Collaborative learning using service-oriented architecture: A framework design

Chua Fang Fang *, Lee Chien Sing

Multimedia University, Faculty of Information Technology, Persiaran Multimedia, 63100 Cyberjaya, Selangor, Malaysia

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ABSTRACT

Collaborative learning serves as an important part of e-learning, increasing interactivity and accessibility to various learning resources either synchronously or asynchronously among users. Distributed interactivity through Web services thus forms the focus of this paper. The paper reviews related work on service-oriented architecture (SOA), distributed infrastructure, business process management (BPM) and highlights the need to integrate SOA technologies for meaningful and interactive collaborative learning processes. The significance of the study is an SOA approach to enhance the interoperability, flexibility and reusability of e-learning content in a collaborative environment.

1. Introduction

Service-Oriented Computing (SOC) is widely accepted as a new paradigm for delivering useful functionality in a cost effective way. It forms a new trend to be adopted by organizations in mitigating legacy system problems as in to maximize interoperability, reusability, flexibility and cost efficiency. Service-oriented architecture (SOA) is suitable for modularization, and the resulting SOA-framework can be used as a basis for implementing specialized e-learning services, specified by future standard frameworks and reference models. Grewal et al. [1] presents a model of Web Services-based e-learning lifecycle. The lifecycle defines all the functionality needed for the interactions between the service provider and the service requester. Many research have identified and created common services, which are essential for the creation and authoring stages of a typical e-learning system.

1.1. Problems to be addressed

SOA research has mainly dealt with code reusability in LMS and less on its use for collaborative learning. There is a need to realize the SOA design in the e-learning domain as there is not much implementation done based on the designed models or architectures. For this paper, our scope focuses on designing the scope of services and business processes, which are to be published in the service registry. The business processes are directly dealing with collaborative activities from the consumer (learners') perspective.

The research questions for this paper are:

(1) How can SOA (conceptually and technically) be designed to allow flexible interaction between different components in LMSs in enhancing collaborative learning environments?
(2) How can we utilize business process management (BPM) to manage learning processes?

The outline of the paper is as follows: Section 2 presents related works on service-oriented architecture and its benefits to e-learning. Section 3 focuses on related works concerning business process management. Section 4 presents our proposed collaborative learning framework design using a Web Service approach. The paper is concluded in Section 5.

2. Related work on SOA

2.1. Why SOA?

The typical learning management system is built based on a component-based architecture. However, Web services provide a better alternative as services are loosely coupled and can be subscribed anytime any place. Furthermore, leveraging web standards in an e-learning environment will allow the dynamic integration of applications distributed over the web and encourage reuse of learning objects. An example of the significance of Web services is in the context of collaborative learning. According to Chang et al. [2], collaborative learning focuses on generation of interaction, assessment and collaboration in the team environment and involves five phases: co-presence, awareness, communication, collaboration and coordination. In their work, Chang et al. [2] have integrated both web services and workflow technology to

* Corresponding author. Tel.: +60 383125406; fax: +60 383125264.
E-mail address: fang2x81@gmail.com (C. Fang Fang).

construct a workflow-based learning environment, which helps to facilitate collaborative learning more efficiently and effectively.

2.2. Benefits of SOA to e-learning

Wilson et al. [3] explains the potential benefits to the e-learning community in adopting a service-oriented framework approach to infrastructure development. There has been a shift from monolithic application silos towards service-oriented approaches where flexible granular functional components expose service behaviors accessible to other applications via loosely coupled standards-based interfaces. In a service-oriented approach, the application logic contained in the various systems across the organization is exposed as services, which can then be consumed by other applications. Another benefit is that a learning environment consists of a dynamic mix of many different types of resources and facilities, which should be aware of, and adapt to, the learner in his/her current context [4]. This multiplicity of technologies and situations demands a service-oriented approach. Collaboration and contextualization are important pedagogical goals, and must therefore be supported through services, which can be created and modified dynamically to suit the current needs and situations of learners. Some of the pedagogical features associated with good educational practice in learning environments that can be included are Collaboration, Ubiquity and Accessibility, Experiential and Active Learning and Realism [4].

