An Extendable Open Source Architecture of e-Learning System

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Abstract—In this paper, we present an extendable open source architecture and model of an e-Learning system. The system composed of essential e-Learning core components and optional open source extensions. Open source extensions, developed and maintained by open source community, enhance the functionality of e-Learning system. In the other system components, the server side extension manager validates the portability, e-Learning standardization and security issues before approval of any extension to the community of the e-Learning system. The client side extension manager checks for new extensions/updates and allow/disallow these extensions/updates. The open source development process of system components can improve the security, reliability, quality and evaluation of the system.

Keywords—electronic learning; distance learning; system architecture; open source software; layered architecture; service oriented architecture.

I. INTRODUCTION

The exponential growth of Internet and impact of information technology on education and learning is very significant. The term e-Learning refers to the use of various kinds of electronic, information and communication technologies in education and training. Some other terms that are interchangeably used for e-Learning are technology-enhanced learning (TEL), computer-based training (CBT), internet-based training (IBT), web-based training (WBT), virtual education, etc. Collaborative tools and technologies, particularly, Web-based e-Learning systems increase the accessibility of learning resources and provide media rich contents to remote users 24/7.

Design through modeling of an e-Learning system needs investigation of the structure, behavior and architecture of the system in the early stages of development. The integration of e-Learning components in the IT infrastructure and web services requires building of software modules and interfaces compatible with existing environment [1, 7]. At present most of the e-Learning systems are rigid in a sense that users have no freedom to extend the functionality of the system, any enhancement or update is solely provided by the vendor. Further to restrict the users’ freedom, in the propriety e-Learning systems the source code of system components is not available for evaluation, testing and modification. The objective of this paper is to present an architecture of e-Learning system that is extendable in a sense that functional components, we called them extensions, are open source and can be integrate into an existing e-Learning system. The initial e-Learning system is simple and composed of core modules or extensions. Based on user or institution requirements addition components (extensions) are integrate into the existing system.

Almost all the architectures of e-Learning system can be elaborated from two perspectives. One perspective is division of e-Learning system into different layers. For example, well know three-tier-architecture has three layers namely presentation, logic, and data. In the context of e-Learning, presentation layer is user interface, logic layer provides the main e-Learning functionalities, while data layer stores user and course data. A layer can be further split into more layers, e.g., a network (Internet/Intranet) layer can be added to separate the user interface from the e-Learning software on remote server. The second perspective is to view the e-Learning system as set of services between different parties. For example, a service oriented architecture classify an e-Learning system into e-Learning service consumer, e-Learning service provider and e-Learning service broker. In a typical Web services oriented architecture for e-Learning systems all the learning components are connected via web services (html, xml, soap) [8, 9]. As a matter of fact, both the views (layers and services) of e-Learning systems are complementary. In a layer architecture each layer provides some services, while in service based architecture, a service is built upon one or modules or components and these components are part of some layer. The proposed extendable open source architecture can be fit in either of these categories (layers or services). In the proposed architecture, each open source extension can be perceived as provider of one or more services. Depending on the nature of extension and its service, it will be plug in to some layer at the client side or service provider side.

II. RELATED WORK

Client server architecture for an integrated learning environment based on Web services (.NET remote services) is presented by [11]. The system allows remote students to simultaneously and collaboratively complete learning exercises. A Personalized e-Learning system Based on Multi-layer Architecture is described by [12]. The system is user-
centric and provides interactive actions based on user’s learning archive information. The multi-layer architecture includes Web including presentation layer, service layer and resource layer. The service layer is divided into business service layer and common service layer that improve the software reusability. Web service architecture for e-Learning is presented by [2]. The model of [2] is based on messaging and distributed components and uses SIMD (Single instruction, multiple data) and MIMD (multiple instructions, multiple data) collaboration. Concept and characteristics of cloud computing in the context of e-Learning are presented by [3]. The authors assert that cloud computing is economically better option for e-Learning. However, we believe that it depends on cost and availability of cloud services. Nevertheless, cloud base architecture is a viable option for those educational institutes that cannot afford to host e-Learning servers due to technical or some other reasons. “KnowledgeTree”, an architecture for adaptive e-Learning based on distributed reusable intelligent learning activities is presented by [4]. The “KnowledgeTree” architecture assumes the presence of at least four kinds of servers: activity servers, value-adding services, learning portals, and student model servers. These servers represent main stakeholders in the e-Learning process: content and service providers, course providers, and students. A model and structure agile e-Learning system is described by [6]. In the agile e-Learning system, learning objects are educational material such as text, image, audio, video, etc. The system is adaptable, reusable and easy changeable content. The author achieved adaptability using ontology, i.e., information is linked based on given set of rules and learning objects metadata. Rules can be change to create dynamic links.

The organization of rest of the paper is as follows. Section III describes layered architecture of an e-Learning system. Service oriented architecture is discussed in Section IV. The proposed extendable open source architecture is elaborated in Section V. Some characteristics of open source architecture are presented in Section VI. Concluding remarks are in Section VII.

III. LAYERED ARCHITECTURE

In the layered architecture, the system is broken down into layers. Each layer provides/receives one or more services and communicates to layers above or below it. Fig. 1 shows the layered architecture of e-Learning system. User interface layer provides interface, usually though browser though not necessary, to access the functionality of e-Learning software. The e-Learning Software is installed on some server and the users connect to it through Internet/Intranet connection layer. In order to provide physical independence between e-Learning software and physical storage, a database layer is provided. It means underlying physical storage of data (e.g., file formats) can be changed without affecting e-Learning software. The e-Learning software provides all the main functionalities (services) of a typical learning management system. The e-Learning software connects to database to store and retrieve data. The database stores user profiles and learning material. The bottom layer is infrastructure layer that includes operating system, servers and other hardware components.

