A Proposed Semantic Recommendation System for E-Learning

A Rule and Ontology Based E-learning Recommendation System

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***Abstract*— with proliferation of learning contents on the web, finding suitable ones has become a very difficult and complicated task for online learners, to achieve better performance. Nevertheless, recommender systems can be a solution to the problem. However, recommendation systems haven't been sufficiently used in e-learning, in comparison with other fields (*i.e.* commerce, medicine and so on). In this paper, we propose a semantic recommender system for e-learning by means of which, learners will be able to find and choose the right learning materials suitable to their field of interest. The proposed web based recommendation system comprises ontology and web ontology language (OWL) rules. Rule filtering will be used as recommendation technique. Our proposed recommendation system architecture consists of two subsystems; Semantic Based System and Rule Based System. Modules for either subsystem are; Observer, Learner profile, Recommendation storage and User interface.**

Keywords- e-learning; ontology; personalized; recommender system; rule based; semantic web (key words)

I. INTRODUCTION

With the rapid growth of electronic course contents and virtual classrooms, e-learning systems are efficiently used for education and training in academic and non-academic places. Adaptive e-learning system is one of the developments in e-learning domain that adjusts itself based on system changes. Personalization plays an important role in adaptive e-learning system. This needs user profile due to different information and characteristic among users. Due to increasing trend of learning contents and material sources on the web, it is difficult to find learning contents related to user request.

A recommendation system offer suitable learning contents based on user profile. The first time recommender systems introduced in 1996. Produce a mapping of scores to items for the users, a set of recommended items, a ranking of items or a combination of these three [1]. Semantic recommender systems are different to common recommender systems. Semantic recommender systems employ semantic web parts to recommend some items to user.

This paper proposes a semantic recommendation system for e-learning domain to help the learners find subject they need to learn. This system recommends some learning contents based on learner knowledge level, learner profile and some learner evaluations.

II. BACKGROUND OF RESEARCH

Conventional e-learning systems have several following problems. The first problem is the amount of time spent searching for the right contents [2]. Learning can take place at any time and place. However, with the increase of learning contents on the web, it is a time-consuming effort for learners to access desired and suitable contents. Therefore, conventional e-learning systems do not provide flexible content delivery.

In addition, there is an inadequate search technique for searching the web contents. With the absence of semantic parts in web service technologies and rapid increase of web services; it is difficult to find appropriate web service on user's request [3]. Semantic web technology put more emphasis on knowledge representation and management. The semantic web is realized by adding semantics to the web, to facilitate information searching, extracting, representing, interpreting and maintenance. The main purpose of the semantic web is to enable automated collaboration over the Internet, based on ontology as semantic terminology definitions. Ontology is the backbones of semantic web. By using ontology, the semantic techniques are provided in conventional e-learning. In addition to, semantic relationship between learning contents by using ontology has more powerful reasoning than the other types of representations.

Another problem is the absence of personalization in conventional e-learning systems. Learners with the same plan have the same content lists for learning, even though they have different previous knowledge about their plans [4]. User profiling for all learners can solve this problem since user model is created for every learner. The system can recommend learning contents based on the model.

Nowadays, to offer appropriate learning content to the right learner in a correct way is a big challenge in e-learning systems [5, 6]. Recommender Systems can solve these problems and improve conventional e-learning systems. To do this, the user's profile is compared to some reference characteristics. These characteristics may originate from the information item (the content-based approach) and the user's

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social environment (the collaborative filtering approach). These approaches were named information filtering. It is also called a recommender system, which use predefined rules to filter information and recommend contents to learners [7, 8]. Content filtering recommends based on the similarity between contents for one user while collaborative filtering works based on similarity between user profiles. Content filtering and collaborative filtering work based on rating system.

However, collaborative filtering has a problem called "cold start", which indicates dependency on a collaborative filtering technique that relies on inadequate user information from the past [9]. Another limitation of collaborative filtering systems is that they need a community of people who know each other. Thus, Collaborative filtering is unable to recommend anything. Content based filtering considers to one user, so the results are not shareable [7]. Therefore we propose a web-based semantic recommendation system. We will use rule filtering as the recommendation technique. The quality of recommendation by using rule filtering is subject to the predefined rules.

