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Early Requirement Engineering for Design of Learner Centric Dynamic LMS

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***Abstract*—**We present a modeling framework that supports the engineering of early requirements specifications for design of learner centric dynamic Learning Management System. The framework is based on i* modeling tool and Means End Analysis, that adopts primitive concepts for modeling early requirements (such as actor, goal, and strategic dependency). We show how pedagogical and computational requirements for designing a learner centric Learning Management system can be adapted for the automatic early requirement engineering specifications. Finally, we presented a model on a Learner Quanta based adaptive Courseware. Our early requirement analysis shows that how means end analysis reveals gaps and inconsistencies in early requirements specifications that are by no means trivial to discover without the help of formal analysis tool.

***Keywords*—**Adaptive Courseware, Early Requirement Engineering, Means End Analysis, Organizational Modeling, Requirement Modeling.

I. Introduction

REQUIREMENT engineering is a primary activity in producing significant software products. In recent past, some approaches of requirement framework have been designed to provide an end to-end solution for system development life cycle. Design of a customized learner-centric dynamic E-Learning Framework taking into account of knowledge and objective of individual learner by analyzing Early Phase Requirements now become a growing challenge in the area of E-Learning. For any web based courseware, as the learners are from various cross sections of life including country, age, gender, culture, learning style and learning requirements [13], [14] unless appropriate learner-centric dynamic behavior has been embedded at the time of designing, it might not even be possible to attain the desired level of learner-centric dynamic behavior in the final product [1], [2]. Every learner is considered as different from his/her own way of learning, his/her input knowledge level and his/her desirable output objective (behavior). At the same time every teacher has his/her own teaching style and a senior teacher can teach according to different pedagogical requirement of the learner. Same or almost equivalent knowledge can be learnt from web material presented in different form and same knowledge can also be delivered to a learner by a teacher in different sequence according to the pedagogical requirement of the learner. In some cases we may see that new generation students may like materials full with multimedia support including various videos, interactions etc., where seniors may like to take a print out of text material and read it in off-line mode. Thus facilities for all such varieties should be made available in the courseware. In order to design of learner-centric dynamic E-Learning Framework to meet the requirement of individual learner, concepts of Learner Quanta (LQ) & Learner Quanta Cloud (LQC) had been proposed in [7]. In [7]-[9] authors tried to devise an algorithm which selects a set of LQs from LQC to cater the requirement of any learner having some background knowledge. In [10] attempt had been made to present the proposed algorithm through UML representation, which elicits the methodology in a simple way. Concepts of the learner-centric modular LQ had been extended through a Graph based model in order to identify the appropriate data organizations of the Learner Quanta Cloud [11]. From the matrix representation of the graph, 'Reachability' property and several other properties along with their algorithm had also been discussed in [15].

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II. A Short Description about i* Modeling & Means End Analysis

The ***i**** framework was developed for modeling and reasoning about organizational environments and their Information systems [16]. It consists of two main modeling components. The Strategic Dependency (SD) model is used to describe the dependency relationships among various actors in an organizational context. The Strategic Rationale (SR) model is used to describe stakeholder interests and concerns and how they might be addressed by various configurations of systems and environments. A more formal presentation of the framework appears in [16]. The ***i**** framework has also been applied to business process modeling and redesign [3], [16] and to software process modeling [16], [18].

The central concept in ***i**** is that of the intentional actor [17]. Organizational actors are viewed as having intentional properties such as goals, beliefs, abilities, and commitments. Actors depend on each other for goals to be achieved, tasks to be performed, and resources to be furnished. It has been found that by depending on others, an actor may be able to achieve goals that are difficult or impossible to achieve.

We tried to analyze goal, task, resource and soft goal through means-end link and decomposition link by development of a graph. This graph captures the relationship between the goals of each actor and the dependencies through which the actor expects these dependencies to be fulfilled.

III. Requirement of a Learning Management System

Requirements of a LMS have already been identified in [12]. For the sake of completeness central issues of the pedagogical and computation requirements are reproduced below. More details have been reproduced in Appendix.

