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).

Bomsdorf [4] developed a system prototype which enables to select material depending on a given situation- this takes into account learner profiles such as their location, time available for learning, concentration level and frequency of disruptions.

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 ACQUISITION IN E-LEARNING

Context is referred to as any information that can be used to characterize the situation of an entity where an entity can be a person, place and a physical or computational object [6]. In e-learning environment the context is basically concerned about learner and learning environment.

Before modeling the user context model, the most important point in context-aware applications is the acquisition of context information. There is no single way of determining a

user's context in e-learning. Our proposed system draws upon three fundamental sources of contextual information- learner profile, user interface and context detection service.

- Learner profile: Personal details of learner such as identity, organization and role require the learners to fill in before they participate in the e-learning.

- User interface: Once the basic material provided to the learner based on personal profile and device context, the user interface provides environment to obtain the personal preferences of the user based on which the system will deliver the preferred material.

- Context detection service: The device context detection service provides the details about the device being used by user for e-learning.

The contextual information obtained from different context sources are then integrated into a single context abstraction as shown in Figure 1.
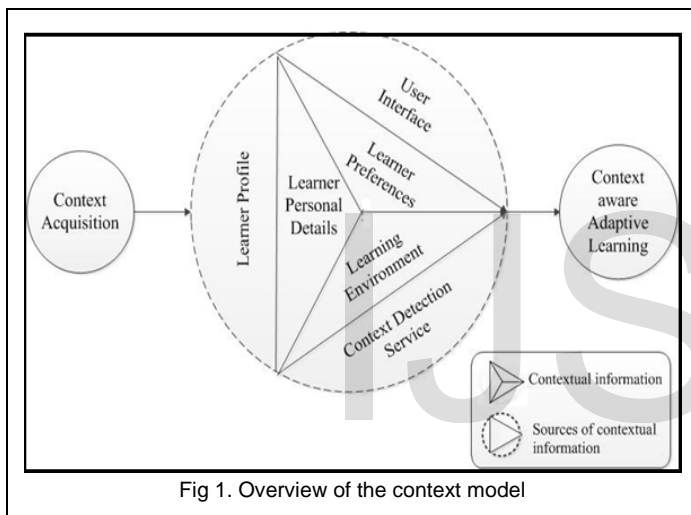


Fig 1. Overview of the context model

## 4  ONTOLOGY-BASED CONTEXT MODEL

According to Semantic Web led by W3C (World Wide Web Consortium), ontology is a way to describe knowledge systematically; a typical and explicit specification about concepts and conceptualization, that is, it also defines concepts and relations required to describe meaning and information [7], [8].

In the context of the knowledge management, ontology is referred as the shared understanding of some domains, which is often conceived as a set of entities, relations, functions, axioms and instances [9].

Ontologies are one of the most functional means for representing contextual data. They map three basic concepts in a context model (classes, relationships and attributes) to the existing things in a domain [10]. The formalism of choice in ontology-based models of context information is typically Web Ontology Language (OWL) [11] or some of its variations,

Our approach heavily relies on semantic modeling of the learner's environment. For this purpose, we make use of ontology for modeling contextual knowledge of the learning environment to use them during the context aware adaption process.

## 4.1 Proposed Ontology Context Model

Unlike most of the previous related works, we prefer to create learner ontology for context-aware adaptive e-learning environment. This ontology has mainly categorized in to three classes which refers to all subclasses and instances. The three classes cover all contextual knowledge from learner's personal profile, learner preferences and learning environment. The high level of ontology in which three main classes is derived from the base class "learner". The brief description a

Learner class: The "learner class" is the base class for all the contexts in context aware learning environment. Any instance of the learner class represents a conceptual context. Different contexts can be indexed hierarchically based on class hierarchy, such as Personal, Preferences and Environment as shown in Figure.2.

Personal class: The "Personal Class" contains the personal information of learner; the contextual information collected from leaner's personal profile is included as sub classes in this class. It is to check the background details of learner due to current request of topic.

Preferences class: It includes all prerequisites and preferences of learning topic that is entered as learner request, to check the learning style of learner. User interface plays an important role in this system for learner to selects the learning activity and to enter his preferences, then the system runs the predefined semantic query on the ontology and returns the desired learning material.

