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Adaptive Learning: A Survey

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Abstract: Adaptive learning is a much needed requirement to improve the efficiency of recommending an e- learning content. Adaptive learning supports learning content specific to a student's learning behaviour. Hence, it is very important part of adaptive learning to learn and track the student's learning path and decide the appropriate learning content which can be recommended to an individual. In This paper a survey has been done to propose mechanisms to implement the adaptive learning efficiently in e-learning.

Keywords: e-learning, learning behaviour, learning path, ontology.

I. INTRODUCTION

The strength of web technologies to reach as many users as possible has directed to an increasing recognition on e-learning activities. Each user accesses similar learning content associated with particular course while browsing through different websites; however it doesn't provide the learning content as per user's interest, his learning behaviour and his understanding level and abilities.
If above facts about e-learning are considered then a static learning content is not a good option to every user as each user will have different needs about a particular subject he wants to study. Adaptive learning is a critical requirement for e-learning systems which dynamically adapts learning content to learner's educational needs for promoting learning results. It is a branch of e-learning which provides a learner with personalized learning by creating user profile specific to each user, it increases the efficiency to predict and recommend a learning content personalized to a user profile. Now a day's adaptive learning has got attention of most of the researcher's. Ontologies are used to promote adaptive e-learning which allows creating specific user profiles and content models.

Ontologies are the most suitable means for representing knowledge due to their flexibility and extensibility in designing concepts and their Relationship. It is made of concepts, properties of concepts and instances. Some of the ontology languages are RDF, OWL, SPARQL and SKOS. The paper presents a detail survey of various e-learning systems in which adaptive learning has been used with different techniques, algorithm and advantages and limitation of each

II. MECHANISMS TO ADAPTIVE LEARNING

A. Smart Shortest Path Algorithm for Course Units.

In [2] authors proposed the Shortest Path Algorithm to implement Adaptive Learning. The graph is a significant, considerable, and efficient representation of online courses in the computer Based implementation of an educational system. E-learning and M-learning systems are modeled as weighted directed graphs where each node represents a course unit. The learning Path Graph represents and describes the structure of domain knowledge as well as the learning goals and all available learning paths. In [2] authors proposed an optimal adaptive learning path algorithm using learner information from the learner's profile to improve E-learning and M- learning system in order to provide suitable course content sequence in a dynamic form for each learner in order to meet different learner needs.

1. Learning Path Graph: The learning Path Graph represents and describes the structure of domain knowledge as well as the learning goals and all available learning paths. In order to create and generate the Domain model, a two-step procedure is used:
Step 1: Designing the Learning Goals and Concepts Hierarchies of the domain model.
Step 2: A personalized learning path is selected from the graph that contains all the available learning paths, based on the learner's attributes in the user model.

2. User profile
An optimal adaptive learning path algorithm that uses the learner information form of the learner profile to improve the E-learning and M-learning systems in order to provide suitable course content

3. Using graphs to represents course units
E-learning and M learning systems are modelled as a weighted directed graph where each node represents a course unit. The course content is divided into portions called learning atoms that could be implemented at all levels of learning modes. Those nodes contain the course concepts after partitioning the graph. The course concepts could be: Slide, Text,

4. The adaptive shortest path consists of two stages
Stage 1**:** Determining the minimum cost matrix between each pair of course learning units.
Stage 2**:** Find and construct an optimal learning path for each learner. The shortest path is constructed in an adaptive environment for individual learners based on the minimum cost between each pair of course learning units and their relevant personal information.