3. BPM and e-learning

Helic [5] discusses the possibilities of using BPM technology for the management of collaborative learning processes. The generic learning processes framework is shown in Fig. 1.

Business process is a set of linked activities that create value by transforming an input into a more valuable output. Typically, e-learning adopts content-oriented, tool-oriented or the task-oriented approach [5]. However, none of these approaches deals with the learning process itself, but addresses only certain parts of such a process. The author in [5] highlights the dynamics of collaborative learning process where there are typical changes in external factors and consequently, impact on learning processes. Since there are close connections between collaborative learning processes and business processes at a number of levels, basing management of collaborative learning processes on BPM technology will bootstrap its development. Therefore, research needs to be conducted to realize successful application of BPM in learning process management. They have thus suggested the following:

- Step 1: Modeling of collaborative learning processes should be supported. (Using BPMN or UML.)
- Step 2: Mechanism for the mapping of conceptual learning process onto their executable counterparts should be introduced.
- Step 3: Seamless integration of run-time execution procedures and a general e-learning system must be achieved. e-Learning functionality might be exposed as a collection of interoperable services and through open standards accessible functionality, e.g. in the form of Web Services.
- Step 4: Seamless integration of work list user interface with the existing user interface of an e-learning system must be achieved.

In supporting the point of view that learning objects are suitable for Web services, Paquette et al. [6] justifies that in a service-oriented approach, the application logic contained in the various systems across the organization, such as student record systems, and LMS are exposed as services. Each service can then be utilized by
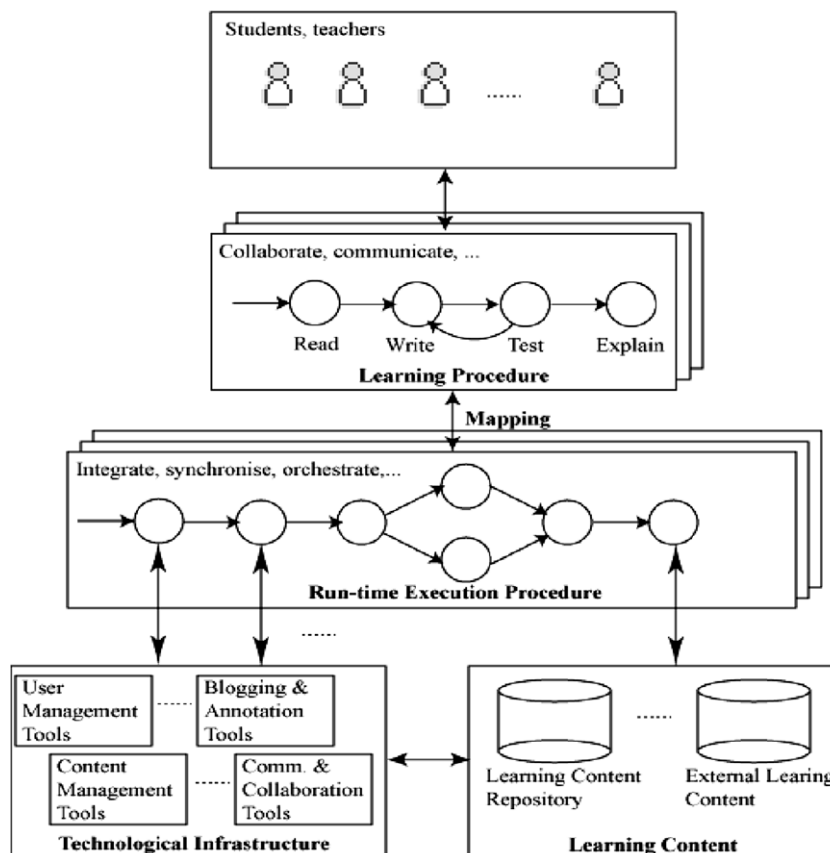

Fig. 1. Generic learning processes framework.

other applications. For example, a student record system may expose services defining student enrolment and registration processes, which can then be used by an LMS. SOA is a design framework for construction of information systems through combination of services [7]. A service is a program unit which can be called by standardized procedures, and which can independently execute assigned functions. From the literature reviewed above, it shows that while there are theoretical work being performed on SOA frameworks and architectural models for e-learning, there are still not many implementations to be found.