Environment class: The learner's learning environment details is represented in "Environment class": the information about time, location and the learner device details such as type of device its software and network connectivity.

The ontology context model, for context aware learning environment made by OWL because OWL has been developed most recently is an ontology language which defines classes and properties and also their relationships more clearly. The proposed ontology context model consists of one base class ("Learner") three top-level classes ("Personal, Preferences and Environment") and their sub classes, the properties describe the relations between individuals in top level class and its sub classes.

OWL defines the vocabulary of context model. It provides a mechanism to define adaptive -specific properties and classes of context to which those properties can be applied, using a set of basic modeling primitives (class, subclass, properties, domain, range, type). The context model can be specified using OWL encoding, "Figure 3(a, b)" shows that each statement is essentially a relation between an object (a class), an attribute (a property), and a value (a resource or free text).  "Figure 3(c)" shows an example OWL coding part for small part of our proposed ontology.
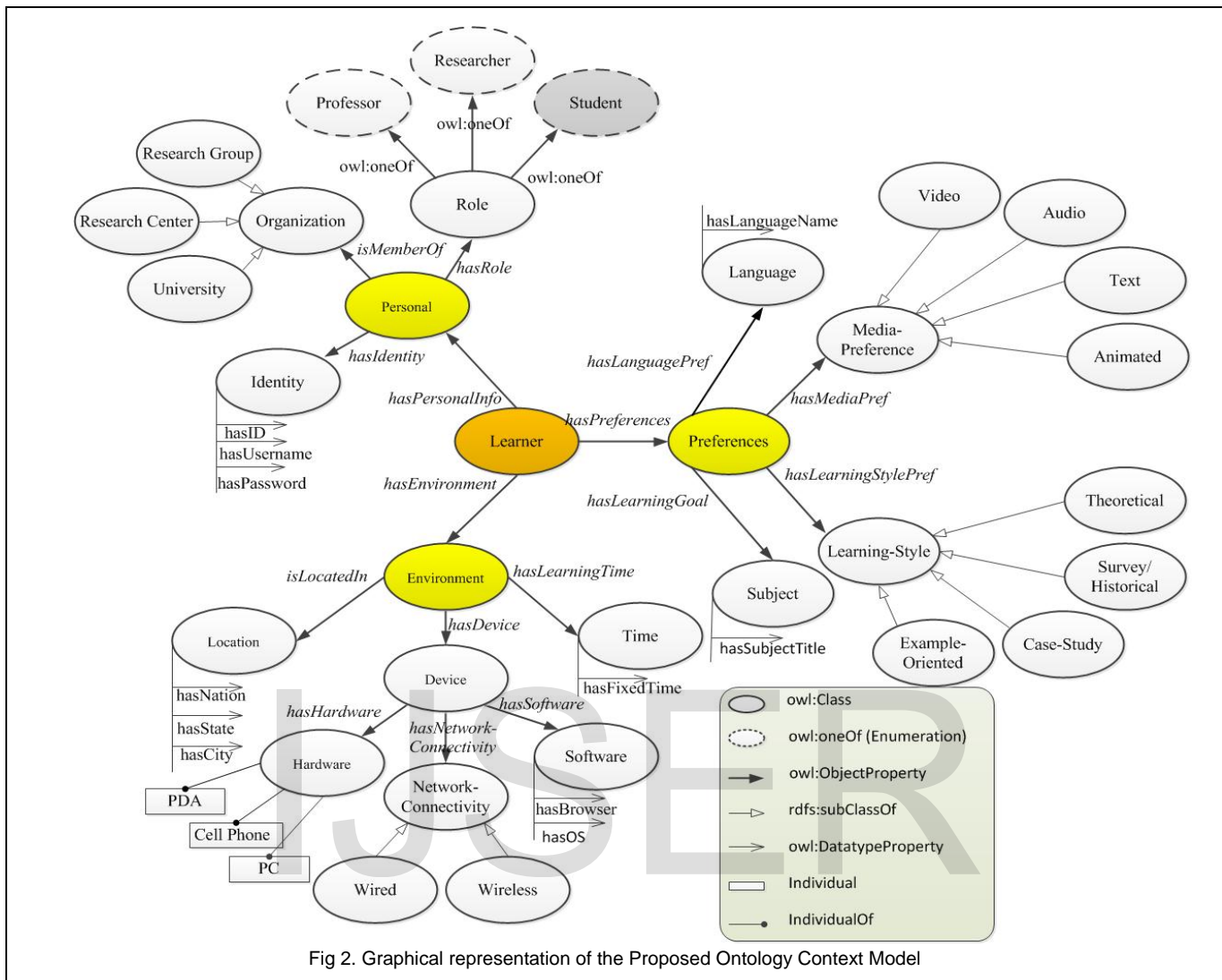
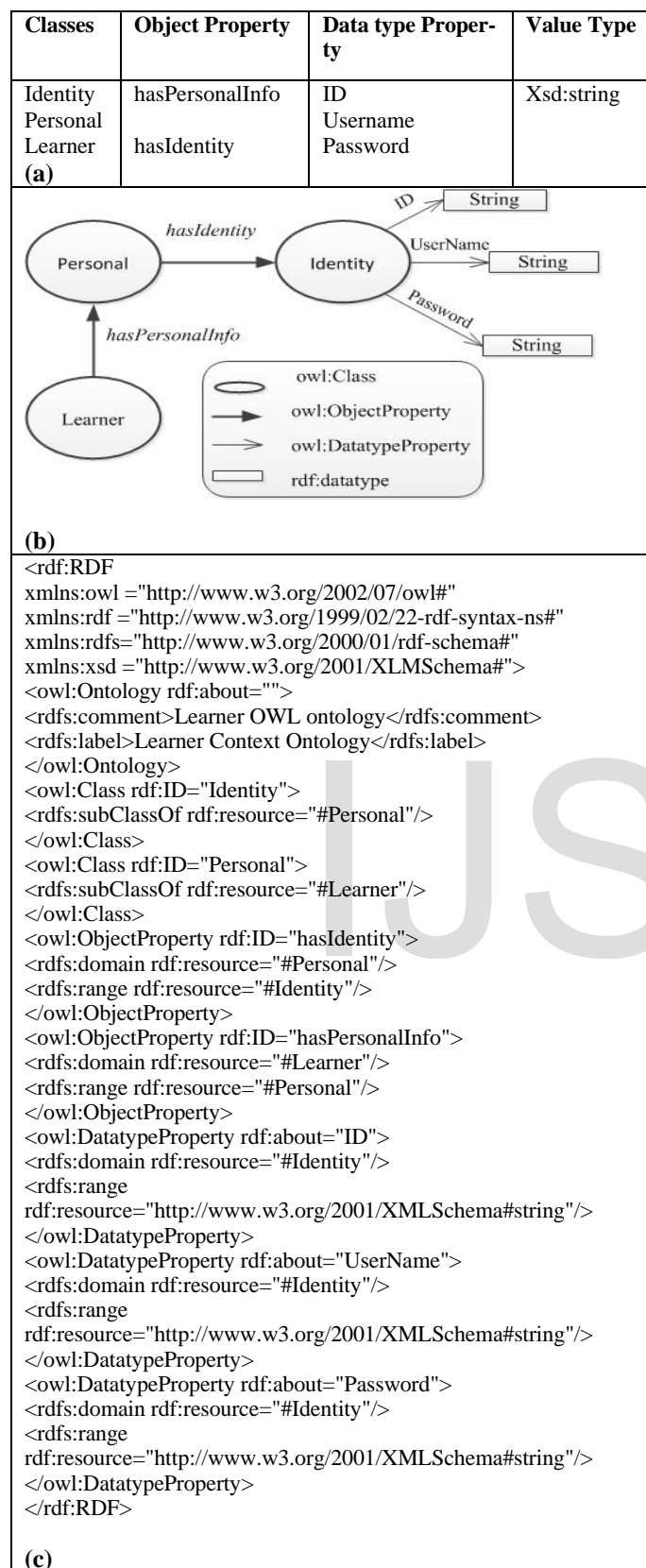Fig 2. Graphical representation of the Proposed Ontology Context Model

## 5 ARCHITECTURE OVERVIEW

The majority of current web-based learning systems are closed learning environments, where courses and materials are fixed and the only dynamic aspect is the organization of the material that can be adapted to allow a relatively individualized learning environment [12]. The motivation for using context awareness for our system is as follows.

