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Design an Adaptive E-learning Application Architecture Based on IEEE LTSA Reference Model

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Abstract

Adaptivity in the field of e-learning and an innovative framework for personalised adaptive e-learning is often considered to be new or in an early development stage. In this paper, we propose architecture for development of adaptive e-learning system. This architecture is based on the IEEE 1484 LTSA (Learning Technology System Architecture) reference model. The model is based on the learners' preference and knowledge level. According to these profiles, the learners are served with learning material that best matches their educational needs. Furthermore, we also accomodate the learner feeback regarding to difficulty level of learning material. The design of our proposed models is prepared using UML notation. Our goal is to assist the instructional designers in developing adaptive e-learning system based on the IEEE LTSA models efficiently.

Keywords: adaptive e-learning, IEEE LTSA, architectural model

1. Introduction

The rapid development of information technology makes the data communication and information delivery technology most effective. Moreover, this development has considerable advantages in every field of life, especially in education sector. Qomaruddin [1] proposed that using e-learning has many advantages over conventional learning, such as: quick feedback to students, saving of time in marking, consistently in marking and improve monitoring in students. While there are numerous e-learning solutions available today, the differentiating factors are the innovative instructional design and custom content development process [2]. Furthermore, to establish learning and development theories in web based learning, the system design should able to recognize the individual learning requirements [3]. The system has to recognize the individual requirements for ergonomic reasons, or adaptations to learning styles for an easier introduction into a topic.

In the context of e-learning, the adaptation is about creating a learner experience that purposely adjusts to various conditions over a period of time with the intention of increasing success for the effectiveness of e-learning application. The adaptation concept in e-learning application has been on the e-learning research agenda for well over three decades in different research topics such as intelligent tutoring systems [4], adaptive hypermedia [5-7] and Multi-agent systems [8] often based upon an instructional design model or guidelines and concept understanding. Linawati [9] explain that the students wer satisfied with adaptive hypermedia courseware, their academic achievement were rise significantly and the dropout rate were diminished.

Meanwhile, several studies have focused on the pedagogical aspect of e-learning systems over the past few years, but they have provided insufficient guidelines for e-learning designers [10]. The development of e-learning standards is a complicated, time-consuming, and challenging process. Some projects have focused on determining the standard architecture and format for learning environments, such as IEEE learning technology systems architecture (LTSA), instructional management systems (IMS), and sharable content object reference model (SCORM) [11].

Nowadays, the standardizations of e-learning application are abundant and cover all aspects of e-learning and distance education, from representation, packaging, and publishing of learning objects (LOs); to metadata that describe LOs. Furthermore, some standards

encompass aspects of learning design, instruction delivery, assessment procedures, and learners, architectures of learning management and educational applications.

A number of organizations, institutions, industry representatives, committees, working groups, and other bodies are involved with e-learning standardization efforts and initiatives. For example, learning object metadata (LOM) standard which is developed by IEEE [12]. LOM is a conceptual structure for metadata elements based on defined hierarchical categories. IMS content-packaging (IMS-CP) standard developed by IMS Global Learning Consortium is a set of structure that enables exchanging learning content [13]. Learning Technology Standard Architecture, developed by IEEE, is a high-level, pedagogically neutral, content-neutral, culturally neutral, and platform/technology-neutral architecture for learning technology systems based on abstract components [14]. Shareable courseware object reference model (SCORM), developed by ADL Initiative, is a unified content and communication reference model for implementation of e-learning application [15].

The primary purpose of this study is to model the e-learning architecture for adaptive e-learning systems because we are of the opinion that the e-learning application architecture can help an instructional designer to design and implement an adaptive e-learning system. In order to illustrate the context of our work, this paper starts with a brief introduction to related works. After introducing our learning contents structure model, we will present our proposed model.

