2009

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Abstract

E-learning has evolved dramatically in the past decades. With the emergence of more and more advanced technologies such as Web services, development of light weight, flexible, and intelligent E-learning systems becomes a reality. This paper proposes a novel architecture for E-learning systems based on Web services and intelligent agents. This architecture provides a flexible integration model in which all the learning components and applications are loosely connected and can be distributed on the Internet. In addition, through the use of agents, learning content can be intelligently customized to fit the context and the special learning needs of particular users.

Disciplines

Physical Sciences and Mathematics

Publication Details

Wei, X. & Yan, J. (2009). An e-learning system architecture based on web services and intelligent agents. International Conference on Hybrid Intelligent Systems - Volume 2 (pp. 173-177). Shenyang, China: IEEE.

2009 Ninth International Conference on Hybrid Intelligent Systems

An E-learning System Architecture

Based on Web Services and Intelligent Agents

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Abstract — **E-learning has evolved dramatically in the past decades. With the emergence of more and more advanced technologies such as Web services, development of light-weight, flexible, and intelligent E-learning systems becomes a reality. This paper proposes a novel architecture for E-learning systems based on Web services and intelligent agents. This architecture provides a flexible integration model in which all the learning components and applications are loosely connected and can be distributed on the Internet. In addition, through the use of agents, learning content can be intelligently customized to fit the context and the special learning needs of particular users.**

Key words: E-learning system architecture, intelligent agent, Web services.

I. INTRODUCTION

E-learning, as an efficient and flexible method of learning and teaching, has drawn more and more attention from researchers and practitioners in the past decades. With the popular acceptance of E-learning, there are already about 1 million courses on the Internet today with many of them making didactic use of the World Wide Web [1]. At the same time, learning software, tools, and platforms have been increasingly developed as well. E-learning conveys a great amount of arranged solutions via the Internet in order to promote acquirement of knowledge and performance of learners. With the support of E-learning systems, learners and instructors can interact more efficiently to achieve better learning results [3].

From Computer Based Instruction (CBI) to Intelligent Tutorial System (ITS), and from online learning to mobile learning, many E-learning content and applications have been developed by different vendors. As these software and tools are generally developed independently with different technologies, it becomes difficult to share data and to interconnect heterogeneous systems [2]. Most existing E-learning systems are based on plain monolithic client-server or peer-to-peer models. Therefore, they suffer from drawbacks like poor scalability or complicated interchange of content [4]. These E-learning systems' functional modules are tightly coupled. They are often able to integrate the homogeneous products from their own company only. In addition, as the learning content becomes prosperous, the users will not be satisfied with getting materials from a single learning system. Actually, it is impossible for one E-learning system to provide all the learning materials to meet the needs of different users. Very often, users require learning content provided by several different learning systems to be composed and then delivered to them.

In the future, the E-learning system should have the ability to discover various learning content residing remotely on the Internet, and then to compose the distributed learning content and deliver customized content to the user. In this paper, we propose a novel E-learning system architecture based on Web services and intelligent agents. The proposed architecture supports loosely coupled, interoperable, flexible, intelligent, and personalized E-learning systems. The Web service technology is adopted in the proposed architecture to allow for the selection and integration of required functionality from a set of existing E-learning related Web services. At the same time, intelligent agents are used to enable personalized and intelligent delivery of learning content.

The rest of the paper is organized as follows. In Section 2, we introduce current state-of-the-art of E-learning and the related technologies, namely Web services and the intelligent agent technology. Then, in Section 3, an architecture for E-learning systems are proposed and discussed in detail. Finally, in Section 4, the paper ends with conclusion and remarks on future work.

II. BACKGROUND

A. E-learning

The concept of E-learning originates from distance learning. In the past, many vendors developed E-learning systems for different purposes, and using different tools. The data and

978-0-7695-3745-0/09 $25.00 © 2009 IEEE
DOI 10.1109/HIS.2009.147

application integration issues are hardly considered. Therefore, it is a burning question that how to provide loosely coupled, interoperable, flexible, intelligent, and more personalized E-learning systems which can reuse existing learning content on the Internet according to the needs of individual users. Many researchers and standardization bodies have dedicated to achieving this. IEEE [15], ADL [7] and IMS [6] have published some standards and specifications in E-learning, defining [5],

- Metadata (for labeling the learning content and catalogs)[15],
- Content packaging (for facilitating exchange of learning content between different learning system) [6][7],
- Learner profile (storing learner related information), [6]
- Learner registration (inform system what offerings should be delivered to learner) [6], and
- Content communication (communicate learner data and previous activity information to the content) [7].

Obviously, most standardization efforts focus on data integration but not on application integration. Complying with these standards, the interchange of educational content between servers or peers is till a problem which has not been solved satisfactorily [8]. It is necessary to develop a new E-learning system architecture which can integrate both data and applications. The next generation E-learning systems should have the following characteristics [9]:

- open architecture and interfaces,
- integration,
- loose coupling
- flexibility,
- reusability,
- maintainability
- compatibility, and
- personalization.