- Shih [13] noted that the Conventional keyword-based content retrieval schemes do not take context information into consideration, and therefore they cannot fulfill the basic requirements of e-learning to provide users with adaptive results.
- Through retrieving learner's contextual information we can deliver appropriate learning material to the user based on his role, preferences and learning environment.

Here we are aiming to construct a system which will have some of the typical functions as shown below:

- In first moment the retrieved result depends only on the query, context information from learner profile such as role and learning-area etc and learning environment regardless of user's preferences.
- Based on primary results the user enters his preferences like media-preferences, learning style, specific concept etc.
- User preferences enable the system to suggest appropriate learning material to the user, taking into account the aggregated view of all information supplied by different context sources.
- As the user changes his preferences in user interface, the delivery of learning material gets changed dynamically.

| Classes | Object Property | Data type Property | Value Type |
|---|---|---|---|
| Identity Personal Learner **(a)** | hasPersonalInfo<br><br>hasIdentity | ID<br>Username<br>Password | Xsd:string |



**(b)**

```
<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:comment>Learner OWL ontology</rdfs:comment>
<rdfs:label>Learner Context Ontology</rdfs:label>
</owl:Ontology>
<owl:Class rdf:ID="Identity">
<rdfs:subClassOf rdf:resource="#Personal"/>
</owl:Class>
<owl:Class rdf:ID="Personal">
<rdfs:subClassOf rdf:resource="#Learner"/>
</owl:Class>
<owl:ObjectProperty rdf:ID="hasIdentity">
<rdfs:domain rdf:resource="#Personal"/>
<rdfs:range rdf:resource="#Identity"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="hasPersonalInfo">
<rdfs:domain rdf:resource="#Learner"/>
<rdfs:range rdf:resource="#Personal"/>
</owl:ObjectProperty>
<owl:DatatypeProperty rdf:about="ID">
<rdfs:domain rdf:resource="#Identity"/>
<rdfs:range
rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:about="UserName">
<rdfs:domain rdf:resource="#Identity"/>
<rdfs:range
rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:about="Password">
<rdfs:domain rdf:resource="#Identity"/>
<rdfs:range
rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
</owl:DatatypeProperty>
</rdf:RDF>
```

**(c)**

Fig 3. (a) Few specifications of model, (b) The equivalent directed semantic graph, and (c) An example of OWL code.

Figure 4 shows the pedagogical architecture of our pro-posed system, which is divided mainly into three parts (1) Context knowledge base, (2) Learner context description module and (3) Context adaptation rules.

Context knowledge base: It preserves context information for each learner, obtained from various sources, such as learn-er profile, user interface and context detection layer. The learner profile gives the learner's personal information such as identity, organization and role. Preferences like subject-area, language, presentation-media and learning-style are entered by the learner through user-interface. Context detection layer gives the information about learning environment, such as location, time and type of device being used by learner.

Context description module: Context information obtained from knowledge base is represented in the form of proposed ontology context model written in OWL. OWL defines the vocabulary of context model. It provides a mechanism to de-fine adaptive-specific properties and classes of context to which those properties can be applied, using a set of basic modeling primitives (class, subclass, properties, domain, range, type).

Rules for context adaptation: The ontology based context adaptation rules will be used to select appropriate learning material for the learners, according to their personal details, preferences and learning environment. An alternative ap-proach to using learning styles is to use learning strategies [14]. The adaptation rules reasons out the context and inter-preting context information.

Here, we classify context basically into two categories as learner context and learning environment context. The learner context can be once again classified into static and dynamic. Learning environment context information is acquired through context detection layer. The contextual details from learner profile can be considered as static because for any par-ticular learner the personal details such as location, identifica-tion, organization etc., does not change during learning process. The user interface receives learners' queries and pre-ferences during learning process. Learner gives his preferences based on primary material that delivered to him by consider-ing profile data such as qualification, course of study etc., Here the preferences can be considered as dynamic contextual information because, based on preferences the system have to update the delivery of learning material dynamically during learning process.