We propose this system to help learner choose and find learning contents they want to learn. Based on semantic web technology, the ontology will be used to gather learning contents. The proposed architecture consists of two sub systems called *Semantic Based System* and *Rule Based System*. In addition, the system also has *Observer, Learner Profile, Recommendation Storage* and *User Interface.* Semantic based system consists of learning contents related to the domain. This learning content is represented by ontology. We use the World Wide Web Consortium (W3C) recommender ontology language, web ontology language (OWL) to create ontology. Rule based system consists of Rules and Reasoning engine. This subsystem will execute semantic rules defined previously. Learner history, learner's knowledge level and learner characteristic are in the Learner profile. Learner profile will be updated by the system dynamically. Observer will evaluate learner's performance. It takes quiz from learners and will measure time spent reading on current topic. User profile is dynamically updated based on the result of evaluation. Finally we will design a friendly interface for learner to have transaction with the system.

III. PREVIOUS RELATED WORKS

A. E-learning recommendation system

The first recommender system was developed in the mid-1990s [10]. Many recommendation systems in various domains such as movies, music, commerce and medicine have been developed but few in education field [9]. Compared with another fields, learning content recommendation is a new topic with the appearance of e-learning. Many recommendation techniques have been used previously. Majority of researchers employed collaborative filtering in their systems to develop recommendation system [2, 11, 12, 13 and 14]. Baloian [11] developed COLDEX system in which learner's preferences and hardware/software characteristics contribute the materials for learning. Tan et al. [12] used person correlation to calculate the proximity between learners by neighborhood algorithm. Domain in these two recommendation system are indeterminate. Adaptive e-learning system is ontology based where by this research works on preference and neighbor interest. Applied ontology in this research consists of Java programming languages which named JLOO (Java Object Learning Ontology).

Kerkiri et al. [13] offered a framework for recommendation which embedded heuristic rule for best recommendation besides the collaborative filtering. Employed domain in this research is indeterminate. Framework in this research is for Mp3 objects [14]. This system recommends based on mood and situation. Authors in this research have applied collaborative filtering and rule inference. The collaborative filtering is for context-aware recommendation and Rule for adaptation recommendation based on user profile.

The second groups of related works use content filtering. Ghauth and Abdullah [15] developed an e-learning content based recommendation system. They used Vector Space Model and good learners' average rating strategy in their research. They prototyped this recommendation system for several set of presentation slides and word documents of learning material.

In addition, some of the related works applied hybrid filtering. Hybrid filtering is a combination of collaborate filtering and content filtering. Liang [7] has proposed a personalized adaptive e-learning system based on collaborative filtering and content based filtering but in this recommendation system, data mining techniques play important role. Learning contents are gathered using data mining techniques. Khribi et al. [16] employed hybrid filtering for their recommendation algorithm. Web mining techniques and search engine (Nutch) were used for content modeling in their recommendation system. They extracted learner profile and content based profile respectively by web mining and information retrieval techniques.

Another technique for recommendation in related topics is "Rule". E-learning recommendation in this framework is based on *Semantic Web Rule Language* (SWRL) [6]. This research was based on learner goal(s). Three kinds of goals were defined in this framework. Recommendation system recommends learning content based on learner goals. These goals specify the learning path. However, research did not mention the levels of learner's knowledge. This approach employs the quiz parameter to evaluate learner.

Shen [17] presented learning content recommendation based on ontology where sequencing rules were used to connect learning objects. The rules were created from the knowledge base and competency gap analysis. Henze et al. [18] proposed a framework to observe personalization in e-learning system based on ontology. They created user ontology, domain ontology and observation ontology. They also used reasoning mechanism over distributed Resource Description Framework (RDF) annotation. The query rule language used in this system is Triple.

Yu et al. [19] proposed a recommendation system based on ontology. This recommendation system works for context aware e-learning. They employed semantic relevance to offer

recommendation list after refining some of the items. This recommendation is graph based.

Other of related works applied data mining technique to build recommendation system. Zaiane [20] employed data mining technique such as rule association to build a software agent. User can use this recommender to find related materials or related web sites. This recommendation is based on user behavior. In addition Tai et al. [21] have designed an e-learning recommendation based on self-organizing and data mining techniques. They used neural network to find out cluster of learners. Sieg et.al [22] and Gao et.al [23] used similar approaches which is spreading activation model to discover user's interest in their recommendation systems. These researches demonstrated how to generate user profile and create the user ontology.