B. Web services and intelligent agents

Web services is a distributed middleware technology that uses a simple XML based protocol to allow applications to send and receive data across the Web [10]. It is interoperable, independent of operating systems and programming language, usable on different Web services engines, and can interact with each other [11]. Web services is a major trend in the industry for loosely coupled service-oriented architecture and interoperable solutions across heterogeneous platforms and systems [12]. The most fundamental standards for web services are Simple Object Access Protocol (SOAP), Universal Description, Discovery and Integration (UDDI), and Web Services Description Language (WSDL).

An intelligent software agent, in computer science, is a piece of software that acts for a user or a program in a relationship of agency [13]. The attributes of an agent are:

- Persistence: agents can run persistently without external command.
- Autonomy: agents can select the task and have the ability to decide the task priority without human intervention.
- Social ability: agents can communicate with other components via the agent language and cooperate to complete a task.
- Reactivity: agents can make corresponding reactions according to environment changing by perceiving the context.

Agents can usually be classified as intelligent software agents, autonomous agents, distributed agents, multi-agent systems, mobile agents, fuzzy agents [14]. Intelligent agents have been introduced ten years ago but it has gained popularity in the recent times because of the following two capabilities [17]:

- Ability to adapt. Once perceiving environment changing, agents can change the problem solution rules or algorithm, sometimes can discover new problem solving strategies to make a new reconfiguration. Adaptation also includes an agent's internal construction, such as recruiting processor or storage resources.
- Ability to learn. Agents can learn from the error and have the ability of introspection and analysis of behavior and success. From another aspect, agent can abstract and generalize from example.

Intelligent software agents are adopted in our E-learning system to provide personalization. Intelligent software agents can learn from users' interests, preferences, habits, behaviors, and learning-style, based on that proactive and personalized assistance can be offered to users.

III. ARCHITECTURE OF E-LEARNING SYSTEMS

A. architecture overview

Generally, there are several groups of people involved in an E-learning system, namely authors, learners, administrators and trainers. Authors and learners are main players [8]. In a traditional E-learning system, all the functional modules needed by users are resided in the server. In our proposed architecture, only a set of key functional modules will reside in the learning management server. Other assistanting functional modules will be distributed on the Internet and can be invoked on demand via standard interfaces. All the functional modules are implemented as Web services that can be easily integrated and reused. Therefore, the E-learning systems with this architecture are highly interoperable, flexible and light weight, and can be extended by choosing required functionality from E-learning related Web services remotely residing on the Internet according to the user's requirements.

As depicted in Figure 1, the proposed E-learning system architecture contains several basic services in the local server, which are detailed in the following.

- *Login service:* this service is responsible for the user login. Once the user login to the system, the login service will search the user profile database and communicate with the user agent.

- *User agent:* the user agent performs the following four functions:

a) react to login service and activate the search services,

b) approach the user profile to get or to store the user information,

c) depending on the searching result, the user agent will decide whether to communicate with the authoring service or not.

d) communicate with the content agent and exchange the information with the content agent.

- *Search service*: this service is responsible for searching proper content from the Internet.
- *Content management service:* this service can communicate with the content providers or the authoring service, and then take charge of content transferring and using.
- *Content agent*: the content agent plays two roles in the system:

a) determine what kind of content should be produced based on the level of the user, and

b) provide the information to the user agent to record the users' actions.

- Authoring service: this service is responsible for informing authors to develop the learning content and transferring content to the content management service.
- Delivery service: after the content agent prepares the content, the delivery service will deliver the proper content to the user.
- Other services: other services are assisting services for E-learning systems. These services are distributed on the Internet and can be used when needed.

From the above description, it is clear that the proposed system architecture adopts the Web services and the intelligent agent technology to achieve a personalized, flexible, intelligent, loosely coupled, and light weight system. The system maintains several main functional modules. Assisting services are distributed on the Internet and can be integrated into the system easily. Based on Web service oriented architecture, when these assisting services are needed, they can be discovered and invoked. As all learning objects and applications are wrapped as Web services and learning content will comply with the standards and specifications, all services can interact with each other freely and the content can be transferred and shared among them. As shown in Figure 1, the system does not have to maintain the learning content database. Learner profiles are stored in the system for personalization via intelligent agents. The agent records users' actions and uses these data and the data logged by the system to provide the customized learning content to different users. The user agent and the content agent work together and customize the content of E-learning according to user's knowledge, skill and needs. Through extraction of the user's actions, level of knowledge, and the learning style, the system can provide the information dynamically and personally. In the next section we will describe how functional modules work together to provide the system's functions.