## 6 CONCLUSIONS AND FUTURE WORK

In this paper, we have described our proposed ontology-based context model and about the appropriate architecture over-view of e-learning system for context-aware and adaptive de-livery of learning material.
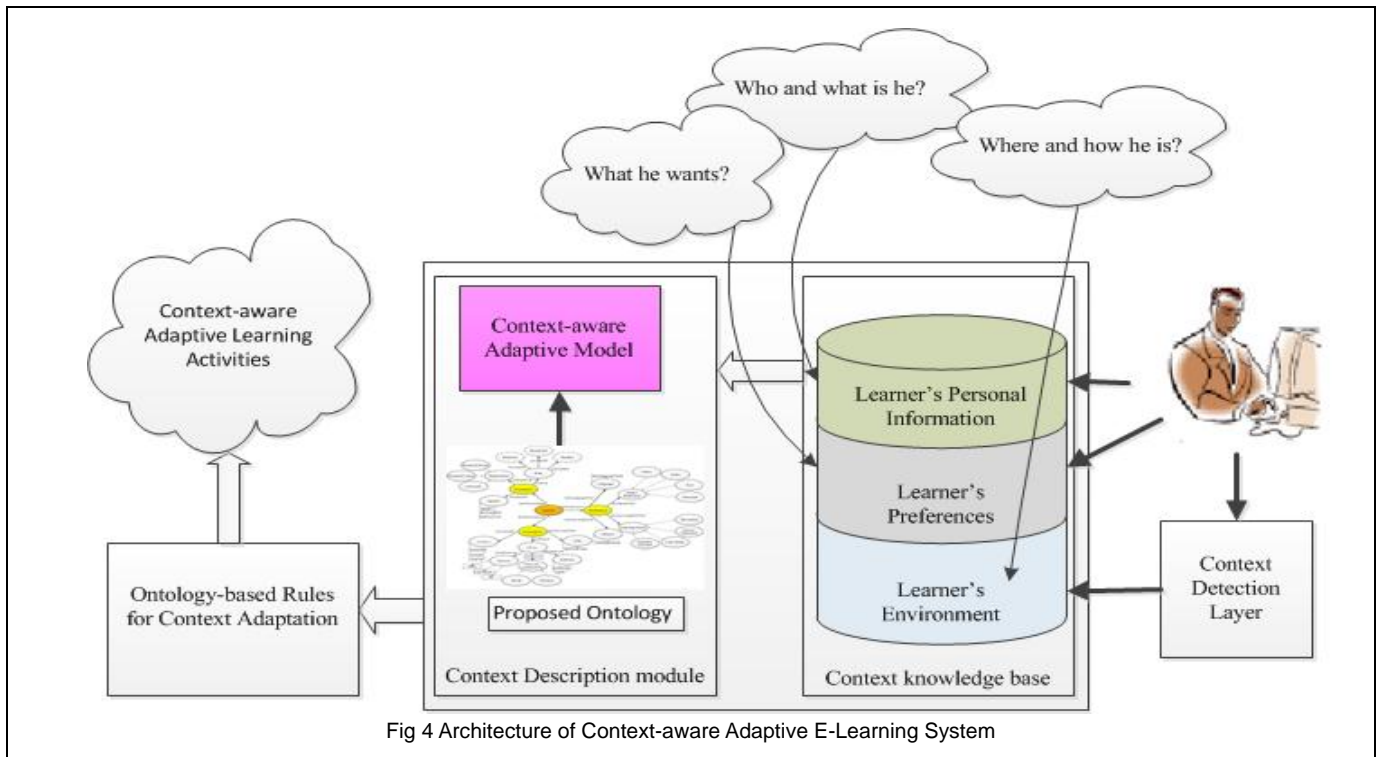
Fig 4 Architecture of Context-aware Adaptive E-Learning System

As identified in the system architecture, the most crucial point is how the system manages the acquired information about the user's context. Here methods have to be developed that cope with the dynamics of this information. In the near future, we plan to extend this work to investigate how the system manages context information and how ontology based context adaptation rules can be derived.

We believe that the primary advantages of our otology-based context model, contains a hierarchical content relationships between concepts. It can provide related and useful context based information for searching learning material in e-learning environment.

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