To summarize, a comparison between various systems is presented in Table 1.

TABLE I. COMPARISON OF E-LEARNING REOMMENDATION SYSTEMS

Recommendation technique	Refer to References	Learning Contents resource
Collaborative filtering	[13], [14]	Ontology based.
	[2]	Ontology based.
	[11]	Indeterminate.
	[12]	The web access logs, course information, and course rating scores.
Content filtering	[15]	Set of presentation slide and documents.
Hybrid filtering	[7], [16]	Data mining technique to gather learning content.
Rule filtering	[17]	Ontology based, sequencing rules.
	[6]	Ontology based SWRL rules.
	[18]	Ontology based, Triple rules.
Graph based	[19]	Ontology based.
Data mining techniques	[21], [20]	Data mining algorithm.
User ontology and Spreading Activation Model	[22],[23]	Ontology based.

B. Problems with e-learning recommendation systems

There are several shortcomings identified in previously discussed systems.

- he most important problem related to learning content is content gathering. Data mining is one of the approaches used to mine user profile and find learning contents from databases [7, 16]. However, this approach is not reusable. Usually, in this approach, it is better to gather data for any systems individually even though these systems have the same data. There is contradiction with the e-learning systems which requires sharing and reusability. The lack of reusability and share ability of current knowledge in e-learning systems is a problem. One of the main reasons for the lack of reusability is that assumption and performance of knowledge are not explicit. Ontology is an explicit specification of conceptualization [24] and it realizes knowledge sharing and reusability. A good e-learning system allows for reusability of learning objects, so we propose to solve this problem using ontology. Our framework will use the semantic web and ontology because, ontology enables data to be reusable and sharable due to its' structural nature.

- The previous related works which employed semantic web in their system used various techniques for recommendation. The commonly used techniques among them are collaborative filtering [12, 11, 13 and 4]. Collaborative filtering recommend learning contents to users based on similarity between user profiles. In this approach getting real rating for course material is difficult. The quality of recommendation in these systems depends on these rating. In addition this technique has "cold start" problem. Therefore this approach is not suitable for making an accurate recommender agent for e-learning activities. Hence, we propose rule filtering as recommendation technique. Rule filtering applies as predefined rules and rules are more accurate than ranking.

In this research, we will use three parameters to evaluate learners based on their performance and their knowledge level. Similar to previous works we will administer quiz to learners to evaluate their performance [6] but quiz alone is not sufficient for evaluation since answering quiz depends on types and number of questions beside time constraint. Therefore, time spent on current topic will also be measured. Furthermore, based on this time and quiz results, the performances of learners will improve. All the knowledge level of learners will also be evaluated.

IV. SCOPE OF RESEARCH

This paper proposes a model for semantic recommendation systems in e-learning. To create a recommender system is necessary to define personalized technique and recommendation algorithm. Hence, semantic web technique will be used to personalize the recommendation. Ontology is backbone in semantic web, so ontology will be used to present our learning contents. Our rule based system is based on OWL rules and will employ the inference engine according to our rules. In the framework, the *Observer* will evaluate learner's performance. Evaluation in current system is based on quiz andTtime. The observer will measure how long user spends time to learn the current topic. The system also administers and evaluate quiz to learner. Finally, observer estimates learner's performance according to result quiz and amount of time spent. In addition to performance evaluation, the system will also evaluate learner's level of knowledge. One of the most important features of our proposed system is the learner profile. Learner profile consists of learner history, learner knowledge and learner characteristic. Some of these characteristics will change during the learning process. Learner profile will update all changes in the system.

V. PROPOSED SYSTEM ARCHITECTURE

Our recommender system has two sub-systems; *Semantic Based System* and *Rule Based System*. In addition other modules are; *Observer*, *Learner' profile* (history, knowledge level and characteristic), *Recommendation storage* and *User interface*. These modules participate in two sub-systems. The architecture is presented in "Fig.1".

