Towards Learner Model Sharing Among Heterogeneous E-Learning Environments

R. Shyamala[1], R. Sunitha[2], Dr. G. Aghila[3]

Department of Computer Science, Pondicherry University
Pondicherry, India
shyam31oct87@gmail.com, manila@yahoo.com

***Abstract*— Web-based adaptive educational systems incorporate complex intelligent tutoring techniques, which enable the system to recognize an individual user and their needs, and consequently adapt the instructional sequence, learning content as well as the presentation of the learning content. The personalization of adaptive learning systems is done through the user model. There are many works related to user modelling and adaptation models, but they focus mainly on how to model the user and adapt the system accordingly, but doesn't lookup on sharing and reusing user data. So we propose a system which enables adaptation of the learning environment by sharing the learner information among heterogeneous learning environments.**

Keywords- Learner Model; Adaptive System; Heterogeneous Learning Environment

I. INTRODUCTION

Knowledge is becoming more and more valued and learning is a part of our everyday life. New demands and development of new technologies have also changed the traditional educational systems, which now better and use more efficient teaching and learning methods. E-learning environments [15] [16] are becoming popular in today's scenario because of their convenience and accessibility. A system which adapts itself to various circumstances or conditions is called an Adaptive System. Adaptive system for e-learning is called an Adaptive E-learning System [14], which focuses on personalization and adaptation of learning content. Adaptive Educational Hypermedia System (AEHS) [2] can be defined as the technology that allows personalizing for each individual user of a hypermedia application the content and presentation of the application according to user preferences. Modelling user in e- learning is largely in research; learner model is an essential component in adaptive e-learning systems. The adaptation of an e-learning system mainly involves choosing and presenting each successive teaching activity based on the learner's knowledge and other relevant features of the learner, which are in turn maintained in a learner model. Therefore, the learner model is used to modify the interaction between system and learner to suit the needs of individual learner. There are different e-learning environments from which knowledge can be pursued, this is usually know as heterogeneous learning environment, the heterogeneity may be the difference in: User interface, Platform, Data representation etc. When a learner wants to switch over from one environment to the other, the system requires the learner to set his learning preferences, learning goal, knowledge inferred, to proceed his training. Instead learner data can be shared between environments so that his model can be used, modified and updated in the other environment. Recent works in user modelling focuses mainly on how to model the user, but doesn't lookup on sharing and reusing user data in heterogeneous environments. We propose a system which collects the traces i.e. the activities performed by a learner in different environment, models it, transforms it to a normalized form and allows sharing and reusing of the learner model in heterogeneous learning environments. The remaining part of this paper is as follows Section 2 discusses about the user model. Section 3 describes about the related works in user modelling. Section 4 describes the proposed system. Section 5 concludes the paper.

II. USER MODEL

A User Model [19] is defined as a knowledge source in an intelligent system which contains assumptions on different aspects of the user that may be relevant to the system's adaptive behavior. A user model [1] is a set of information structures designed to represent one or more of the following elements: 1) goals, plans, preferences, tasks, and/or abilities 2) common characteristics of users pertaining to specific user subgroups or stereotypes; 3) the classification of a user in one or more of these subgroups or stereotypes. User modelling is the process, dealing with elicitation, representation and utilization of the user models. The User Models are used for several purposes they are

- Offer information adjusted to the user.
- Adapt the interface to the user.

- Give the user feedback about his knowledge.
- Support collaborative work.

A. Content of the Learner Model

A learner model contains information about the learner's domain knowledge, the learner's progress, preferences, goals, interests and other information about the learner, which is important for the adaptive systems. The content of the learner models [2] can be classified into two types according to the nature and form of information contained in the models.

- Domain dependent data
- Domain independent data

Domain dependent data: This information reflects the status and degree of knowledge and skills which learner achieved in certain subject.

Domain independent data: Domain independent data includes goals, interests, background and experience, learning styles, aptitudes and demographic information.