Pedagogical Perspective:

a. Focus of attention
b. Motivational states
c. Emotions of Learner
d. Tie up with prior knowledge
e. Learning Preferences
f. Learning Styles
g. Learning Progress

Computational Perspective:

a. Reachability of Learner Query
b. Optimality in LQ delivery & sequencing
c. Customizable Content design
d. Customizable Content Selection
e. Course Timings
f. Network bandwidth Information
g. Learner fund information
h. Hardware/Software/Operational Environment information
i. Learner Assessment
j. Evaluation and Goal Analysis

IV. i* and Means End Analysis of the Requirement of a LMS

In [12] we had identified several functional, non-functional and behavioral requirements from pedagogical and computational perspective. Pedagogical requirements of adaptive learning process, e.g. attention, motivation, emotional aspects, learning styles had been identified and analyzed according to LQ based adaptive dynamic courseware. Like Pedagogical requirements; requirements from computational aspects for the adaptive learning process e.g. content centric issues like content delivery, content sequencing, LQ storage issues, LQ delivery issues had been identified and analyzed according to LQ based adaptive dynamic courseware. Our proposal adopts the ***i**** organizational modelling framework [3]-[6], which offers the notions of actor, goal and (actor) dependency, and uses these as a foundation to model early and late requirements, architectural and detailed design. Here actors are represented as circles; dependums– goals, softgoals, tasks and resources – are respectively represented as ovals, clouds, hexagons and rectangles.

Fig. 1 depicts an excerpts i* model of our requirement those we have identified in [12] towards development of learner centric dynamic E Learning frame work. The main actors are Learner, E-Learning system, Course Author and System Coach. Learner depends on E-Learning system to reach his/her objective. At the same time, Learner depends on E-Learning system for E-Learning Environment. Conversely, E-Learning system is also dependent on Learner for course fee. System Coach is also dependent on Learner behavior for Learner Management. Since the dependum Learner Management cannot be defined precisely, it is represented as a soft goal. The Learner also depends on E-Learning System for course selection (task dependency). The E-Learning System is dependent on Course Author for course content production. Furthermore, E-Learning System depends on course Author to get courseware (resource dependency). As we have identified the relevant stakeholders of the system and their goals, we also tried to present a model through a means-ends analysis [3] to show how these goals (including soft goals) can actually be fulfilled through the contributions of other actors.

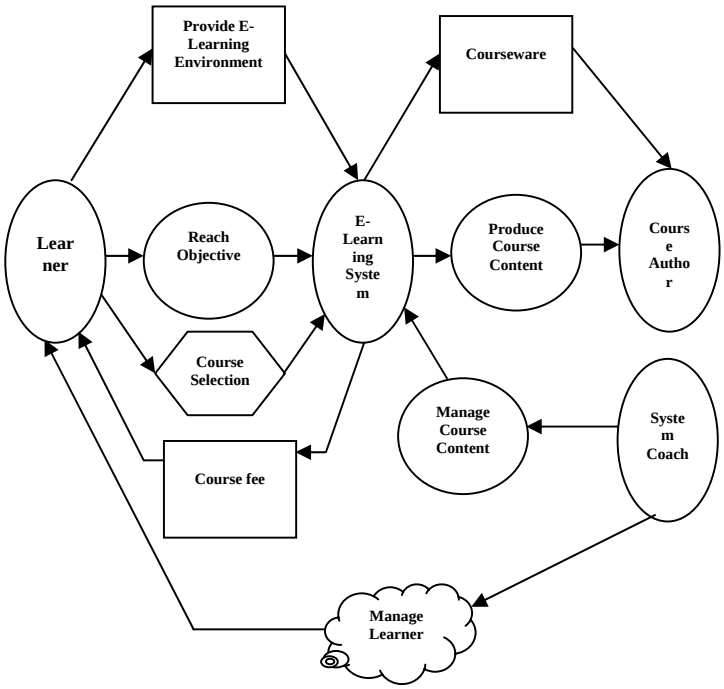

Fig. 1 *i** model for Learner centric dynamic E-Learning system

In this paper we have focuses on one of the (soft) goal dependency (Fig. 2) identified for learner centric dynamic E-Learning system, namely Manage Learner. To achieve that soft goal, the analysis postulates three sub goals Track Learner Learning Styles that can be fulfilled by means of a task Track Learner Learning Styles. This task can be achieved by goal Track Learner Content Selection that can be fulfilled by means of a task Track Learner Content Selection. In Means End Analysis every task can be decomposed into goals and/or subtasks, whose collective fulfillment completes the task.