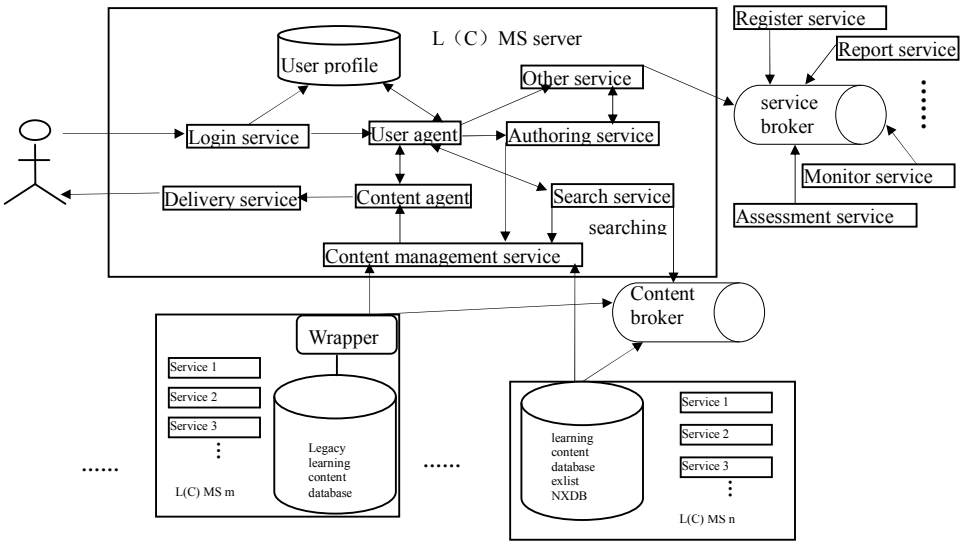

Figure 1. Architecture of E-learning system based on web services and intelligent agents

B. Interaction among functional modules

Each studying session must begin from the invocation of the login service. When a learner logins into the system, the login service will check the database and decide whether or not the learner is authorized to use the system. After that, the login service will communicate with the user agent and the user agent will take charge of the next step. The user agent will firstly access the user profile and get the learner status and the records. Then, based on the learner's information, the user agent will decide what kind of content should be searched from the Internet or developed by the authors for this learner. The user agent will invoke the search service to find the matching content from the content broker. As we mentioned earlier, the content developed nowadays is usually interchangeable because it is based on the universal standards and specifications such as ADL SCORM, IEEE LOM metadata, and IMS content packaging specifications. However, there is also a large amount of content that was developed before the standards. To make use of such learning content, a wrapper will be used to facilitate the content transformation and sharing. In the proposed system architecture, all content is registered in the content broker and could be searched by the search service.

If the search service finds the related content from broker it will return a true value to the user agent and send necessary information to the content management service. Subsequently, the content management service will use this information to communicate with the content provider and take charge of content transfer and using.

In the case that the proper content is not found, the search service will return a false value to the user agent. Subsequently, the user agent will communicate with the authoring service and provide some customized description about the learner's requirements. Then the authoring service will inform authors to develop the content needed. After the content is developed by authors, it will be transferred to the content management service.

After the content is made available by the content management service, the content agent will be responsible for the next step. The content agent will determine how to organize and handpick content based on the information of the learner. The content agent will receive the information and the request of the learner from the user agent. When the content is received by the content agent, it will customize the content according to learner's personal context and provide the information dynamically. For example, according to Felder's learning-style model, sensitive student like fact and data and experience but intuitive student prefers principles and theories [16]. So when a sensitive student studies a lesson, the content agent will get his/her information from the user agent and produce the learning content with more fact and data. However if an intuitive student is using the learning system then the content agent will produce the learning content with more theories and principles. Finally the content agent will send the customized learning content to the delivery service which will subsequently deliver the content to the student.

At the end of a studying session, the content agent will communicate with the user agent to provide the necessary information so that the user agent can record the learner's action. The user agent will save this information into the user profile database to record the particular user's context and update user profile database.

Different users usually have different requirements about the system functions. For example, some users may not need the system to provide the assessment function whereas other users may need both the assessment function and the reporting function. To meet different users' requirements, the proposed system will extend the functional modules in accordance with users' requirements. As each functional module is offered as a service by different service providers and published in the service broker, our system could search the service broker to find the right service and bind with service provider then invoke the service easily.

IV. CONCLUSION

Adopting Web services and the intelligent software agent technology in E-learning system enables the integrated, flexible, intelligent, personalized, and light weight system. Web service as a new technology becomes popular for its ability to achieve the loosely coupled distributed system. The intelligent agent technology is an effective method in providing intelligent and personalized system. We took the advantages of both technologies and presented a novel E-learning system architecture.

In the future, further research would be carried out to develop and implement the system. Design of the user profile database to satisfy the needs of the user agent is an important issue to be addressed. Additionally, detailed mechanisms will be designed to facilitate communication between agents and services.

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