CHAPTER 1

INTRODUCTION

**Objective:** This chapter introduces the problem consciousness of research, the basic components of ontology based context-aware adaptive e-learning system, and some backgrounds necessary to understand the rest of the thesis. The chapter is concluded with overall organization of this thesis.

1.1 Initial Situation and Motivation

The explosion of huge learning material, advances in mobile communication technologies and personalized web-based applications in an educational domain help learners achieve more effective learning while bringing enormous opportunities and challenges to the research community.

Ontologies have proven their success in many application domains like bio-informatics and e-commerce. Educational systems are gradually incorporating semantic web technologies aiming to provide a more adaptable, personalized and intelligent learning environment (Bittencourt et al., 2008). The recent research trend is that the ontologies are being used in educational domain for semantic based management of learning material and their use can be extended to take adaptive decisions. The ontology based representation of learning material metadata will make learning repositories allow advanced search options through capturing characteristics of the learning resources and allow learning management system to record detailed information about the domain.
The ontological orientation to represent learner context model will be able to capture all the details related to the learning device and the activity of e-learner so as to obtain context aware adaptive delivery of learning material.

Current standards for educational metadata focus on content-centered and keyword based search approaches. The conceptual or semantic based search is one that is based on meaning rather than the keyword based search approach. The semantic based search needs domain knowledge of the subject that is to be captured using ontology of the domain, which helps to obtain precise and more exact answers on the semantic basis, i.e., to compare concepts rather than words. The adoption of new extensions to the existing standards is proposed in this research to obtain more effective semantic based and educative support metadata information.

The introduction of ontology-based technology in the area of personalization is a promising research direction (Gauch et al., 2003). The domain ontology plays central role as a resource structuring the learning content and supporting flexible adaptive strategies for navigation through it (Angelova et al., 2004). The adaptive modeling of the context or situation of the learner is needed, to better understand the learner’s activities and to adapt the content to his/her (as per the) requirements. This leads to the design of context-aware adaptive system that delivers more suitable learning content to satisfy learner requirements.

The ontological approach for an enhanced representation of the relevant knowledge about the user context and domain contents will enable improvements in the retrieval process and the performance of adaptive capabilities (Cantador et al., 2008). The objective of this work is to provide an
ontological approach for effective context-aware personalized delivery of learning material. This needs semantic description of learning material with educative-support information and context aware ontology-based learner model so that user context can be matched to content meaning to obtain adaptive functionality.

Most of the current e-learning applications and their learning contents are not suitable for mobile devices due to computational and technical barriers that can impede access to existing online learning resources. In this work, the researcher has discussed basic categories of context and diversity in device context, then addressed the device context and learner context detection approaches so as to deliver suitable content based on contextual information. The need for content adaptation to the features of end-device needs the access to information from mobile devices. Context-aware systems, therefore, should respond to context changes. The further details of context detection and description mechanism are available in section 5.5.

1.2 Research Focus

The e-learning repositories contain materials that are authored by different people for various purposes. These learning repositories have semantic and structural heterogeneity and various interoperability issues that must be solved in open environments. The ontological framework presented here is to strengthen metadata of learning resources and to make e-learning domain to cope with semantic based search. The learning materials are accessed by learners that differ in a wide range of characteristics, requirements and activity. The proposed learner-ontology facilitates the context aware and semantic based searching of learning contents based on the learner preferences and interests under the context of particular domain.
The adaptive functionality in the proposed e-learning approach encompasses the combination of the static details of the learner that are taken from learner profile and learner contextual information that is obtained dynamically through monitoring learning device characteristics. Based on this information the system has to update the delivery of learning material dynamically during learning process. The ontology based context adaptation rules are used to select appropriate learning material for the learner, through investigating the learner profile and learning context. The adaptation rules reason out the context through interpreting context information for searching learning material in e-learning environment.

1.2.1 Objective

Shih and Tseng (2009) noted that the conventional keyword-based content retrieval schemes do not take context information into consideration, so they cannot fulfill the basic requirements of e-learning system to provide users with adaptive results. Therefore, the researcher proposes a learner model with learner’s contextual information, which can helps in delivering appropriate learning material to the user based on his preferences and learning environment.

The success of any e-learning system depends on the organization of learning content with respect to a domain knowledge structure, and the facility to retrieve relevant learning materials (Roy et al., 2008). To facilitate the knowledge based retrieval of learning content, the thesis focuses on the study of existing metadata standards, issues in existing standards, possible approaches to strengthen metadata and the need of ontological approach to manage learning contents.
This dissertation targets to propose adaption framework, to meet the following objectives:

Content Model:
Describing some of the features to be considered in developing resource description ontology and then proposing an ontology called Context-aware Adaptive Learning Resource Ontology (CALRO) which is particularly useful for context-aware adaptive e-learning situation.