2. IEEE LTSA Reference Model

This paper is addressed to concentrate on the IEEE LTSA. This model is generic enough to represent a variety of learning systems from different domains [14]. Based on Devedzic [14], LTSA that is developed by IEEE is high-level, pedagogically neutral, content-neutral, culturally neutral, and platform/technology-neutral architecture for learning technology systems based on abstract components. With its level as reference model, LTSA is used as communication standard architecture for reference model. The communication standards specify how the learners access educational content during online learning, assessment, collaboration, and other Internet-based educational services. The Learning Technology Standards Committee of the IEEE Computer Society has proposed the IEEE 1484 LTSA specification (IEEE 1484.1/D9 LTSA, 2001). This Standard is composed by five layers as shown in Figure 1.
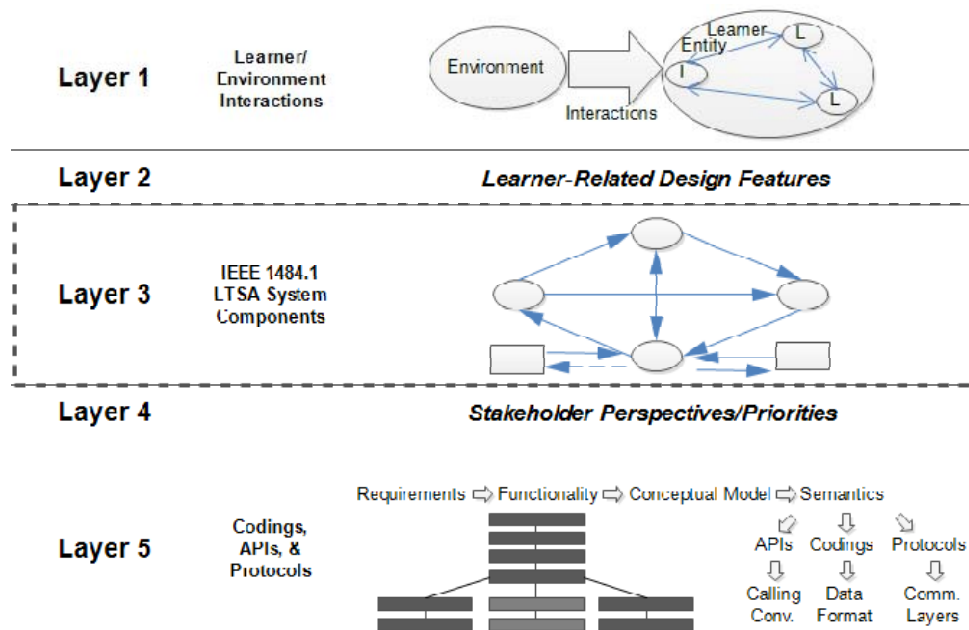

Figure 1. LTSA model [13]

The technical description of this architecture has two types: normative and informative. The normative text should be implemented as is proposed. In LTSA reference model, the normative layer is only the layer 3 (system components). The others are informative layers and provide texts with examples, explanations and guides of how the proposals can be implemented. The conceptual model of layer 3 is described in Figure 2.
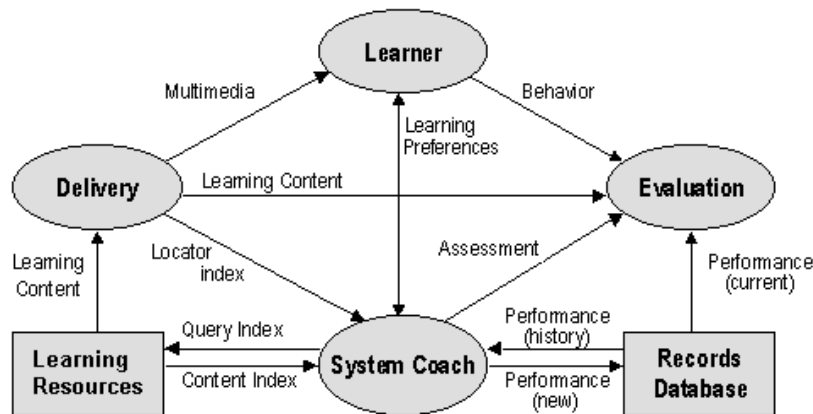

Figure 2. The conceptual model of IEEE LTSA [12]

Figure 2 shows the conceptual model of IEEE LTSA specified in layer 3. The ovals represent processing elements, boxes represent repositories; solid arrows represent data flows and dashed arrows represents reflect control flows. Regarding to this, then we can summarize as follows:

1). Firstly, there are 2 stores (learning resources and learner records).
   - Learning resources: stores presentations, tutorials, tutors, tools, experiments, laboratories, and other learning materials as resources for the learning experience.
   - Learner records: stores and retrieve students performance information of the past (history), present (current assessment), and future (new).
2). Secondly, there are 4 processing elements (delivery, learning entity, evaluation, coach)
   - Delivery process:
      The Delivery processes send Locators index to the Coach and retrieves Learning Content from the Learning Resources. It transforms the Learning Content into a Multimedia presentation for the Learner Entity.
   - Learner entity:
      The Learner entity represents a single human learner or group human learner. It receives multimedia presentation from Delivery process, while the Learning Preferences of a Learner entity are negotiated with the Coach.
   - Evaluation process:
      The Evaluation is the processing of Behavior to produce Assessment and Performance information. The Evaluation process creates Performance information that is stored in the Learner Records
   - Coach:
      The Coach negotiates the Learning Preferences with the Learner Entity. The Learning Preferences could be learning style, learning strategy, etc.

