UML Design Approach for Learners' Quanta based Dynamic Courseware

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Abstract: **One of the primary objectives of the Computer-Aided Distance Learning (CADL) is to design customized courseware taking into account of the input knowledge level and specific objective of each individual learner. In our earlier work, we have proposed a learner-centric, self-adaptive, modular approach, named LQ model, in which the modules are dynamically selected from a pool. In this paper, this LQ model has been extended and a UML-based analysis and design has been manifested. The UML representation of the proposed algorithm helps us to extract the implementation methodology in a more convenient manner. The modular and incremental architecture of the LQ based algorithm makes it an ideal candidate for UML based analysis, design and development. The work in this paper brings in the much needed formalism in the analysis and design of courseware based on our LQ model.**

Keywords –Adaptive Courseware**,** Computer Aided Distance Learning, Dynamic Courseware, Learner Quanta, UML

1 INTRODUCTION

The identification of specific requirements for individual learners of vastly different background and the design of effective courseware for the use of distance learning are being considered as a challenging problem all over the globe. Several efforts in this regard have been reported which are mostly course-specific. The non-linear way of storage of information in the form of hypertext has brought a revolutionary change in the teaching-learning process [1, 2, 3, 5, 7, and 12]. In the hypertext document, links have been established in such a way that the user can explore, browse and search for not only a particular item but can also get information regarding relevant/associated issues. Cockertion and Shimell evaluated hypermedia document as a learning tool [4].

They have focused their study on hypermedia document and included graphical controls for simple interaction behavior. Vassileva and Deters designed a dynamic courseware generator tool based on AI planning techniques [11]. These works emphasize more on pedagogical and other issues rather than identification of requirements.

Keith S. Taber and his associates [10], at the University of Cambridge put forward a project aimed to integrate English and Science standards using technology as a vehicle. The emphasis, however, was merely to improve the presentation of the learning material. Dr. John Munro [8] of the University of Melbourne has also worked on identification of the requirements for the effective delivery of course content. He essentially tried to analyze learning based on some pre-defined key issues. Guanon Zhang [13] has designed a computer based knowledge system for assisting persons in making decisions and predictions upon human or data-mining knowledge. This work is one of the closest researches as we are doing. However, in spite of having an almost identical goal to offer maximum flexibility to the individual learner, our approach to meet the target is distinctly different.

Our earlier work [9] [14] [15] presents the LQ model where course is sub-divided into several topics or LQ clouds. Using some algorithm subsets of LQs are selected which caters the requirement of the user. A second algorithm ensures the proper learning sequence of the selected LQs so that the learner can navigate through it. Besides, the pool of LQs is so designed that it would be able to cater to a wide spectrum of learners with varying requirements.

The working group IEEE "1484 Learning Technology Standards Committee (LTSC)" has designed an architecture called Learning Technology System Architecture (LTSA) to standardize web-based content delivery for all learning technology systems [6]. The LTSA specification follows a basic hypermedia approach with management software working behind which controls the sequencing of the hypermedia documents. However, LTSA does not include software design issues and designing of a Learning Management System (LMS) directly from LTSA is not desirable. In this paper we try to represent our algorithm [9][14][15] (which follows the LTSA architecture) with the help of UML so that a comprehensive LMS can be designed afterwards. Section 2, 3 and 4 represent the LTSA architecture and the Algorithm based on the concepts of Learners' Quanta. The algorithm is presented here for the sake of completeness. Section 5 deals with the proposed UML design.

2 LEARNING TECHNOLOGY SYSTEM ARCHITECTURE (LTSA)

The Learning Technology System Architecture (LTSA) is an architecture based on abstract components. It was developed (1996–2002) in the IEEE 148.4.1 Architecture and Reference Model Working Group of the IEEE Learning Technology Standards Committee (LTSC). This standard specifies a high-level architecture for information

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technology-supported learning, education, and training systems that describe the high-level system design and the components of these systems. This system has several layers, namely -

Learner Environment Interactions represents the Information Technology issues of the Learning Technology Systems and useful for common well-understood Software Engineering analysis and design techniques

Learner related design features: This refinement layers concerns the learner effect on the design of the learning technology system.

System Components describes the processes, stores and flows of the LTSA.

Stakeholders' perspective: This Layer is considered as separate refinement layers because stakeholders mapping contains an informative summary of many stakeholders' perspectives.

Operational Components and Interoperability: The major areas of Operational components and Interoperability described as coding, API, and protocols.