V. Benefits of the Modeling

By using i* modeling

1. Early requirements towards design of a LMS has been represented in a systematic manner
2. Representational aspects of the requirement elicitation has been dealt for LMS with reasonable details
3. A suitable requirement analysis structure by extracting metadata can also be developed from the representation
4. Means End Analysis helps to achieve Goal through task by resolving resource dependency

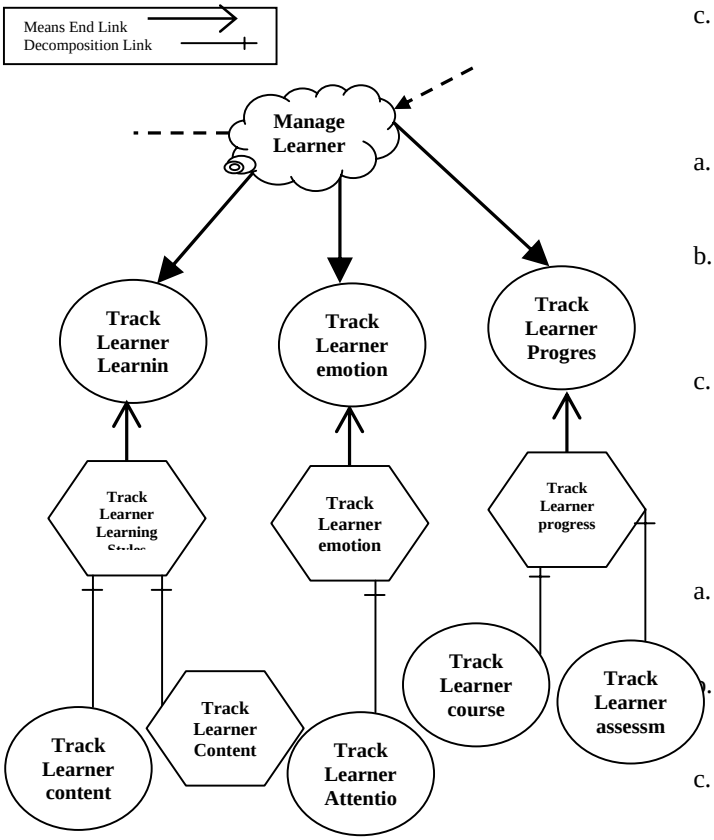

Fig. 2 Means-Ends Analysis for the Soft goal Manage Learner

VI. Conclusions

Embedding pedagogical requirements in an LMS has been gaining its necessity as putting rich study materials in an LMS with the help of various computational tools and techniques are found not very effective as all such presentations do not include the basic pedagogical issues in the right spirit. This paper proposes development of early requirement model considering requirements from both the pedagogical and computational perspective so that the LMS framework can contribute significantly in the teaching-learning process. It also helps in an effective design of the data organization necessary for further development of the system.

Appendix: Details of Pedagogical and Computational Requirements [12]

Pedagogical Perspective

1. Focus of Attention

a. Illustration: Focus of attention determines if a student mentally follows a lecture and, therefore, if the intended behavioral change affects a learner at all. Adaptive courseware particularly requires a strategy for getting and keeping the learner's attention.
b. Requirement: LQ based adaptive courseware requires a strategy for getting and keeping learner's attention.
c. Analysis: To judge focus of attention learner login duration, course LQ selection etc meta data may also be collected for better results

2. Motivational States

a. Illustration: Motivational states of students are of importance when questioning how the stimuli given by the teacher promotes the learning process.
b. Requirement: LQ based adaptive courseware requires focus on the course authoring part in preparation and improvement of LQ based on learner's interaction with the LQ.
c. Analysis: One content may be represented both as audio content and video content and offered to the learner parallel. Intermittent interaction of the learner with the teacher may improve the learning experience of the learner and change the motivational states

3. Emotions of Learner

a. Illustration: Emotion has a strong impact on the learning process points out findings on students' performance depending on anxiety
b. Requirement: LQ based adaptive courseware requires focus what types of test students are preferring in terms of preparing themselves
c. Analysis: LQ based adaptive courseware may require study on the data about a LQ and its associated test parameters. It takes input from the learner that what type of test and content type they are comfortable with and allow them with such data

4. Tie up with Prior Knowledge

a. Illustration: Tie up with prior knowledge can help learner to transfer knowledge in the same or in the similar context
b. Requirement: LQ based adaptive courseware requires attention on the learner and deliver them course as per his/her prior knowledge
c. Analysis: LQ based adaptive courseware may takes input knowledge level of the learner [9] and take decisions about the LQ based on that metadata

5. Learning Preferences

a. Illustration: Learning preferences usually result from predispositions or orientations to learning and can be seen as influences by the context
b. Requirement: LQ based adaptive courseware requires attention in designing and delivery of the LQ with respect to the learning preferences of the learner
c. Analysis: LQ based adaptive courseware creates outline of the LQ offering sequence to better understanding of the learning so that catalog metadata may help learner to choose it content according to it choices.