Goals – To establish the correct teaching strategy, it is important to know the learner's goals. These goals answer the questions why the learner uses the e-learning system and what the learner wants to achieve. Goal expresses learning purpose i.e. what the learner wants to achieve from a learning course. There are two types of goals: long-term and short-term. Long-term goal is relatively permanent in a course e.g. lifelong study. Short-term goal is called problem-solving goal, where a learner solves a particular problem e.g. passing an examination, doing exercise etc.

Background and Experience - Background includes skills, knowledge that leaner gained in the past. For example, if the learner experiences difficulties in previous courses then the system should deliver exercises accordingly to the learner. Experience represents knowledge about the learning environment. Learners who are new to a particular learning environment or even new to e-learning may need different system support regardless whether they are novices or experts in the subject domain. This information might be used to select the appropriate adaptive navigation method.

Learning styles - Learning styles were defined as the way learner prefers to study. Some users prefer Auditory, Pictures, and Text etc. Auditory- prefer to listen the content. Pictures - prefer learning material as pictures. Text-prefers learning material as text. Tactile Kinesthetic - prefer to interact with learning material such as: puzzles, games. Internal Kinesthetic - prefer to make connections to past learning experiences.

Demographic information is used to identify person. E.g. Name, Age, ID no, Date of birth etc. Some Adaptive systems need demographic information to be modeled E.g. In adaptive e-commerce systems demographic information plays an important role.

B. Learner Model Elicitation

There are two principle ways for an adaptive system to obtain leaner modeling information: to ask a user directly or to derive it based on user's activity with the system. The former is called Knowledge based Model and the latter is called Behavioral based model. The Knowledge-Based adaptation typically results for data collected through questionnaires. The Behavioral adaptation results from the monitorization of the user during his activity. For example a learner solving a problem needs to provide answers at the end, based on which the system can infer his knowledge of concepts. A user involved in a dialog with an adaptive help system may express his interest in a certain topic by asking about it. Some systems, however, rely only on their ability to mine knowledge about a user from the logs of the learner actions.

C. Learner Model Representation

There are many classic approaches to represent the acquired learner information: Overlay, Stereotypic, Perturbation model etc.

Overlay – The first definition of overlay user modeling is coined by Carr and Goldstein as "Overlay modeling is a technique for describing a student's problem solving skills in terms of a modular program designed to be an expert for the given domain. The model is an overlay on the expert program in that it consists of a set of hypothesis regarding the student's familiarity with the skills employed by the expert" [12]. Overlay is the oldest approach to user model representation. The overlay user model [14] describes the learner knowledge as a subset of the domain/ expert model. The main component of the overlay approach is the domain model which is the aggregate of concepts; a concept represents an atomic piece of domain knowledge, coherent and semantically complete, they can be topics, knowledge elements, learning outcomes etc. The learner knowledge relies on the domain model and consists of a set of concept-value pairs, where a value represents an assessment of modeled characteristic for this particular concept, this value could be binary (0 - doesn't know or 1 - knows), a categorical variable (low, medium, high). An overlay model is capable to dynamically and precisely reflect the evolution of

user's characteristics, which it is important for AEHS. The benefit of overlay user model is its precision and flexibility. A disadvantage of overlay model is the incapability of storing errors or mistakes made by the learner.

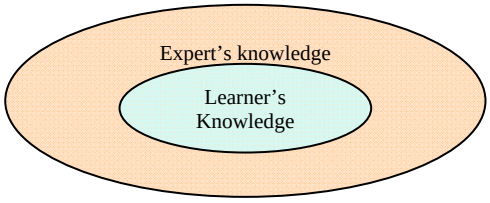

Figure 1. Overlay Student Model

Stereotypic approach - A stereotype [10] [13] is a collection of frequently occurring characteristics of users. Using stereotypes is a very common way of user modeling. There are two types of stereotyping: fixed and default. In fixed stereotyping learners are cast according to their performance into a predefined stereotype that is determined by an academic level. Default stereotyping is a much more flexible approach. At the beginning of a session the learners are stereotyped to default values, but as the learning process proceeds and learner performance data is obtained, the settings of the initial stereotype are gradually replaced by more individualized settings. A user can be described by one stereotype or a combination of several stereotypes. To implement a stereotype the system has to know stereotypes and its triggers. When a learner has to be assigned to a stereotype, it has to be activated on the occurrence of a particular event; stereotypes are activated by its corresponding triggers. A trigger is an object associated with a particular situation or event and it has the name of the stereotype to be activated. Stereotype-based user modeling is advantageous when there is a little evidence about a user from which the system should infer a great deal of modeling information.