System components

System Components describes the processes, stores, and flows of the Learning Technology Systems Architecture. Processes are described in terms of boundaries, inputs, process (functionality), and outputs. Stores are described by the type of information stored, and by search, retrieval, and updating methods. Flows are described in terms of connectivity (one-way, two-way, static connections, dynamic connections, etc.) and the type of information across the flow. A brief report on the various system components are given below:

Learning styles strategies and methods etc. are negotiated among the learner and other Stakeholders and are communicated as learning preferences.
Learner is observed and evaluated in context of Multimedia Interactions.
The evaluation produces assessment and or learner information
The Learner information is stored in the Learner history database
The coach reviews the learner assessment and learner information such as preferences past performance and history and possibly future learning objective.
Searching of the learning resources by using query
Or from the catalog information can be done by the
System Coach.
It also extracts the locator's from the available catalog information and passes the locator's to the delivery process like Lesson Plan.
The main task of the delivery process is to extracts the learning content from the learning resources based on locator's and transforms the learning content to an interactive multimedia presentation to the learner.

3 THE LEARNERS' QUANTA MODEL

In this model a course is sub-divided into several topics. A participant may choose one or more topics or the entire course as per his requirement. There shall be a large number of LQs for a subject area or topic of study. These LQs together form a LQ cloud for the specific topic of study. In other words, a topic is constituted by a suitable combination of LQs as chosen by the course coordinator in accordance with the requirement/learning style of the participant.
Learners' Quanta of Study: *A Learners' quantum of study is a measured part of a topic with a well defined set of output objective(s) and requiring a precise input knowledge on the part of the learner*.
Several Learners' Quanta [9] on some topics or sub-topics are being designed and developed by the authors and they constitute Learners' Quanta Cloud (LQC). In any LQC, there may exist more than one LQs on the same topic or sub-topic written by same author or different authors having same or different output objectives and input knowledge specifications. Based on the requirement of each participant, a subset of LQs are chosen from the LQC and sequencing of the LQs (i.e. LQ chaining) need to be done so that on completion of the entire chain of LQs, the participant can be elevated to the desired level from his initial knowledge level.

3.1 Major Advantages of Learners' Quanta Model:

In this section, we just briefly mention only the major advantages of using the LQ approach keeping in mind the limited space.
Reusability: Design, development of web-based study material is still a costly affair and this can be reduced by reusing the same. In this model, a set of Learners' quanta of study may be reused by different course coordinator for different programs. Naturally more effective course-material may be produced by the author, if he gets his investment back through re-using.
Requirement Identification: The flexibility is increased highly by this approach and the participant can play a significant role in selecting his choice. This in turn leads to evolve a more effective requirements specification.
Cost: The cost of learning may be trimmed off by avoiding un-necessary portion of study. Re-usability also causes a drop in the cost.
Quality Improvement: The collaborative effort of the stakeholders not only improves the effectiveness, but improves the quality of the end-product, i.e., the designed courseware, in this case.

3.2 Terminology used

Let us present a formal introduction to all the terminologies that are referred in the rest of the paper. Keeping in mind the limited space we are not giving the algorithm in details, for the details of algorithm please refer to the paper Ray S., Chaki N., Dasgupta R.: Design of an adaptive web-based courseware.

Learner's Quanta (LQ): A Learner's Quantum of study is a measured part of a topic with a specific output objective requiring a specific input knowledge on part of the learner [5].

Learner's Quanta Cloud (LQC): A Learners' Quanta Cloud (LQC) is a collection of semantically related group of learners' quanta. Any arbitrary quanta, LQi could be part of more than one LQC, where LQs are grouped based on different semantics.

Knowledge Factor (KF): A Knowledge Factor (KF) is an atomic element of information. Each LQ is associated with a unique set of input KF and another set of output KFs. The intersection of the input and output set for a particular KF is usually a Null set.

Target Knowledge Factors: The Target Knowledge Factors (TKF) is the set of KFs specified by the user as the set of output objectives he/she wishes to acquire.

Known Knowledge Factors: The Known Knowledge Factors (KKF) is the set of KFs specified by the user as the set of already known elements of information for a particular learner.

LQ Dictionary: The LQ dictionary for a subject area refers to the entire set of LQs with their corresponding KFs stored in one specific place. The dictionary is different for each subject area.

5. VARIOUS DIAGRAMS FOLLOWING UML STANDARD

Based on the UML 2.0 the algorithm has been represented by different diagrams like use case diagram activity diagram, sequence diagram, class diagram. Keeping in mind the limited space, we present only the Use Case diagram and the Sequence diagram

5.1 Use Case Diagram

The use case diagram is shown in figure 3 and the other descriptions follow in the subsequent sections.