3. Results and Analysis

The proposed architecture includes a learner interface, which already encompasses most aspects of a standard e-learning architecture with reference to the IEEE LTSA, through the learning material, tests and assignments, learner profiles, etc. In this section we propose an architectural design of a Learning Management System using UML diagrams. This design consists of use case diagram, sequence diagram and activity diagram as shown in Figure 3.

The basic architecture behind the design is LTSA reference model but augmented with some added features like adaptive model of learning, two mode evaluation process and student counseling.
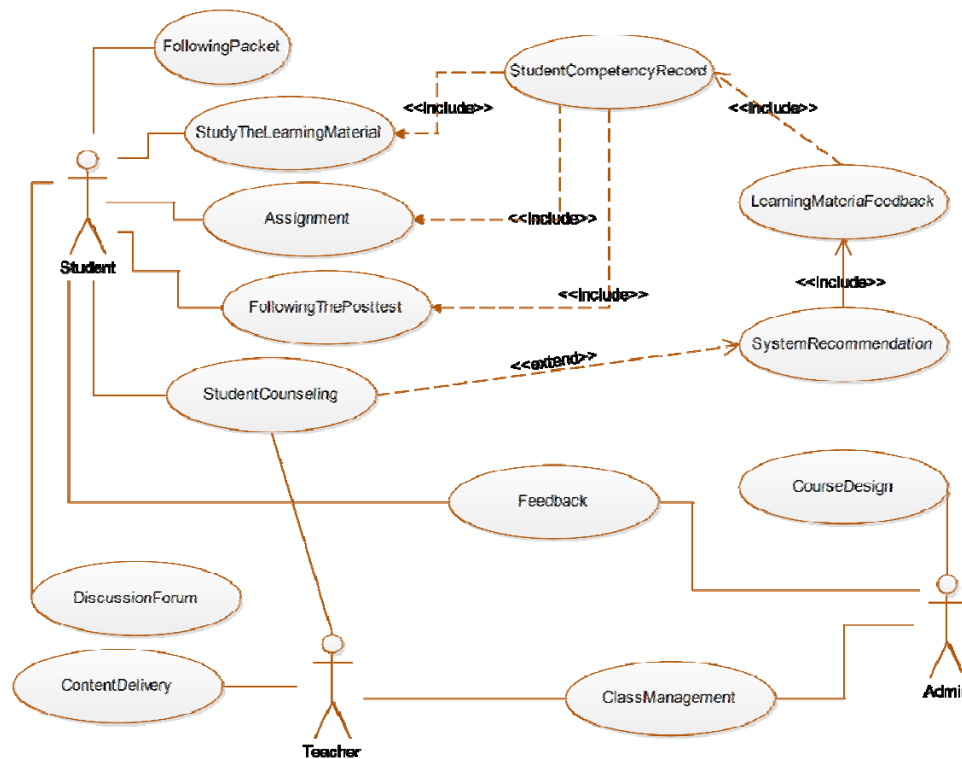

Figure 3. Global view use case diagram

In the use case diagram as shown in Figure 3; teacher, student and administrator are identified as the main actors and it supports both contact learning and distance learning (i.e. hybrid model). The students' competency record is stored and used for determining learning material feedback and learning recommendation. Furthermore, the learning recommendation is used for student counselling. Feedback is the place where the students can interact with teacher and admin, thus satisfying the part of layer IV, variety of perspectives.

In the students' activity diagram as shown in Figure 4, the initialization of learning material is the first step. This design specifies the adaptive and personalization learning to be the next step. The students follow the pretest and then the system record students' competency. Afterwards, the system assign sets of recommendation learning material to the individual student based on his/her test result and difficulty level of learning material. In our model, the performance of the students is evaluated in two ways, namely online test (pretest and posttest) and offline test (which is mainly submission of assignments). Next if the performance is not achieved up to a desired level then students cannot move to the next learning material. After completing the recommended learning package, then the students are supposed to take the posttest. Therefore, this design implement the basic learning cycle described in LTSA layer II that is combined with hybrid model of learning and two mode evaluation technique. A design class model would show greater detail since it provides class diagrams and the supporting specifications that describe model elements including classes, relationships between classes, and interfaces. Figure 5 depicts an analysis UML class diagram of our proposed model.