4. Collaborative learning framework design using SOA

The uses of learning objects, which can benefit from SOA, are such as Reusability, Interoperability, Accessibility and Modularization. Thus, different components/learning objects can be implemented as Web services so that the system components and content can be distributed all over the Web, and by different service providers. Section 4.1 explains how the SOA methodology can be used in designing the collaborative learning framework. Further details are provided in Section 4.2.

4.1. SOA methodology

Our methodology is as follows: First, from the given service requirements, we identify the business process which includes collaborative activities. All the possible workflows are identified. Then from the business process, we identify the reusable service(s), which are to be invoked and composed later.

4.1.1. Service requirements
Service requirements, which contain service functionalities and non-functionalities, can be analyzed using Unified Modeling Language (UML). The business process identified from the service requirements can thus be represented using Business Process Modeling Notations or Activity Diagram.

4.1.2. Service design and execution
As shown in Fig. 2, the Application UI layer represents the presentation layer for the clients. Orchestrating and invoking the required services provided by the service provider execute the business process. The application UI can be the client program, which discovers and invokes the business processes or services from the service registry. The services being invoked can be a single service or a composite service depending on the user learning goals. As users vary according to ability, prerequisite knowledge,

learning pace and learning objectives, it is ideal to provide customized e-learning services to them. The business process is represented using BPMN or activity diagram while the business process language is represented using BPEL. The services, which are published to the service registry can be discovered and invoked through the interface-WSDL.

4.2. Detailed collaborative learning framework design using SOA

Our collaborative learning service design is illustrated in Fig. 3. Explanations are in the subsections.

4.2.1. Identifying business process (BP)
In the e-learning scenario, activities can be perceived as processes or workflows. It represents a series of tasks or activities to be executed to achieve the individual or group learning goals. The processes in the e-learning context are similarly related to the BPM context. BPMN or activity diagram can be used to represent the workflow/scenario/e-learning activities. Functionality can be reconstructed through suitable service compositions. There are several BPs, which can be performed but we only focus on a few in this paper. The candidate business processes are such as achieving learning goal through learning companion, searching for available services, creating the concept map and communicating with the other users. Two possible business processes are being represented using BPMN as follows:

4.2.1.1. Business process 1.
The learners search for information from the knowledgebase and discuss the learning tasks with peers.

4.2.1.2. Business process 2.
The learners seek assistance from a tutor while chatting.

4.2.2. Identifying services
The components for collaborative learning implemented as services in SOA consist of Login, Content Authoring, Chat/Discussion, Concept Mapping, Tutoring, and Learning Companion Services. We will only focus on the four main services. For further details, please refer to the subsections as follow.