5.2 Description of the Use Cases

The main functions of adaptive web based courseware algorithm are to allow an intended Learner to register for a tailor-made course (s) from the courseware data base. Every learner when asked for course then based on his/her requirement and input knowledge set a course can automatically be configured for them. Through the Use Case Diagram we just tried to point out the various scenarios that analyze the above situation. Let's examine every possible scenario in this use case.

5.2.1 The "Select a Course "helps participant who wants to participate in a course in a selected topics

5.2.2 The "Give Pre-Test" identifies after selection of the course, participant has to insert the requirement knowledge set and input knowledge set as RKF (Requirement Knowledge Factor) and TKF (Target Knowledge Factor).

5.2.3 The "Capture Requirement" it accepts the requirement knowledge inserted by the participant.

5.2.4 The "Map Requirement" basically maps the requirement set provided by the participant in the format

5.2.5 The "Capture Input Knowledge It accepts the input knowledge inserted by the participant.

5.2.6 The "Map Input Knowledge" basically maps the input knowledge set provided by the participant with the requirement knowledge set provided by the participant and determines the required knowledge set for the participant.

5.2.7 The "Form Minimal LQ Cloud" Use Case

This use case identifies irreducible set of LQ from the LQ cloud required to meet target knowledge factor (TKF).

5.2.8 The "Remove redundant LQ" Use Case

This use case basically helps in the iterative process of selecting minimal LQ set if Input knowledge set dose not cover the prerequisite of minimal set of LQ through removal of redundant LQ.

5.2.9 The "Allocate Sequence to the LQ" actions specified by this use case is once LQs are identified, allocate sequence through which the learner will proceed.

5.2.10 The "Link LQ" Use this use case is once LQs are sequenced then linked those LQ through in proper order which the learner will proceed.

5.2.11 The "Register this use case is once the desired course is available by the system coach then it allows user to input personal information for registration.

5.2.12 The "Authorize User" this use case it verifies information provided by the user at the time of login.

5.2.13 The "Generate LQ" this use case it allows Author of the course to develop several learner's quanta on some topic or sub topics which is accumulated to form a LQC

5.2.14 The "Process LQ" Use Case this use case it allows Author of the course to assign Every LQ an unique LQ-id

5.3 Use Case Analysis of the Algorithm

Main Level:

1. Participant comes to the course ware web site for having a particular course with Input Knowledge Set and Specific requirement Description.
2. A requirement analysis system will ask Participant to specify his/her requirement according to the system.
3. Participant fills requirement information including Input Knowledge set.
4. System presents full course information as per information specified by the Participant
5. Participant browses from the list and selects course as per need
6. Participant fills personal information including financial
7. System authorizes Participant
8. System confirms the course for the Participant