Class user is generalization from class Student and class Teacher. Each student has pretest and postest profile that is recorded in class StudentCompetencyRecord. Class Student also related with class RecommendedLearningPackage which contains several learning

material and assignments in sequence. Therefore, this model is suitable with the design the basic learning cycle described in LTSA layer II.
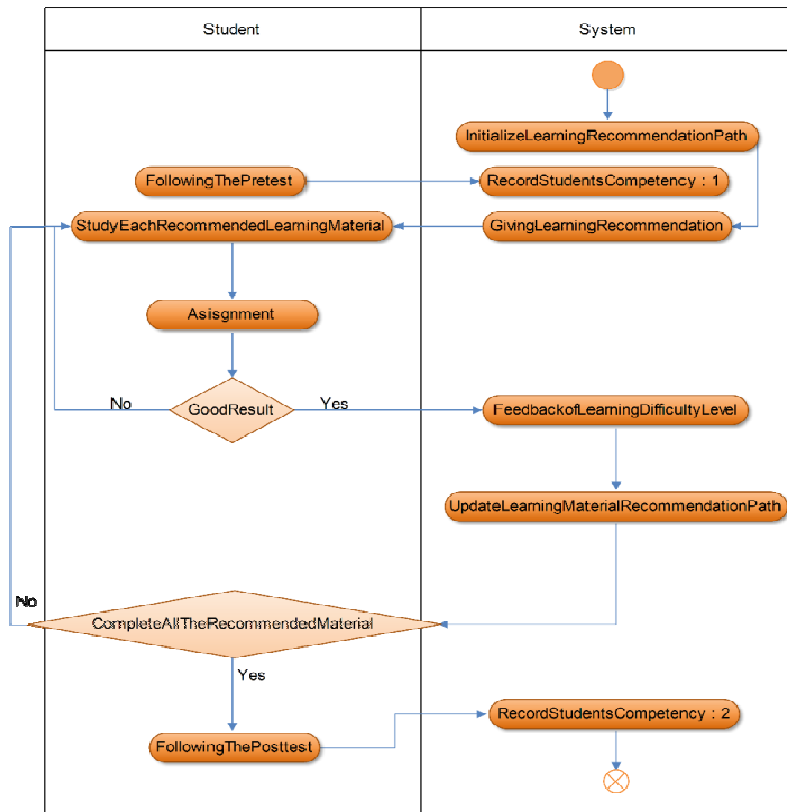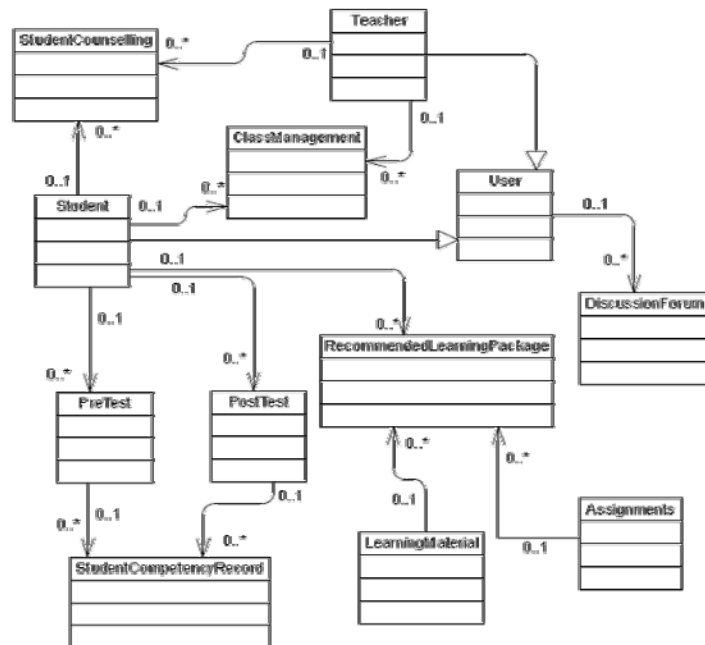

Figure 4. Students' activity diagram

Figure 5. Class diagram

Our proposed model already covers most aspects of LTSA reference model with several added feature. In LTSA model there are two stores, namely learner records and learning resources. To accomodate the features, we use class StudentCompetencyRecord and class LearningMaterial respectively. Regarding to the processing elements specified in LTSA (delivery, learning entity, evaluation and coach), in our model we have class Class Management, class Recommended Learning Package, class Pretest and class Posttest, and class Student Counselling.

4. Conclusion

The enhanced model proposed in this paper identifies the problem of currently deployed Web learning architecture models and intends to explore an efficient and practical solution. UML is used for the design of a use case diagram and activity diagram. In this way, the proposed solution can help instructional designers design and develop efficient adaptive e-learning systems based on IEEE LTSA model. To evaluate our model, we plan to develop a prototypical Learning Content Management System (LCMS). After developing the prototype system, we will apply it to a local language class in a primary school for evaluation in a real learning situation.

We believe that there are two primary advantages of adaptive e-learning systems model in this paper. One is that the proposed model, which contains a hierarchical contents structure that provide related useful information for searching and sequencing learning resources in e-learning systems. The other is that it can help a developer or an instructor develops a learning sequence plan by helping the instructor understand how the learning process is run.

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