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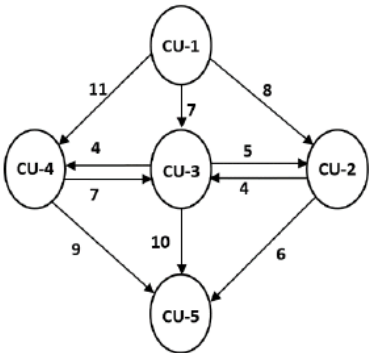

Figure1 Weighted graph represents the course units structure

B. Peer to Peer Technology.

In [1] authors propose a mechanism to predict the adaptive learning content for each student. Most development environment of the existing Learning Management Systems (LMSs) is based on client/server architecture. In such architecture, if there are a great number of students to accessing the LMS concurrently. Such a load is too heavy for the LMS server. To reduce the load on the LMS server, in [1] proposed that a LMS should be based on a P2P environment to improve the transfer speed of the learning content to the student clients. The proposed Prediction mechanism is based on k-nearest neighbour (k-NN) classification and the course content is predicted and suggested to learner

1. k-NN Classification

The reason for selecting the k-NN classification is:

- It does not need a large number samples
- It provides candidate types of learning content when the first prediction type is not suitable for the student

The main goals of the classification technique are

- Analyzing the classification rules and
- Predicting the class to which new data belongs.

According to the k-NN classification, data can be depicted as a point in n-dimensional space, called sample. In the n-dimensional space, similar data have a shorter distance between them. Similar data in the n-dimensional space belong to the same class. New data, which is called unclassified data, can be determined to belong to a class by computing the distance between itself and samples. The distance between xi and xj is defined as:

$$d(x_i, x_j) = \sqrt{\sum_{r=1}^{n} (a_r(x_i) - a_r(x_j))^2},$$

Suppose xi is an unclassified data and xj is a sample where every unclassified data contains n features that can be represented as <a1(xi),a2(xi),…,an(xi)>. ar(xi) represents the rth feature value in the unclassified data xi. Similarly, every sample also contains n features represented as <a1(xj),a2(xj),…,an(xj)>. The function of the k-NN classification is adopted as

$$f(x_i) \leftarrow c_i$$
$$\sum_{i=1}^{k} g(x_i, f(x_i)) = \max\{\sum_{i=1}^{k} g(x_i, f(x_i)) \mid c \in C = \{c_1, c_2, \ldots, c_m\},$$
$$if\ a = b, then\ g(a,b) = 1; if\ a \neq b, then\ g(a,b) = 0\},$$

Where g(a,b) is used to determine whether a and b belong to the same class. If the result is positive, g(a,b) equals one. Otherwise, g(a,b) equals zero.

2. The verification of the prediction mechanism is based on two databases:

- IRIS dataset for finding out the optimum value of k
- Real data in the learning behavioral features of 117 elementary school students