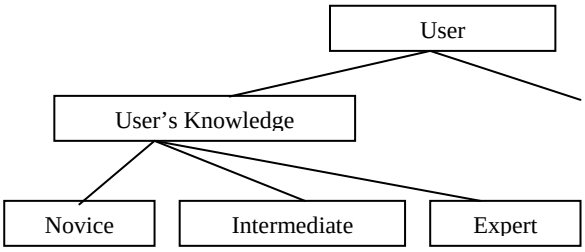

Figure 2. Example Stereotype Hierarchy

Perturbation or Buggy approach – The *perturbation* or *buggy* learner model [14] caters for knowledge possessed by the learner that is not present in the expert domain knowledge. This model overcomes the demerit of overlay approach. The overlay model presumes that learner's knowledge is the subset of expertise's knowledge. They are not interested in learner's errors caused misconceptions or lack of knowledge. These errors were considered as *mal-knowledge* or incorrect beliefs. With a buggy model, it is possible to define and reflect erroneous behaviors of learners and the reasons for these errors. The perturbation student model extends the experts knowledge with the addition of a bug library. The process to create a bug library can be enumerative or generative. The enumerative process lists all possible bugs usually via an analysis of the problem domain and the errors that students make. The generative approach attempts to generate bugs from an underlying cognitive theory.

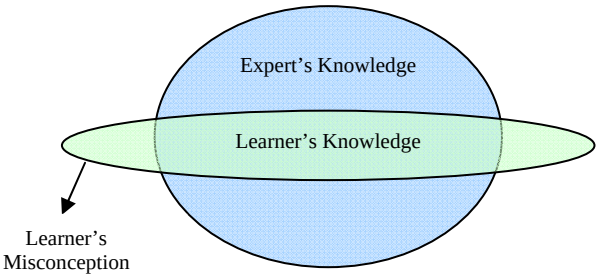

Figure 3. Representation of Perturbation Model

III. RELATED WORKS

The existing works related to e-learning and user modelling is discussed in this section. In literature there are many works related to user modelling [2]: there are classic approaches to represent the learner model: Stereotypic approach, Overlay approach, Machine learning approaches, Bayesian approach, Perturbation model etc. The Learner model can be application dependent or application independent. Application independent learner model is called Learner Modelling Systems. There exist many User modelling systems like General User Modeling System (GUMS), GRUNDY, PROTUM, User Modeling Tool (UMT) etc. Early approaches to user modelling are made in the field of dialog systems; GRUNDY [10] is an example of a dialog system which recommends novels according to its assumptions about user's characteristics. Then user modelling became popular in adaptive systems, then GUMS [9] is proposed by Finin and Drager, General User Modeling System allows abstracting user data from the application system. It is application independent. It allows defining simple stereotype hierarchies in form of a tree structure. GUMS accept and stores new facts about the user. Building a user model takes a lot of sophistication so the user modelling shell systems were introduced. User modeling shell systems provide integrated techniques, which are often used by user modeling components. There are many user modelling shell systems in the literature UMT and PROTUM are examples of user modelling shell systems. The User Modeling Tool (UMT) [17] allows the specification of stereotypes, which contains descriptions of characteristics of user groups in form of attribute-value pairs. It provides a rule interpreter that allows to define inferring rules for user models. The "PROlog based Tool for User Modeling" (PROTUM) [18] which is based on Prolog, combines the advantages of GUMS and UMT. PROTUM contains a dependency management and a truth-maintenance system similar to UMT. In [3] the authors have proposed a framework for collaborative e-learning which applies expert system technology; this framework infers learning process and then accordingly provides learning materials. In some cases user information may contain vague or uncertain information; a fuzzy user model is proposed in [4] to deal with these uncertainties in user data**.** The fuzzy user model uses fuzzy sets for knowledge representation and linguistic rules for model updating. In [5] User Modeling and Personalization Framework (UMP) have been proposed which enables applications to collect and organize their data. The data is collected on one central server and the applications can share data among each other. UMP builds ubiquitous user models based on the collected data. In [6] the authors have discussed about the different data mining techniques and machine learning techniques which have the ability to handle large amounts of data and to process uncertainty. These techniques are suitable for automatic generation of user models. In [7] a Scrutable User Modeling Infrastructure (SUMI) is proposed for life-long User Modeling, the ability to model dynamic and changing user throughout lifetime interactions. In [8] an ontology based user modelling system is proposed to provide specific services in e-commerce application. The ontology based user model is implemented using semantic web technology.

