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Designing learning management system interoperability in semantic web

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Abstract. The extensive adoption of learning management system (LMS) has set the focus on the interoperability requirement. Interoperability is the ability of different computer systems, applications or services to communicate, share and exchange data, information, and knowledge in a precise, effective and consistent way. Semantic web technology and the use of ontologies are able to provide the required computational semantics and interoperability for the automation of tasks in LMS. The purpose of this study is to design learning management system interoperability in the semantic web which currently has not been investigated deeply. Moodle is utilized to design the interoperability. Several database tables of Moodle are enhanced and some features are added. The semantic web interoperability is provided by exploited ontology in content materials. The ontology is further utilized as a searching tool to match user's queries and available courses. It is concluded that LMS interoperability in Semantic Web is possible to be performed.

1. Introduction

In recent years, e-learning systems have become very popular in all fields of higher education. The internet and web technology offer great solutions for presenting, publishing and sharing learning content and information. The extensive adoption of e-learning across the World Wide Web (WWW) has set the focus on the interoperability requirement, especially in terms of learning resources across different Learning Management Systems [1]. LMS is a high-level strategic solution for planning, sharing, and managing all learning processes within an organization, including online, virtual classroom, and distance learning [2]. In addition, interoperability is the ability of different computer systems, applications or services to communicate, share and exchange data, information, and knowledge in a precise, effective and consistent way. Interoperability is required to build the knowledge-intensive, open and accessible learning services [3,4].

Recent developments of LMS specifications such as Learning Object Metadata (LOM), Shareable Content Object Reference Model (SCORM), Learning Design and other pedagogy research in semantic e-learning have presented an inclination of Semantic Web technologies to encourage existing content-focused learning services to semantic-aware and personalized learning services [5–7]. Ontology-based technologies and intelligent agents are expected to support semantic information processing on Semantic Web. Most LMSs currently work in a closed system. Some systems still operate their own framework for learning content description rather than adopting the standard LOM. The concept of course, student, educational resource, summary or grade must be formally described in order to be shared among all the systems in an educational institution [5–8]. These interoperability issues affect the flexibility of the teaching-learning process and head to a decrease in end-user satisfaction and learning success.

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Some studies have been conducted to satisfy the completeness of LMS in university [1,3–11]. Previous research used the concept of synchronization between learning materials in LMS. However, students are unable to follow courses at another university. Only administrator can perform the synchronization. On the other hand, lifelong learning networks must be able to connect some LMSs without any access restriction for users. Semantic web technology and the use of ontologies are able to provide the required computational semantics and interoperability for the automation of tasks in LMS. Semantic Web is a collection of standards, data structures, and software that improve the online experience more detailed and intelligent. The Semantic Web offers students the possibility of having a rich of related content delivered to their desktop without explicitly identifying or requesting it. However, studies about LMS interoperability in the semantic web has not been exploited deeply. Therefore, this work proposes a design of LMS interoperability in the semantic web.

2. Design of LMS interoperability in semantic web

2.1 LMS design

This work assumes that there are four types of the operator for proposed LMS interoperability. They are portal and local administrators, lecturers, and students. Portal and local administrators are responsible for managing a central server that regulates LMS metadata and managing LMS for each university, respectively. Students can find and enroll in their university's LMS as well as they find and join the course from other universities' after paying tuition fees. Lecturers will be part of the LMS after they have been enrolled in university's LMS as a lecturer. They can teach students from other universities. In addition, lecturers can create new course materials. The design of proposed LMS is depicted in Figure 1. This design refers to Moodle context design which consists of three main components: users, front page, and course category.

2.2 Database design

Database design of proposed LMS interoperability is adjusted from Moodle table with some additional tables. Table relationships are depicted in Figure 2. Tables are grouped according to their functions. Group A is an association of tables to store user information (administrator, lecturers, and students). Group B and C respectively are an association of tables to store payment data and serves as a course table group. User log data is stored in group D. In addition, Group E is responsible for managing students' grade data while group F is to classify users and courses. Finally, group G is used for managing the student assignments and table H is to store information of university local-LMS.