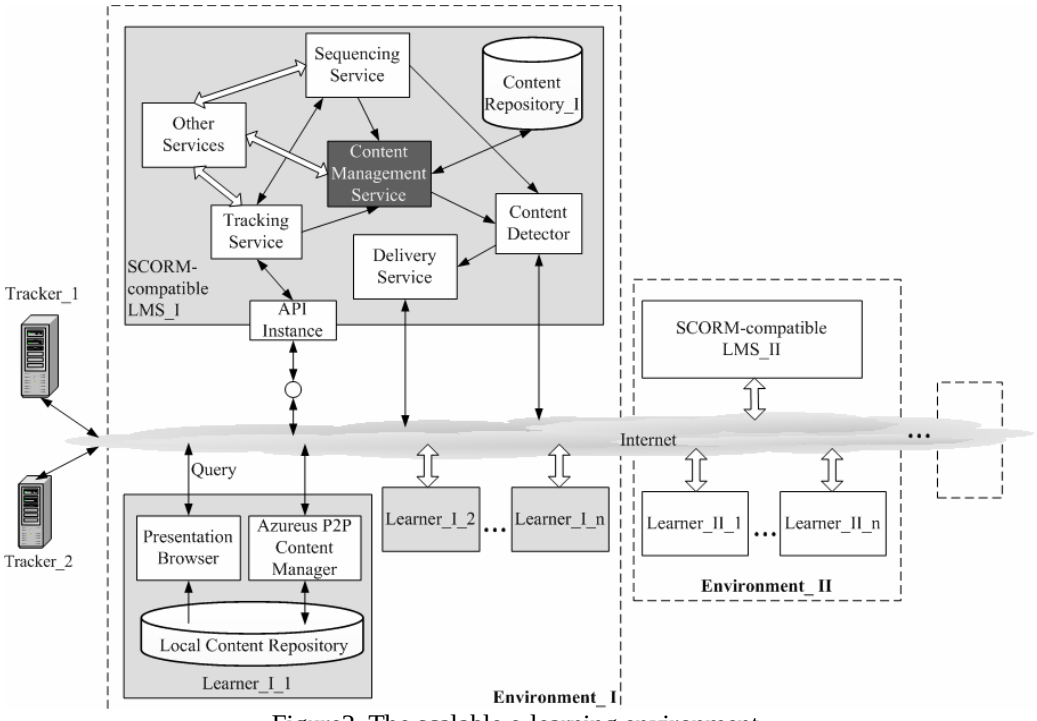

Figure2. The scalable e-learning environment

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C. Decision Support System (Semantic Model).

In [3] a personalized e-learning system has been proposed which must be able to tailor the educational experience to a particular learner. To achieve this goal, a semantic-based adaptive engine is proposed to analyze learners' responses and behavior to regular activities and tests. During the next level of learning, the system suggests suitable learning paths based on analyzed data in adaptive engine.

A Decision Support System (DSS) is a computer-based system capable to support decision-making activities. A DSS is an e-learning system which can analyses data in user profile and allow the learners to select optimized learning paths.

Authors have proposed a DSS adaptive engine which suggests adaptive learning path according to analyzed result Based on learner model data.