4.2.2.1. Chat/Discussion service.
Chat/Discussion service allows the interaction between the learners whereby they can collaborate through discussions to achieve the learning goals. This also enables externalization of knowledge and ideas among the collaborating community thus creating a more interactive environment by integrating from different perspectives and views. Learners need to
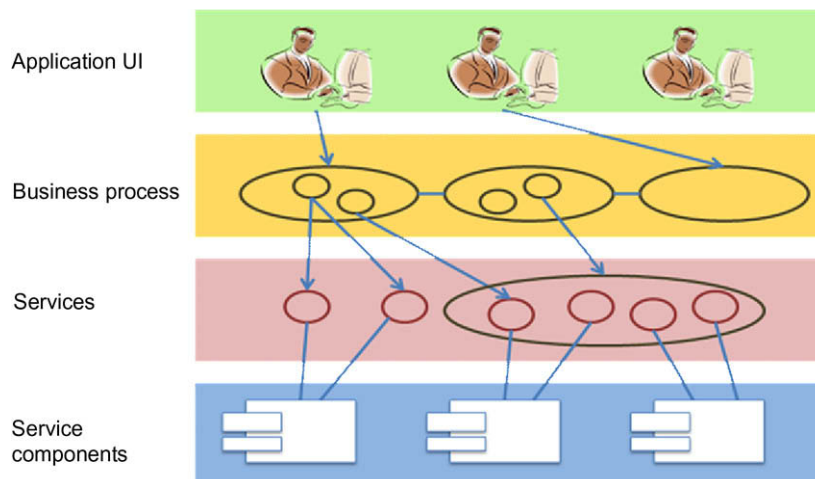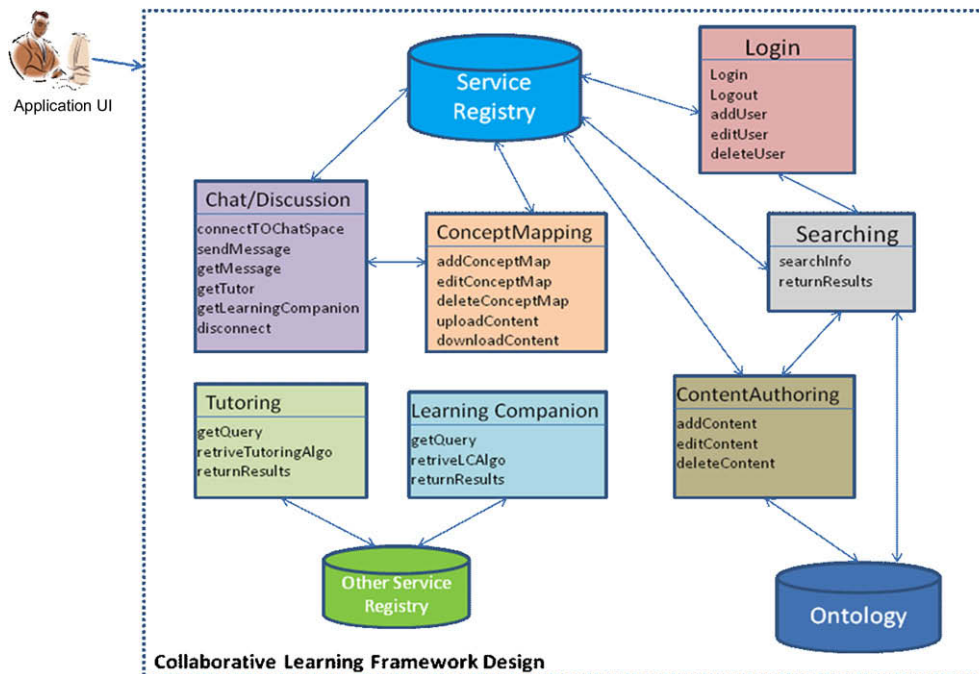

Fig. 2. SOA layers.

Fig. 3. Overall services design.

connect to the chat space before they send and receive chat messages.

4.2.2.2. Concept mapping service. Concept map is a learning tool to facilitate meaningful learning as it provides a graphical template in constructing knowledge. Similar to flowcharts, the Concept Mapping service provides a common visualized workspace for the users to share their ideas and at the same time allows the learners to download/upload the files from the system.

4.2.2.3. Tutoring service. The tutoring service serves as the agent to encourage learners in participating in collaborative problem solving. Besides that, it also serves the purpose to assist learners when they face difficulties in using the available services. It includes the hinting strategy to guide the collaborative learning process.

4.2.2.4. Learning companion service. Learning scaffolds can be simulated as two coexisting agents, a teacher and a companion. The two agents, the computer teacher and the computer companion, together with the human student, form a three-agent learning model, which is called the Learning Companion System (LCS) [8]. The learning companion plays the role of a human student companion in learning. The learning companion agent plays the role of a peer, which learns together and interacts with the learners throughout their collaborative learning activities.

5. Conclusion

Many of the collaborative learning systems are mainly based on client-server architectures, which give rise to the problems of poor flexibility, scalability and interoperability. Collaborative learning using Service-oriented architecture, which serves as a novel approach in the e-learning domain, helps in distributing the learning content more efficiently and promotes reusability. Most research has not addressed the implementation aspects. This paper has addressed the implementation details for the service design aspects, incorporating Web-service BPM and e-learning. The proposed framework using the Web Service approach will increase the efficiency and effectiveness of collaborative learning in terms of Reusability, Interoperability, Accessibility and Modularization.

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