6. Learning Styles

a. Illustration: Cognitive and learning styles are related to intellectual capabilities and preferences. Both kinds of styles try to provide more practical models for teacher

b. Requirement: LQ based adaptive courseware must judge knowledge level of the learner and try to devise metadata
c. Analysis: Learner of different level of input knowledge (Novice/Beginner/Expert) may be served by the LQ based adaptive dynamic courseware differently

7. Learning Progress

a. Illustration: The learning progress-based adaptive courseware pedagogy emphasizes personalized course content delivery depending on a student's learning aptitude and learning progress rules.
b. Requirement: LQ based adaptive courseware must judge learning progress with respect to objective submitted by learner and try to devise rule for customized content delivery
c. Analysis: Learning progress analysis may be thought as tracking of learner achievement based on test results and creation of LQ sequence for delivery

Computational Perspective

8. Reachability of Learner Query

a. Illustration: Reachability is a technique by which a learner may know beforehand whether a requested query is serviceable by present LQ cloud or not
b. Requirement: To do this LQ cloud may be represented as graph model and subsequent represented in a matrix to meet the above objective
c. Analysis: Based on learner input knowledge level and output objective level suitable reachability of a learner query may be satisfied

9. Optimality in LQ Delivery & Sequencing

a. Illustration: Optimality defines selection of best possible LQ sets considering different perspectives of learner
b. Requirement: In response to a learner query it has been observed that there is more than one solution set exists in the LQ Cloud.
c. Analysis: LQ based adaptive courseware must judge all solution sets based on different metadata submitted by learner

10. Customizable Content design

a. Illustration: Content design in adaptive dynamic courseware is temporal issue. It is not necessarily depend on the authoring of LQ but it resembles design of a customized content in response to a user query
b. Requirement: Content design must store data with respect to time.
c. Analysis: As time grows LQ Cloud also grows with different types of LQ like audio, text, animation, video

11. Customizable Content Selection

a. Illustration: Based on the learning preferences of the learner customizable content may be selected by the learner
b. Requirement: Learner should have choice on content type of the similar kind content
c. Analysis: Type of content selection may also based on learning styles and learning preference of the learner

12. Course Timings

a. Illustration: Course timing is a combination of learning and evaluation time.
b. Requirement: Learner should have their choice regarding flexible course timings and flexible course duration. System must allow learner to do so
c. Analysis: Some learners are fast paced learner and some learners are slow paced learner. Learning pace of the learner may be judged by analyzing different data collected from the learning experience of the learner and based on that LQ offering sequence is prepared.

13. Network Bandwidth Information

a. Illustration: In view of design of content network bandwidth is a very important component because it determines size of the LQ
b. Requirement: Learner may have different level Internet connection speed like Broadband/DSL/Dialup. Selection of content may be done based on connection speed
c. Analysis: This information is important because based on the internet connection speed type of content selection is done e.g. For a normal dialup connection LQ with normal HTML content and plain text can be delivered

14. Learner Fund Information

a. Illustration: Learner fund information is important because it focuses on cost effective delivery model of LQ based adaptive dynamic courseware.
b. Requirement: Learner must have some objective with limited fund strength.
c. Analysis: Each LQ is associated with a cost. Customizable course will be configured based on the fund information.

15. Hardware/Software/Operational Environment information

a. Illustration: Choice of Hardware/Software/Browser determines correct working of LMS under cross platform environment.
b. Requirement: Learner should have choice regarding Hardware/Software/Browser.
c. Analysis: LQ is authored in such a manner so that under any circumstance same LQ requested from computer and mobile may be served in same manner

16. Learner Assessment

a. Illustration: Learner assessment may be summative or formative and that choice also made by learner
b. Requirement: LQ may be authored in such a manner so that for a particular LQ there may be more than one assessment tool
c. Analysis: Selection of assessment tool for particular LQ depends on the learning preferences of the learner

17. Evaluation and Goal Analysis

a. Illustration: Evaluation and goal analysis determines how a learner achieved his/her goal with respect to its objective
b. Requirement: Goal analysis also judge metadata about learner performance with respect to objective
c. Analysis: LQ based adaptive dynamic courseware must give focus on input requirement analysis and output objective requirement analysis