2.3 LMS interoperability design

As aforementioned, portal and local LMS layers are proposed in this work. Local LMS only contains web services, while data services are on the portal. The user must log in with a username and password to access portal LMS through local LMS. The system then searches which university has that username and password and verifies them. If the login is successful, the user is registered and listed in `mdl_log`. If a user searches for the desired course, the system will find the course storage and display the search results. If users want to access the course, it will check the user's role as a lecturer or student. Another condition is if the user is a student then it will check the completeness of a course requirement including tuition fee payment as show figure 1 below:

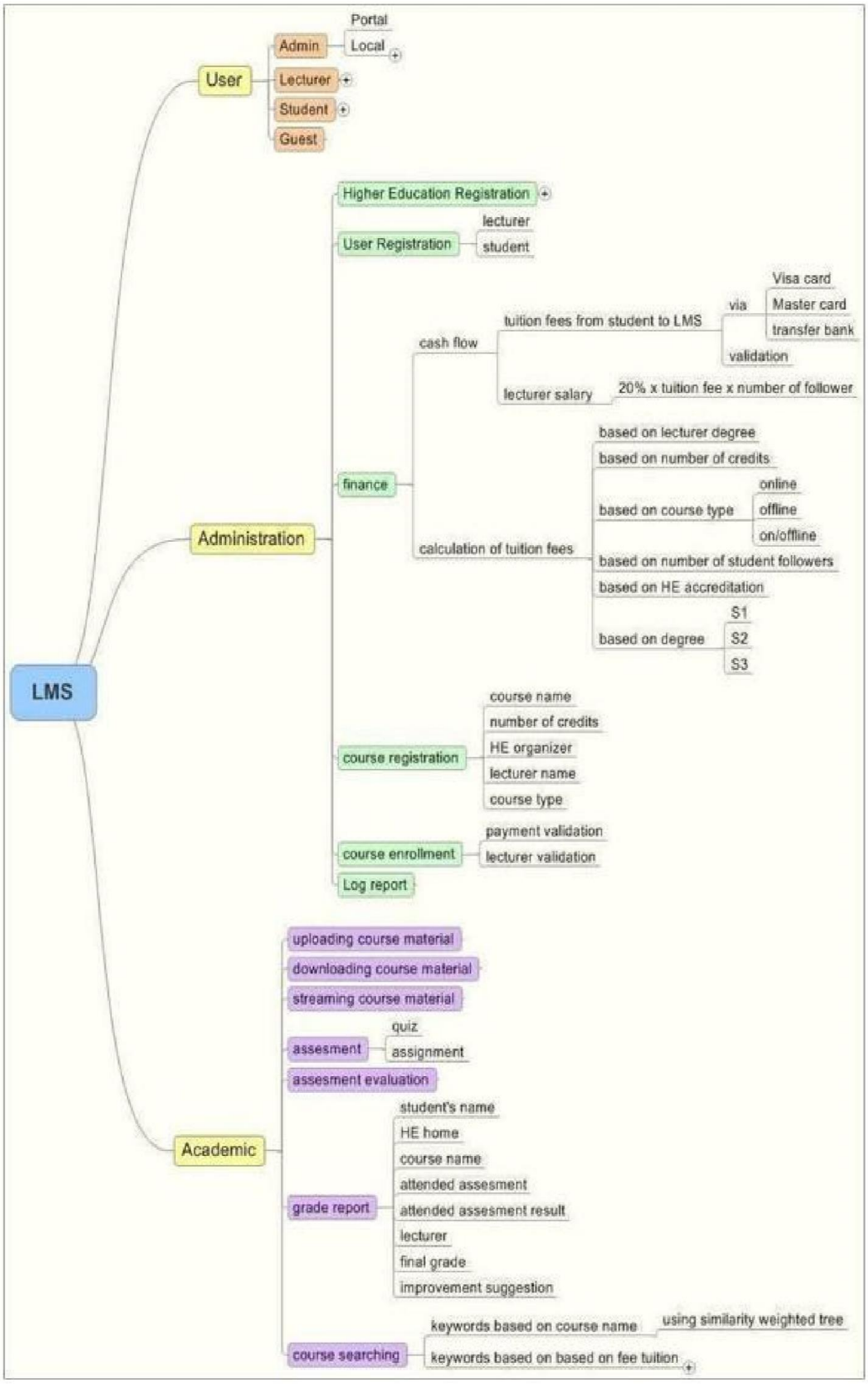

Figure 1. LMS design

Content is assumed as web service in local-LMS since it is an API Web (Application Programming Interface Web) that is accessed by HTTP. The first step, a user must be authenticated by the LMS through a login process. After has been successfully authenticated, the user can log in to LMS and connected to the portal. Users can search for desired courses. The searching process is performed through weighted ontology or other artificial intelligence methods. LMS then finds related courses displays the results. Finally, students can perform various activities such as courses enrolment, discussions, downloading materials, uploading assignments, doing assessments, and following streaming courses as show figure 2 and 3 below:

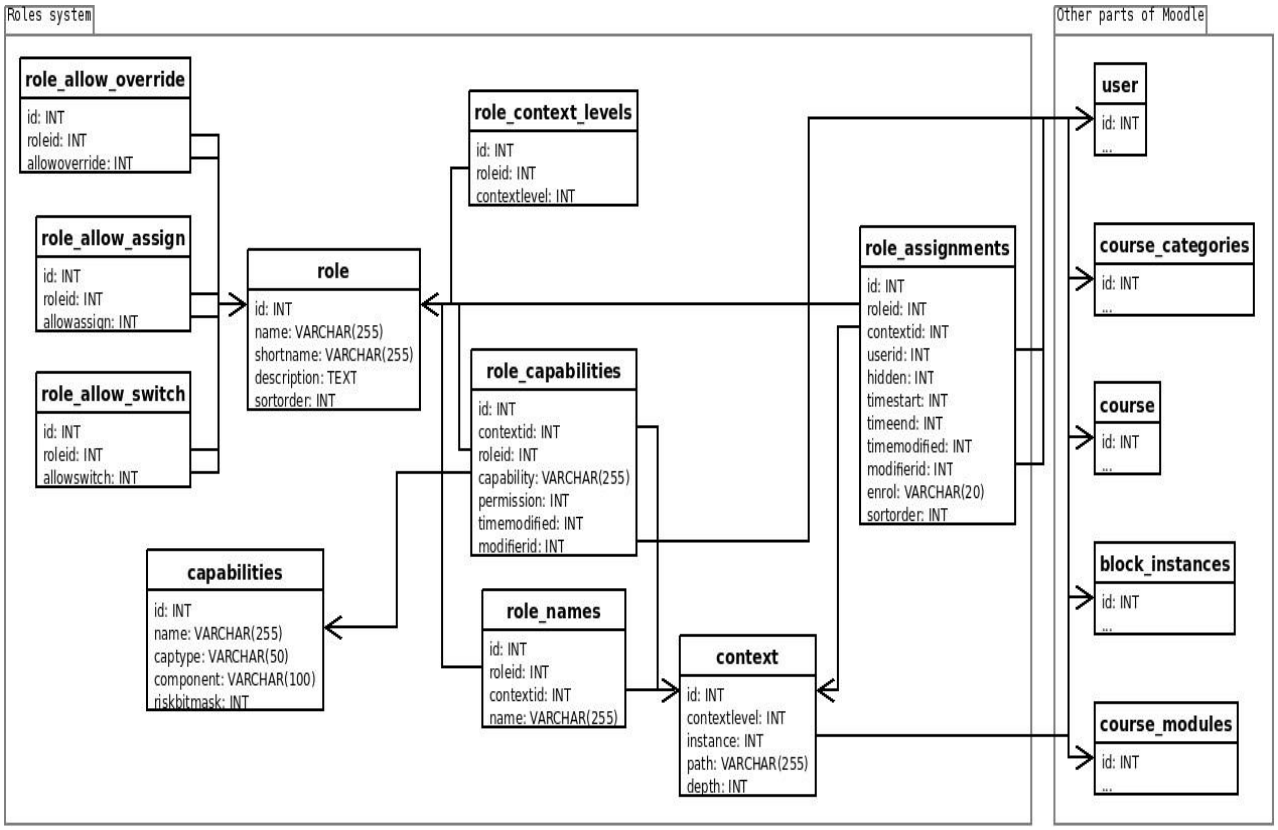

Figure 2. Moodle tables relationships

In this work, semantic search and matching for course subject developed using weighted ontology. Searching and matching tools can provide contextualized queries and searches across repositories of teaching material or repositories in different local-LMS. Furthermore, searching and matching tools are suitable for revealing university capability to the outside world to attract student enrolment. Weighted ontology [11] is built on Learning Content Management System.

Each stored document is extracted and is weighted based on term density which is formulated in (1). The more relations that a term has, the greater weight it has. Let's assume *in(c)* and *in (o)* are in-degree of the concept (c) and in-degree of all layered structure, respectively. Furthermore, let's denote *out(p)* and *out(o)* as outdegree of the concept (p) and out-degree of the hierarchical structure.