IV. PROPOSED WORK

Consider a scenario where the learner interacts with different environments like moodle (E1) claorline (E2). When the learner interacts with E1, he will perform some activities, invoke some events, set some preferences etc. These activities are traces in log files. Due to some reasons the learner couldn't continue his course in E1 so he switches to another learning environment. When the learner switches to E2 to continue his course, he needs to do all the activities that he had done in E1. This will be a tedious process for the learner. So it will be easier for the learner when his progress, preferences etc are updated in E2, so that he can directly continue his course. We propose a system which collects the traces i.e. the activities performed by a learner in different environment, models it, transforms it to a normalized form and allows sharing and reusing of the learner model in heterogeneous learning environments. Our proposed system consists of six components: The learning environments (Ei), Extractor, Modeler, User model (UMi), Mediator and Repository. These are discussed in detail:

Learning Environment (Ei): Learning Environment consists of the various learning environments that the user can access. The activities performed by the learner in these learning environments are traced with the help of log files.

Extractor: The user's activities/events are traced in log files, these files contains some irrelevant data which needs to be separated in order to build a user model. This process of extracting the relevant information about the learner from the log files is done by the extractor. The log files are stored in a repository. Extractor performs three processes: Monitoring, Retrieving and Filtering. A Monitoring component keeps track of the events. Whenever an event occurs the Stimulator is triggered, which retrieves the log files from the repository using publish/subscribe mechanism. The retrieved files are given to the Filter component which filters out the irrelevant information and provides the relevant data to the Modeller.

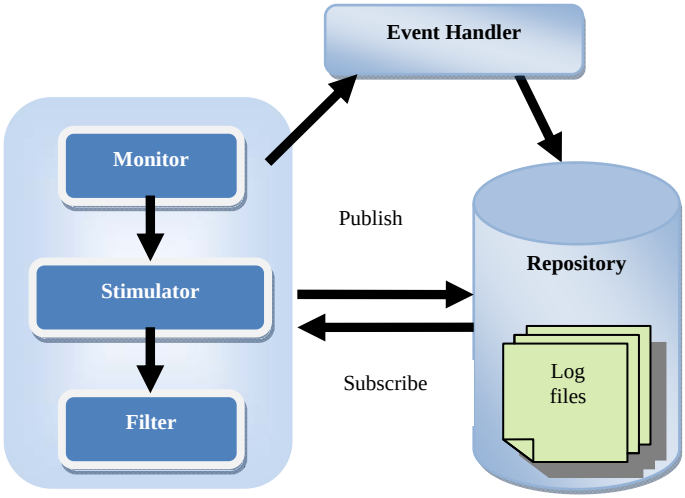

Figure 4. Working of the Extractor

Modeler: The extracted information of the learner is modeled into a structured representation called the learner model. This process is called learner modelling and it is done by the modeller. The process of learner modelling consists of two steps: the extracted information of the learner is analyzed by the analyzer. And the raw data is integrated into higher-level learner model by the Integrator. Integration involves aggregation and abstraction of data into higher level learner model. Here we use stereotypic, perturbation and overlay approaches for user modelling.