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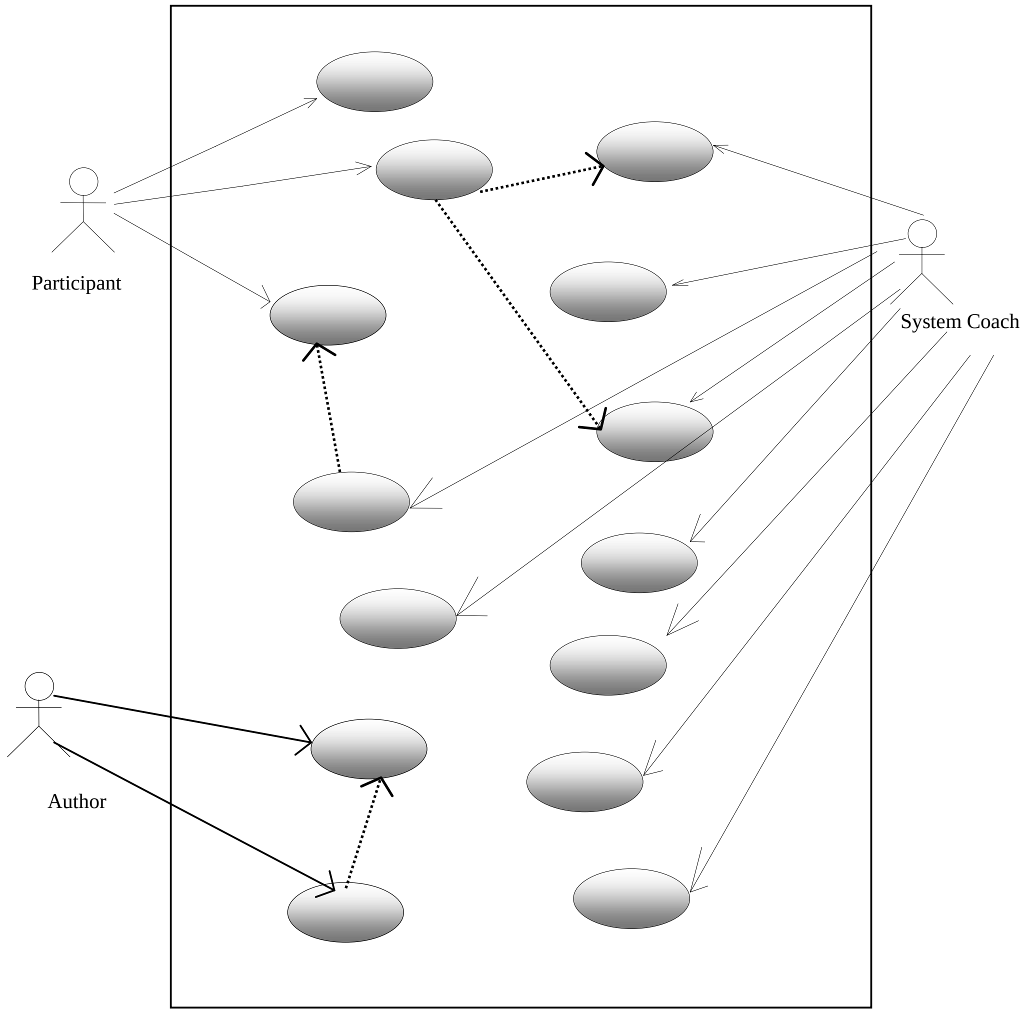

System Boundary

Figure 3: Use Case Diagram

EXTENSIONS:

1. Requirement Analysis System consists of a Pre-Test taken by a module called System-Coach
2. Based on the Participant requirement Specification & Input Knowledge Specified by the Participant system performs following tasks:
   a. Selection of minimum number of LQ from the LQC
   b. Removal of redundant LQ from selected course LQ Cloud
   c. Participant may specify its requirement in its own language then a mapping algorithm is required to map the Participant requirement
3. If system fails to select minimum number of LQ from LQC
   a. Participant rejected from registration process
   b. Information may intimated to the course author for preparation of that LQ
4. If System fails to authorizes the participant
   a. Participant has to re enter the information
5. After confirmation of the course system will performs following tasks
   a. Linking of the LQ by forming of Prerequisite directed graph
   b. Allocation of Sequence of that identified LQ

5.4 Use Case-Actor Description

ACTORS: PARTCIPANT
USE CASE
Course Selection
Pre-Test
Registration Process

ACTORS: SYSTEM COACH
USE CASE
Capture Requirement from the Participant
Mapping of Requirement Knowledge with Objective Set of LQ
Capture Input Knowledge
Mapping of Input Knowledge with Pre-LQ
Formation of Minimal LQ set from LQC
Removal of redundant LQ
Linking of LQ
Allocation of sequence to the LQ
Authorizes User
Confirmation of Course

ACTORS: COURSE AUTHOR
USE CASE
Generation of LQ
Generation of Prerequisite LQ for each LQ

INCLUSION STRUCTURE (IT WILL DESCRIBE WHICH USE CASE INCLUDES OTHER USE CASES)

PRIMARY USE CASE: Register
OTHER USE CASE
Authorizes User

PRIMARY USE CASE: Give Pre-Test
OTHER USE CASE
Capture Requirement from the Participant
Mapping of Requirement Knowledge with Objective Set of LQ
Capture Input Knowledge
Mapping of Input Knowledge with Pre-LQ

PRIMARY USE CASE: Confirmation of Course
OTHER USE CASE
Formation of Minimal LQ set from LQC
Removal of redundant LQ
Linking of LQ
Allocation of sequence to the LQ

5.5 Description of the Sequence diagram

The main logic of the usage scenario of adaptive web based courseware algorithm modeled here through sequence diagram. From the above we can able to identify the basic sequences or steps involves in the whole process:

1. Participant comes to the course ware web site for having a particular course with
2. Pre Registration Process/ Registration Process returns a test object as Input Knowledge Set and Specific requirement Description.
3. Then user will perform test through a requirement analysis system object provided by the system coach process that will ask Participant to specify his/her requirement according to the system.
4. Based on the Participant requirement Specification & Input Knowledge Specified by the Participant system performs following tasks:
    1. Selection of minimum number of LQ from the LQC
    2. Removal of redundant LQ from selected course LQ Cloud
    3. Participant may specify its requirement in its own language then a mapping algorithm is required to map the Participant requirement
5. If system fails to select minimum number of LQ from LQC
    1. Participant rejected from registration process
    2. Information may intimated to the course author for preparation of that LQ
6. Registration Process returns an object Participant fills personal information
7. Registration Process authorizes Participant
8. If System fails to authorizes the participant
    1. Participant has to re enter the information
9. System coach confirms the course for the Participant
10. After confirmation of the course system will performs following tasks
    1. Linking of the LQ by forming of Prerequisite directed graph
    2. Allocation of Sequence of that identified LQ

6 CONCLUSION

The UML representation of the proposed algorithm elicits the methodology in a simple way. The modular and incremental architecture of the LQ based algorithm makes it an ideal candidate for UML based analysis, design and development. In our earlier works, we have experimented with design and implementation of LQ based solutions in bits and pieces. However, the approach demands a formal analysis and design structure to make an impact. Designing of a complete LMS on the LTSA architecture is itself a big challenge. Based on the proposed UML design presented in this paper, we propose to initiate a layer-based implementation of the LQ model of courseware development in future.

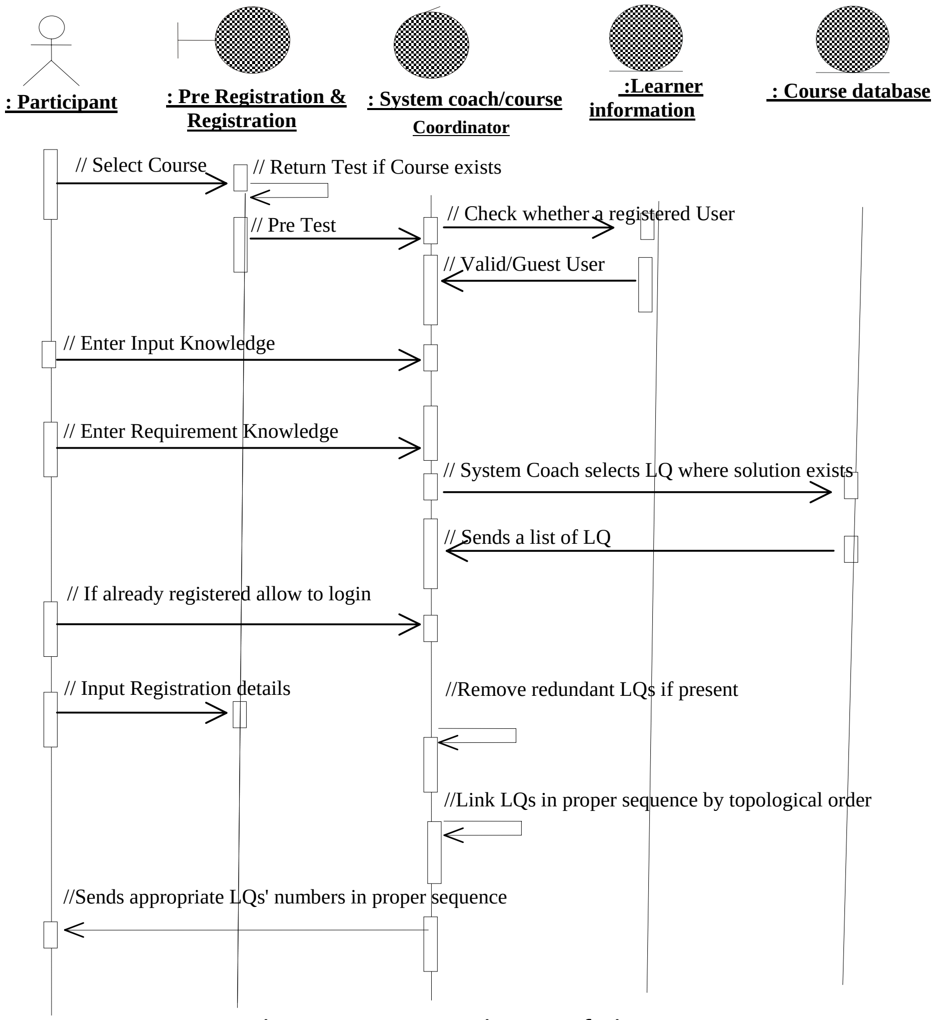

Figure 4: Sequence Diagram of Figure 3

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