Context Model:
The ontology based learner context model for performing adaptive delivery of learning contents based on learner context information such as learning environment, personal characteristics and educational objectives of e-learner.

Adaptation Mechanism:
The rule-based adaptation logic proposed in this research reason out the context, which is derived from context model (device feature, learner’s preferences.), is used to selects suitable content based on resource description metadata. This module is an independent unit that interacts with context model and content model.

Prototype:
Finally, the researcher proposes the design paradigm and prototype implementation of context aware adaptive e-learning system.
1.2.2 Hypotheses

The central assertion of this thesis is that:

A learning content adaptation environment needs to provide an accessible relationship between the learner and the learning resources as per the context of learning environment. Through modeling learner context and context aware description of resources makes content delivery as per the accessibility constraints of e-learner.

The aim of this work is to respond to the challenges for context aware adaptive learning, by proposing an ontological model for resource description with the characteristics that match an adaptive environment and suggesting an integrated learner context model with learner’s learning style and device features.

This study provides a synergy with the current shift in the approaches and mechanism to addressing adaptability, content management and context modeling that together help in delivering appropriate learning content through matching the learner’s needs with the learning resource’s properties.

1.3 Elements of the Research

The proposed approach heavily relies on semantic modeling of the learner’s environment. For this purpose, the researcher has used ontology for modeling contextual knowledge in the learning environment, which helps to obtain context aware adaptation process. Some of the important components of the system that are required to implement the proposed ontology-based context aware adaptive e-learning system are as shown in Figure 1.1.
E-Learning:

E-Learning is a cross discipline artifact that spans domains like psychology, pedagogy, anthropology, artificial intelligence, and human computer interaction (HCI) (Issroff & Scanalon, 2002). One of the major challenges in e-learning development is search and discovery of appropriate learning resources from the distributed content repositories according to the needs and interests of the learner. For this, the educational resources must be managed with standardized, semantic-based educational metadata. The recent development of
semantic web technologies such as XML, RDF and ontologies has enabled the possibility for semantic-based e-learning services in the near future.

Adaptation:

Recent years have witnessed an increasing interest in the benefits of personalization in the e-learning domain and most of the current e-learning platforms are still delivering the same educational resources in the same way to learners with different profiles (Khribi et al., 2008). In e-learning domain, adaptation is the mechanism that is used to select appropriate learning materials based on the learning environment, personal characteristics and educational objectives of e-learner.

Context:

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 (Schilit et al., 1994). Chen and David (2000) have mentioned the definition of context as “the set of environmental states and settings that either determines an application’s behavior or in which an application event occurs and is interesting to the user”.

However, the context is a multifaceted concept that has been studied in multiple disciplines; each discipline tends to take its own idiosyncratic view that is somewhat different from other disciplines and is more specific than the standard generic dictionary definition of context as “the conditions and circumstances that are relevant to an event, fact, etc.". In e-learning environment the context is basically concerned about learner and learning environment (Device).

1 http://www.thefreedictionary.com/context
Ontologies have moved beyond the domains of philosophy, bioinformatics and knowledge representation. Ontology attracts attentions across many fields in computer science recently, since ontology is considered the key enabler of Semantic Web. In the field of computer science, Geroimenko (2004) has given the definition of ontology as “An explicit representation of the MEANING of terms in a VOCABULARY and their inter relationships. In an ontology definition language (such as OWL or RDF), an ontology is the collection of STATEMENTS or other semantic definitions for a DOMAIN”. In e-learning environment the ontology is useful to formalize the notion of learning context and learning resources information and the semantic supportiveness of ontology helps to access learning resources based on their semantics. Here, we are using ontological approach for developing Context aware Adaptive Learning Resource Ontology (CALRO) for description of learning resources and for Ontology based context modeling. The various components of ontology is as below:

Terms: Terms denote important concepts (classes of objects) of the domain such as Individual, instances or objects. e.g. professors, staff, students, courses, departments.

Relationships: Relationships between these terms: the ways in which classes and individuals can be related to one another typically class hierarchies. a class C to be a subclass of another class C' if every object in C is also included in C'. e.g. all professors are staff members.

Properties: Properties, features, characteristics, or parameters that objects (and classes) can have. e.g. X teaches Y.
Restrictions: Value restrictions are formally stated descriptions of what must be true in order for some assertion to be accepted as input. e.g. only faculty members can teach courses.