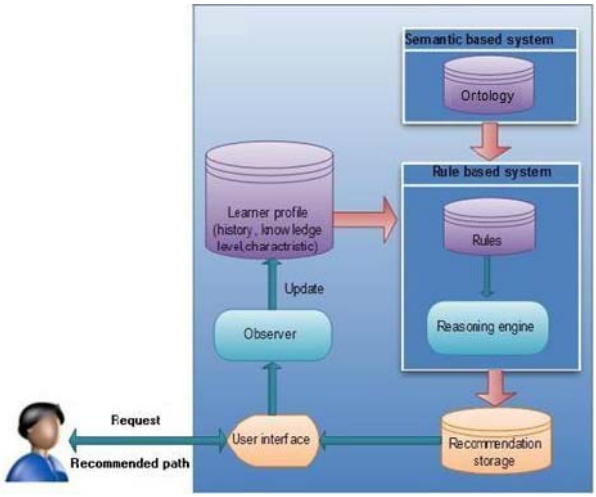

Figure 1. Architecture of proposed e-learning recommendation system.

A. Semantic based system

This subsystem is the most important part in the proposed system because it consists of all semantic knowledge about material contents. This subsystem consists of just the ontology.

1) ontology

The ontology describes materials related to our domain in e-learning and semantic relationship between them. The W3C recommendation ontology language and OWL (Web Ontology Language) will be used to represent this ontology.

B. Rule based system

This subsystem consists of two parts. One of these parts is related to define Rules and another one is Reasoning engine.

1) Rules

This is a rule based recommendation that defines some rules for the system. These rules are based on OWL and define according to object properties and facts in ontology and also learner profile.

2) Reasoning engine

The Reasoning Engine is the main core in this sub system. This engine will process all defined rules and execute them. In this part there is reasoning for the proposed ontology.

C. Recommendation storage

When the learner login to the system; a request is presented. System evaluates learner's knowledge level then recommends some materials based on learner's knowledge level and the request. These recommendations will be stored in recommendation storage, and then in the Observer which refines them based on some parameter.

D. Observer

Observer refines all contents in recommendation storage using learner performance evaluation. Learners have to pass all prerequisites for each material they want to learn. All contents in recommendation storage are locked until learners pass their prerequisites. These relations between materials are available in ontology. Observer will evaluate learner's performance by using quiz score and time spent reading the current page. The result of these evaluations changes learner's profile. If learners have a good level in evaluation then they can move to next page of materials, otherwise they have to stay in the current page and relearn the materials.

The system recognizes the type of learner problems based on the result of evaluation. The first problem returns the amount of reading time, so, system will divide the current page to some short pages and offer these pages to learner. The second problem is based on result of quiz. For this type of problem the system will recommend some examples similar to the quiz contents. Learner can request from the system some examples or more quizzes from every material. Finally, all learning process for learners is based on their performance in the system. Learner profile will updates dynamically based on these changes.

E. Learner profile

Learner or user profile is very important in adaptive e-learning system. Learner profile in the proposed system consists of learner knowledge level, learner characteristics and learner history. Learner characteristic include all personal information about the learners. When the learner login into the system for the first time; a questionnaire about the personal information need to be completed. Learner's knowledge level specifies the learner knowledge in our domain. Knowledge level will be evaluated based on predefined rule in the system. Learner history consists of all materials that learners have mastered and the results of their quizzes. User profile will be updated automatically after any change in learner history.

F. User interface

At the first time, learners ask their request using user interface finally they will get their recommendation by user interface. So we will design a graphically user interface for learners to will have best transaction with system.

VI. CONCLUSION

Web-based learning environment plays an important role in today's education. As the amount of electronic course content becomes very large, providing personalized content recommendation is a significant functionality for today's e-learning systems. The recommender system can provide from a technical point of view, useful resources and tools making easier the learning resources design activity. Thus, it assists learners to choose the most suitable method. Also, it offers the possibility of accurate user monitoring and evaluation during the learning process. This research, propose to use a semantic

web based recommendation approach using ontology and rule. The proposed rule based system consists of predefined rules and rule engine. In the next stage the system will evaluate learner's knowledge and learner's performances. The system will then present recommendation list according to the results of learner's evaluations and profile.

VII. Future Works

For future work, we will create ontology for learning contents in Visual Basic.net programming language and design a rule based recommendation system based on this ontology.

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