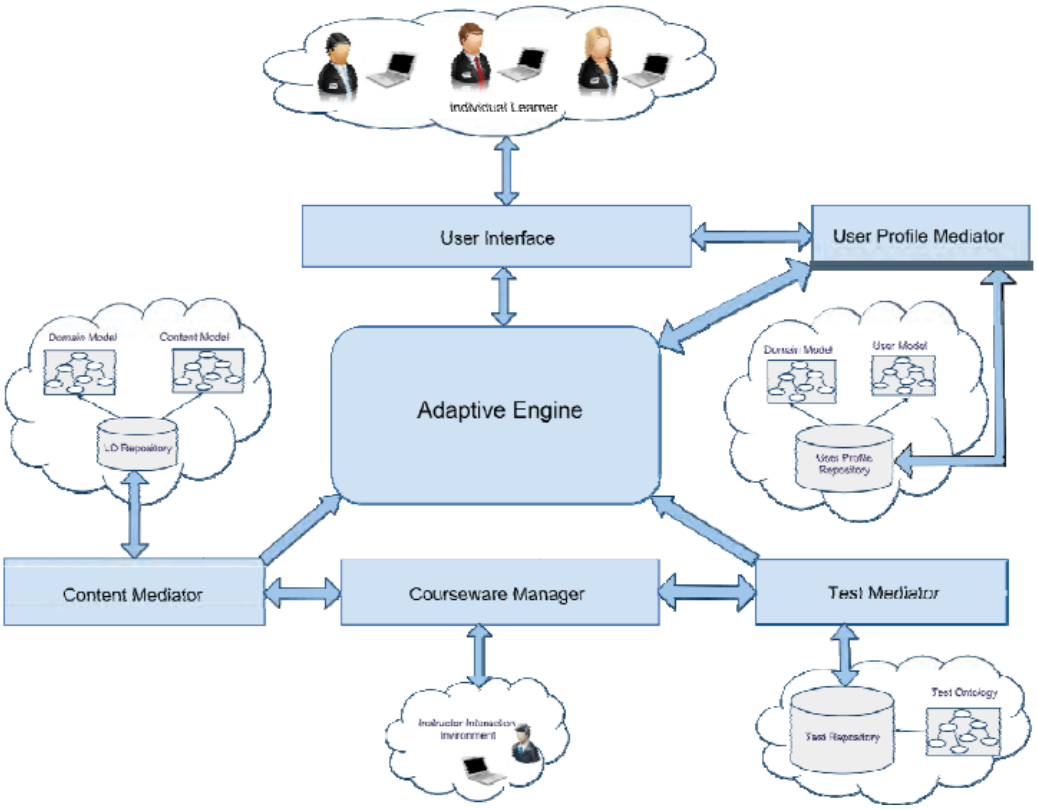

Figure 3. The Architecture of Adaptive E-learning with Decision Support System

SEMANTIC MODEL

In this model a comprehensive description about the architecture of ontology-based adaptive e-learning DSS and demonstration of the individual components needed to implement a proposed approach has been given. The proposed architecture is depicted in Fig. 3 the structure of the system consists of six components:

a) User Interface: The user interface deals with the learner's registration, login process and the learner studies with a recommended learning topic by adaptive engine. It also takes learner's responses from the test items and transfers them into the Adaptive Engine.
b) Courseware manager: The courseware manager allows the instructors to update the content and test repository through their related mediator.
c) Content Mediator, User Mediator and Test Mediator: The different mediators are responsible for handling requests for interacting with the repository to retrieve and update the information.
d) Adaptive Engine: The Adaptive Engine, at the heart of our architecture is responsible for suggesting adaptive learning paths according to learner's characteristics and the result of activities and tests in previous steps of learning process.

However, it consists of six components

a) Activity Unit
b) Test Unit
c) Learning Result Analyzer
d) IRT Analyzer
e) Course Structure Constructor and Decision Support System.

The learning result analyzer analyses the activities and test results from the activity unit and test unit and transfers the Result to the DSS, then learner's response to test is analyzed by the IRT Analyzer to obtain the learner's ability. The Course Structure Constructor performs the process of constructing the annotate course structure by using link annotations and link hiding to offer adaptive navigational support techniques which helps the learner in navigate the domain space. The main part of Adaptive

Engine is the Decision Support System. It obtains knowledge about learners, content information and course structure through related mediators. Subsequently, it classifies this information; analyses previous learning activities, analyses test result to generate the best learning path (that is, learning content, activities and sequences) for the learner. The recommended learning path is presented to the learner via the User Interface.

The Decision Support System supports adaptively from two aspects:

a) Firstly, it provide different presentation and level of the learning content for learner's with different characteristics (e.g. learning styles, ability, preferences).
b) Secondly, it suggests adaptive learning paths (that is, Learning a new topic, repeat this topic with more details, read more examples, doing more activities with lower or higher difficulty levels, repeat of prerequisite topics) according to analyzed previous learning activities and analyzed test results.

Four Ontology based Knowledge models namely domain test, learner and content model are designed to recommend adaptive learning path

III. CONCLUSION AND FUTURE WORK

The personalization provided to an individual in e-learning systems by tracking his learning courses paths is the core feature of the E-learning applications. Therefore, it is very important to provide learners with an adaptive course content which adjusts to the personalized learning path during the learning process. The adaptive shortest path is a major step in constructing an adaptive M-learning system for several engineering disciplines. To enhance instructional efficiency, e-learning systems should understand the learning requirements of learners hence a novel ontology-based approach to design an e-learning Decision support system which recommends adaptive learning paths to particular learner. Adaptive engine analyses user profile data, based on the analyzed results, recommends an appropriate learning path to the learner. According to IRT, learner's responses to test items are analyzed to calculate learner's abilities. The system recognizes changes in the learner's levels of knowledge as they progress and the learner model are progressively updated based on learners' progress and abilities. The prediction mechanism is based on the k-NN classification. A large number of the samples and behavioral features negatively affect the computing efficiency. In future works, a study will be done how to enhance the computing efficiency of the prediction mechanism.

Each work has its own technique, contribution and limitations. As a survey paper, we might not include each and every aspect of individual works; however attempt has been made to deal with a detailed review of the various approaches proposed to implement Adaptive Learning.

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