REFERENCES

[1] Abdel H., et al.: Multimedia Integration into a Distance Learning Environment: Proc. of the 3rd International Conference on Multimedia Modelling, Tolouse. (1996)
[2] Vassileva J., Deters R. : Dynamic Courseware Generation on the WWW : British Journal of Educational Technology, Vol. 29, No.1 (1998)
[3] Castro, J., Kolp, M., and Mylopoulos, J. 2002b. Towards requirements-driven information systems engineering the tropos project. *Information Systems 27*, 365–389
[4] Yu, E. and Mylopoulos, J. 1994. Understanding 'why' in software process Modelling, analysis and design. *Proceedings Sixteenth International Conference on Software Engineering*, 159–168.
[5] Yu., E. 1993. Modelling organizations for information systems requirements engineering. Proceedings First IEEE International Symposium on Requirements Engineering, 34–41
[6] Dardenne, A., Lamsweerde, A. v. & Fickas, S. (1993). Goal-Directed Requirements Acquisition. Science of Computer Programming, 20:3-50
[7] Ray S., Chaki N., Dasgupta R. : Design of an adaptive web-based courseware : Proc. of IASTED International Conference on Intelligent Systems & Control (ISC 2004), Honolulu, Hawaii, USA, (2004)
[8] S. Ray, R Dasgupta, N Chaki; "A Learner's Quant Model based Framework towards Building Dynamic Web-based Courseware"; Proc. of the fourth International Conference on Multimedia and ICTs in Education m-ICTE2006) - "Current Developments in Technology-Assisted Education", Seville, Spain, pp. 238-242, November 2006
[9] N. Chaki, R. Dasgupta, "A Learners' Quanta Based Framework for Identification of Requirements and Automated Design of Dynamic Web-based Courseware" Invited Talk, 14th International Monterey Workshop, Monterey, California, USA, September, 2007
[10] Halder K, Pal S, Chaki N , Dasgupta R " UML Modelling of Adaptive Course ware Algorithm" published at The World Science Congress on Computer Science & Engineering-2008 San Francisco, USA (WCECS 2008) held in 22-24 October,2008 Sanfrancisco, USA ISBN 978-988-98671-0-2 Publisher: International Association of Engineers
[11] Halder K, Chaki N , Dasgupta R "Design of Graph based model for LQ based Adaptive Dynamic Courseware" published at The 2011,International Conference on Frontiers in Education: Computer Science & Computer Engineering(FECS'11) WORRLDCOMP '11 July 18-21, Nevada, Las Vegas, USA ISBN 1-60132-180-5 Publisher: CSREA Press
[12] Halder K, Chaki N , Dasgupta R "Requirement analysis for designing of an LQ based adaptive dynamic courseware" published at The FL2012 4th International Future-Learning Conference on Innovations in Learning for the Future 2012: e-Learning Nov 14-16, 2012, Istanbul, TURKEY ISBN 978-975-404-923-7 Publisher: Istanbul University
[13] Yanhui Lv, Chong Xie An Ontology-based Approach to Build Conceptual Data Model, 2012 9th International IEEE Conference on Fuzzy Systems and Knowledge Discovery (FSKD 2012)
[14] V´itor E. et al (Requirement) Evolution Requirements for Adaptive Systems 978-1-4673-1787-0/12 2012 IEEE SEAMS 2012, Zürich, Switzerland
[15] Halder K, Chaki N , Dasgupta R "Analysis and design of Learner Quanta Graph Properties for efficient query processing in an adaptive dynamic courseware" published at The IEEE International Conference on Teaching, Assessment and Learning for Engineering (TALE) 26-29 August 2013, Bali Dynasty Resort, Kuta, Indonesia, ISBN 978-1-4673-6354-9/13 2013 Publisher: IEEExplore
[16] E. Yu, Modelling Organizations for Information Systems Requirements Engineering, Proceedings of First IEEE Symposium on Requirements Engineering, San Diego, Calif., January 1993, pp. 34-41.
[17] E. Yu, Modelling Strategic Relationships for Process Reengineering, Ph.D. thesis, also Tech. Report DKBS-TR-94-6, Dept. of Computer Science, University of Toronto, 1995.
[18] Dutta A, Kanjilal,Bhattacharya S, Dasgupta R, Bhattacharya S, Engineering of Requirements for a Distributed Teleteaching System: A Conceptual Graph-based Approach ACM SIGSOFT,2013 November