Adaptive e-learning:

An adaptive e-learning is the form of delivering learning contents as per the needs, preferences and learning environment of the learner. Papanikolaou et al., (2002) stated that “An adaptive learning system can provide suitable contents for different learners according to their backgrounds, prior knowledge, individual demands and learning status”.

Jones and Jo (2004) has stated that “Students have the freedom to learn within a learning environment which offers adaptability to their individual needs and learning styles, as well as the flexibility of pervasive and unobtrusive computer systems”. As the traditional ways of e-learning cannot meet the needs of individual learners, the learner context such as preferences, pedagogical needs and learning environment information has to be considered for adaptive and personalized delivery of learning resources.

Ontology based adaptation:

Here, the term learner model is used to refer the special case of user models, tailored for the learning domain. The context based learner-model for personalized learning environment has explicit representation of semantics using ontology. The context information obtained from context detection approach is represented by ontology in the form of Web Ontology Language (OWL) to enable expressive context description and data interoperability with third-party services and applications. 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.

Context ontology:

A context model is 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. The ontology-based context model contains hierarchical content relationships between concepts. It can provide related and useful context-based information for searching learning material in e-learning environment.

Context in e-learning:

The rapid growth of internet technology and the explosion of learning material in educational domain are leading to the next generation e-learning applications that exploit user contextual information to provide a richer experience. The context aware e-learning application is to define a model to represent and manage context information. In an adaptive learning system the context related knowledge allows the system to deliver learning material by adapting learner context.

1.4 Problem Consciousness of Research

E-learning systems are expected to provide the suitable learning materials for learners, through allowing semantic based search option to learner and considering learner requirements and learning environment. However, it is understood that they cannot meet the expectations of users due to:
Content Description (Server side):

The explosion of huge learning material in educational domain, multidimensional similarity of learning material and lack of semantic based organization of e-learning material are the issues which needs to manage learning resources with domain specific, educative and pedagogical needs of e-learner.

Context Description (Client side):

In e-learning environment every learner has a distinct background, learning style, specific goal and learning environment (device), therefore it is required to deliver learning contents based on different characteristics and contextual information of e-learner.

Technologies have been enhancing education all the time and new technologies were always first utilized by education domain (Guangzuo et al., 2004). Adaptation to the context of the users’ current learning environment and preferences is a relatively new research direction, which is also expanded into the area of mobile adaptive systems. This issue can be solved through detecting constraints of learning device and characteristics of the learner and delivering suitable learning content.

This dissertation targets to point out the main issues and propose content description and adaption mechanism to tailor search results to a particular user based on user’s requirements and contextual information. An overview research model of the dissertation is shown in Figure 1.2.
1.5 Structure of the Thesis

In this section we summarize the overall organization of this thesis. The structure of this work falls roughly into four phases and organized in nine chapters as shown in Figure 1.3. A brief summary of the contents of each of these nine chapters is as follows:

1. Introduction
   This chapter presents the context of the project. It contains the brief introduction about ontology and context-aware adaptive e-learning system along with its basic elements of the research.

2. Related Research Literature Review
   This chapter investigates the various aspects of the ontology based context aware adaptation e-learning environment. It provides the brief survey of the
related work in the areas of research projects, learning environments and frameworks.

3. **Metadata and Ontology in E-Learning Environment**
   This chapter presents an overview on current metadata standards in e-learning domain and attempts to identify the drawbacks with existing metadata standards to capture the rich semantic structure and contextual description of learning material. Here, the purpose of ontological approach in learning infrastructure and ontology based content management and learner context modeling is illustrated.

4. **Context and Adaptive E-Learning**
   Various ways of categorization and acquisition of contextual information, contextual diversity and interdependence of context elements in e-learning environment are described along with an overview of context-aware adaptation.

5. **Context Detection and Description Mechanism**
   A discussion of different context elements and its basic categories of context aware e-learning domain and the contextual information acquisition and description approaches are presented.

6. **Adaptation Oriented “Resource” Modeling**
   Investigation into various required features that are to be considered while developing resource description ontology and the resource description ontology called CALRO are presented. Finally its usage scenario and the working behavior of context aware delivery process are discussed.
7. **Context-aware Content Adaptation**

Various approaches, techniques, strategies and issues related to adaptation mechanism are discussed and formal description of learner context ontology and context aware adaptation mechanism is presented.

8. **Prototype Architecture and Implementation**

Objectives of proposed approach are discussed and a novel architectural model of context aware adaptive e-learning system based on MVC design pattern is presented. Here, usability analysis and experimental results on evaluation of usefulness of the proposed system are reported.

9. **Conclusions and Future Work**

This chapter concludes the thesis by summarizing the solutions for the identified problems and current issues of the existing approaches besides offering suggestions for further research.
Figure 1.3 Thesis structure