IV. SERVICE ORIENTED ARCHITECTURE

Service oriented architecture (SOA) has three main parts, (1) Service Provider provides hosting and maintenance of e-Learning contents and services, (2) Service Consumer utilizes e-Learning contents and services, and (3) Service Broker is place of contact and contract between Service Provider and Service Consumer. The communication between three parts could be through interfaces or through messages. Fig. 2 shows the service oriented architecture of e-Learning system. In SOA different e-Learning system components and learning objects can be implemented as Web services, this allows the system components and content to be distributed all over the Web, and by different service providers [10]. Well defined platform independent interfaces allow to access functionality between services. In the e-Learning system, the development and deployment of dynamic contents can be based on HTML or XML. Tags, attributes and element structure of XML provide context information that can be used to interpret the semantic of content. These features of XML allows more efficient searching, intelligent data mining, querying (e.g., SQL) etc. This is a major advantage over HTML or plain text especially in the context of e-Learning systems.

V. EXTENDABLE OPEN SOURCE ARCHITECTURE

In this section, we propose extendable open source architecture of e-Learning system. The architecture overcomes the restrictions and limitations of existing e-Learning systems by allowing the additional components, i.e., extensions to plug in the existing e-Learning system.
To increase the collaboration and to improve the system quality based on users evaluation and feedback the extensions are developed using open source software development model. Following are the detail descriptions and functions of system components:

A. Core Components

These components provide the main functionality of the e-Learning system. We categorize them into following:

- System components: These components handles system level tasks such as interaction with operating system, setting up communication protocols, connecting with peripherals.
- Database components: Deal with efficient storage and retrieval of course material, user profiles, metadata, etc.
- Course Management components: These components provides basic course management services necessary for any e-Learning system e.g.,
  - Delivering and managing contents
  - Assessing learners (assignments, exam, etc.)
  - Keeps track of learner progress (marks, grades, etc.)
  - Sequencing of learning objects
  - Providing communication services (messages, chats, discussion, etc.)
  - Performing administrative jobs (accounts, privileges, etc.)

In the spirit of extendable e-Learning system architecture, these core components are open source. However, to mantaining the integrity of system, it may be more beneficial that they are developed and maintained by one organization.

B. Open Source Extensions

These extensions are developed by open source community to extend the functionality of e-Learning system. Developer submits these extensions for possible inclusion in the e-Learning system. There are numerous possibilities of extensions, e.g.,

- Extension for data compression: Using this extension course files can be compress and decompress in a particular format (e.g., .tar, .zip, etc).
- Extension for messaging: Using this extensions e-Learning user can use SMS or other messaging services.
- Extension for file sharing: Using this extension e-Learning user (e.g., group of students) can work on a collaborative project where file sharing is essential.

C. Server side Extension Manager

This component evaluates the open source extensions for various issues such as:

- Portability: The extension must be portable to existing e-Learning system, operating system and hardware.
- Standardization: The extension must compliance the e-Learning standards, e.g., SCORM.
- Security: The extension is checked for security vulnerabilities, Trojans, viruses, malware, etc.
D. Client side Extension Manager

This component performs the following main tasks:

- Check/Update: Check for new available extensions and update of existing extension via communicating with server side extension manager.
- Allow/discard extensions: The client has the privilege to allow or discard new extension or updates. Client-side Extension Manager initiate a dialog with the client (user) then based upon his/her decision allows/dischards the extensions/updates. If the user approves new extensions/updates then they are installed at the client side.

VI. CHARACTERISTICS OF EXTENDABLE OPEN SOURCE ARCHITECTURE

In this section, we describe the main characteristics of extendable open source architecture of e-Learning system.

A. Modular Design

In modular design software architecture is divided into components called modules. Modular design supports abstraction, increased understanding of the system and concurrent development [13]. Due to distributed nature of proposed e-Learning system, its design must be modular. Modularity is also favorable characteristics for open source development [5]. Modular design with well-defined interfaces helps in effective collaborative development of e-Learning system components and extensions.

B. Community Based Distributed Development

Distributed development is an important feature of open source e-Learning system model. Members from the community contribute to enhance the functionality of system through extensions. Globally distributed software development by virtual teams promises the flexibility, responsiveness, lower costs, and improved resource utilization [14].

C. Reusability

Reusability means segment of source code that can be used again to add new functionalities with little or no modification. This fits very well the characteristics of the open source e-Learning extensions. Many e-Learning extensions are related or similar. Therefore, a developer can obtain the source code of an extension, inspect it, modify it, and then develop another extension.

D. Security

Open Source extensions of e-Learning system are more secure because their source code is available for scrutiny to large e-Learning community. Bugs and security issues can be identified and fixed easily and quickly.

VII. CONCLUSION

Internet and World Wide Web (www) has had an unprecedented impact on our lives. In the field of e-Learning, information and communication technology (ICT) are playing a vital role. Over the past decades various e-Learning architecture and systems are developed. However, the contemporary e-Learning systems are based on non-flexible architecture and very few are open source. We described existing layered and service architectures of e-Learning system.

We proposed extendable open source architecture of e-Learning system that allows the user to enhance the functionality of existing e-Learning system through extensions. The main components of architecture are: (1) core components: provide main functionality of e-Learning system, (2) extensions: developed and maintain by distributed open source community, extend the functionality of e-Learning system, (3) server side extension manager: validates the portability, e-Learning standardization and security (4) client side extension manager: checks for new extensions and updates and allow/discard these extensions/updates. Rigorous testing of code, input and output parameters allows only reliable extensions to be approved for the e-Learning system. Consequently extendable open source architecture of e-Learning system can better fulfill the growing community of e-Learners.

REFERENCES