$$w_{(c)} = \frac{in(c) + out(p)}{in(o) + out(o)} \tag{1}$$

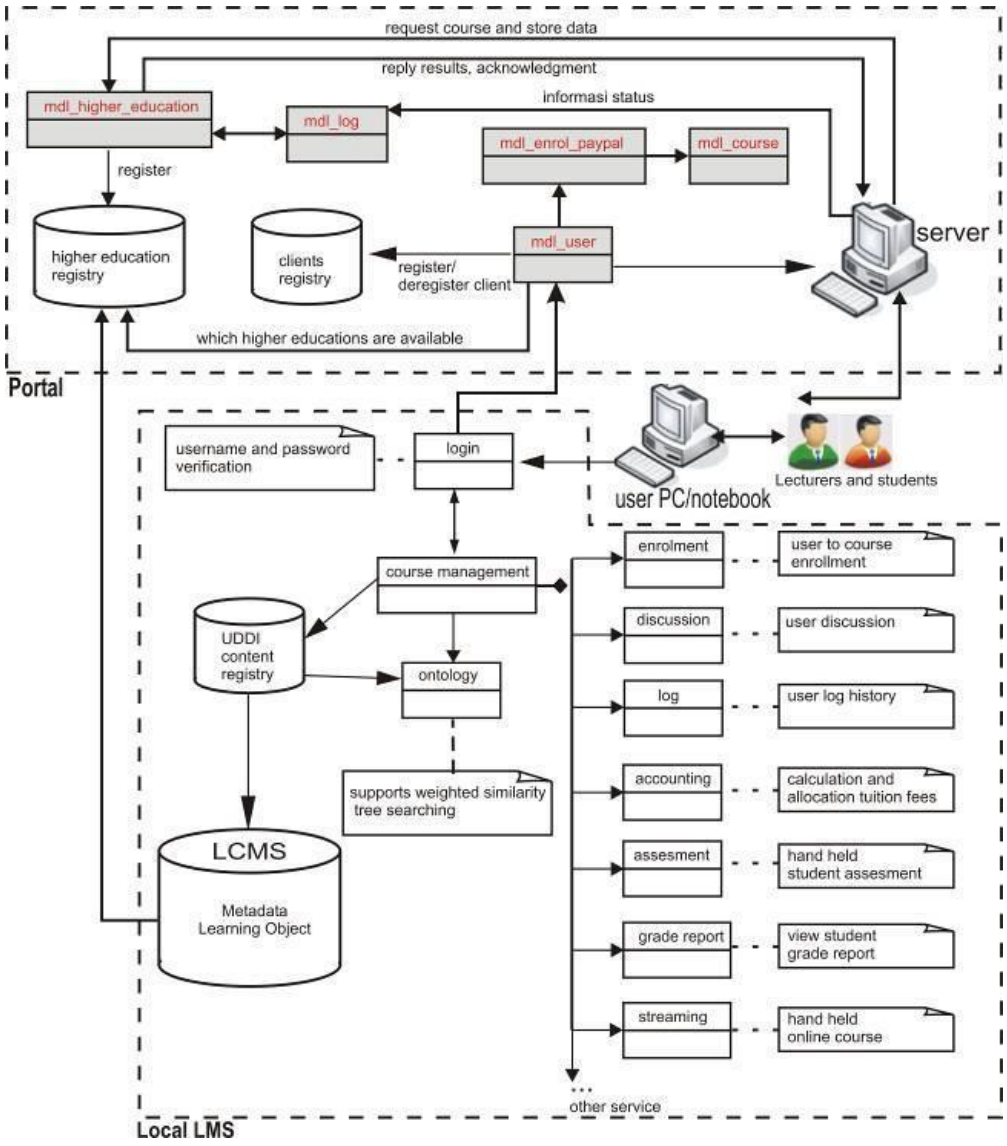

Figure 3. LMS interoperability design

Matching process between two ontology or more is referred to multiple matching. Multiple matching is assumed as *f* function that matches ontology $\{o_1, o_2, \ldots o_n\}$. An input alignment *A*, a set of parameter *p*, and a resource *r* produce an alignment *A'* among those ontologies. Therefore, $A' = f\{ o_1, \ldots, o_n, A, p, r\}$.

3. Conclusion

This paper proposed a design of learning management system (LMS) interoperability in the semantic web. The proposed interoperability is applied in Moodle as an LMS. Supplementary tables added to provide the capability of LMS interoperability in the semantic web. The semantic web interoperability in this work is provided by using an ontology for content materials. The ontology is further utilized as a searching tool. If the previous tuition fees are determined subjectively (no reference to determine tuition fees), in this study tuition fees are calculated based on lecturer education, course taught by teams or individuals, the number of credits, types of classes (online, offline, or on/ offline), accreditation of universities, and the number of enthusiasts. This study also calculates the financial results of the distribution of tuition payment. Tuition payments can be paid via credit card or bank transfer. Obviously, LMS interoperability in Semantic Web is possible to be performed. The next step of this work is to apply this proposed design.

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