Learner Model (LMi): When the learner accesses the environment, he performs some activities which are collected, these traces are modeled into learner models (LMi) corresponding to learning environment. So when a learner performs an activity in environment E1 then he will be saved by the learner model LM1.
Mediator: The heterogeneous user data must be stored in a repository, so it needs to be transformed into a normalized form to maintain the integrity and consistency of the repository. So this component takes care of the conversion of the diverse user model into a unified model and it has the capability to handle heterogeneous data.
Repository: The repository is the central part of the system; it contains all learner models which are converted into a normalized form from different learning environments. The relations between these models are found and accordingly the other environments are updated.

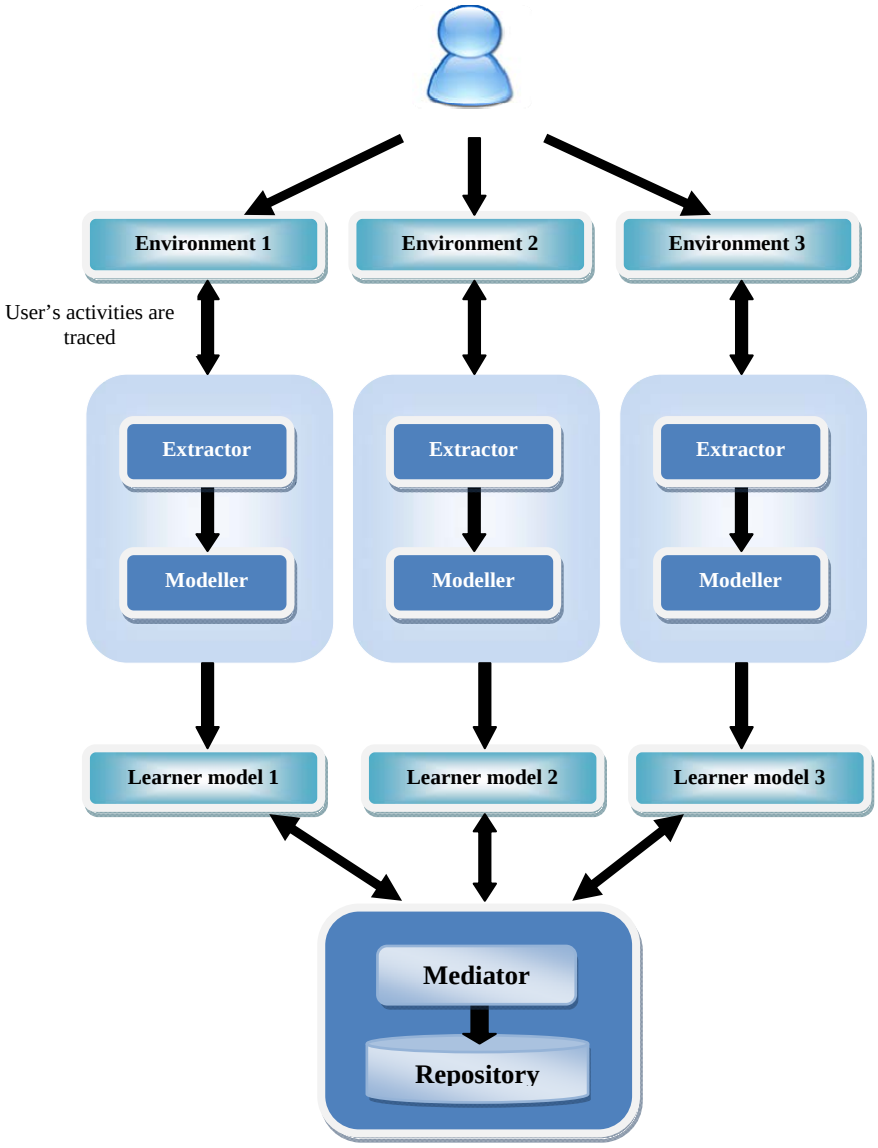

Figure 5. Architecture of the Proposed System

V. CONCLUSION

In Web-based adaptive educational systems personalization is done through the user model, which collects information about the user. Modelling user in e- learning is largely in research, we concentrate on the user model sharing in heterogeneous environments. We analyze the problem of sharing user data and proposed a solution for it. Thus our proposed system allows us to share and reuse heterogeneous user data and accordingly update the learning environments.

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