Virt-Res: Developing Extended Architectural Design for Computer Science Virtual Resources Using SOA

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Abstract

Computer Science Education (CSE) is one discipline that uses the growing and demanding e-learning environment to deliver the computation and technology knowledge to the learners. CSE needs practical sessions as the main part of its education process. Many Learning Management Systems (LMS) have limited resources towards virtual labs. This hinders the free and direct utilization of the software tools that are needed for CSE. As a consequence, researchers attempted to support the LMSs and develop these resources as built-in components in the LMS itself. In this direction, this paper proposes the usage of the Service-Oriented Architecture (SOA) to overcome the limitations of the LMSs towards the practical sessions of CSE. The software developer uses SOA to develop the needed resources as services and then integrates them in the LMS environment. In this paper, all experimental works are carried out on the Moodle environment since it is an open source and used at the Sultan Qaboos University (SQU) in Oman.

Key terms: CSE, Moodle, practical tools, SOA, Compiler, Virtual Resources

1. Introduction

E-learning is the process of converting the education from traditional learning to be online. By using it the learners and general users can access Learning Management Systems (LMSs) anytime without restriction with class time. Also, they can gain knowledge by accessing the resources that are available in LMS to support their learning process. Computer Science Education needs a special effort to prepare the online course for learners. It needs to make the software tools available online as resources for the learners to practice the concepts they learnt. As a support, some researchers indicated that the practical laboratory activities are an essential part of any computer curriculum since they strengthen the concepts presented during lectures [1] and [2]. In this way, learners can practice using the LMS without worrying about the availability of that software tool in their own machine environment. Therefore, the needed software tool should be made available in LMS to be used as a support or as a complement to the traditional approaches. In this paper, Service-Oriented Architecture (SOA) is used as the attempted approach to build the services for the needed software tools and then plug them in within the LMS, which can be accessed by the learners anytime.

This paper explains how to improve the functionality and extend the architectural design of LMS (i.e. Moodle) to support CSE using SOA. It also describes the way of developing the needed services and the integration process to the Moodle environment. Section 2, discusses the literature review. Section 3, provides general information about e-learning and SOA. Section 4, presents the extended architectural design of the Moodle using SOA. Section 5,
describes the model of developing the software tools as services. Finally, section 6, provides conclusion and future work.

2. Literature Review

Many researchers are trying to enhance the functionalities and extend the architectural design of the LMSs. They attempted to prepare the e-Learning environment with virtual resources for the practical sessions of CSE or any other similar fields by using different architecture and integration mechanisms.

Researchers started to support CSE by proposing such architectures to integrate the software tools because CSE needed more effort and it is difficult without the practical session. In 2006, Al-Khanjari and colleagues proposed an architecture to extend the functionality of E-learning portal to better support CSE using the URL and a single page approach [3]. Also, there are many works that discuss adding new plugins to the LMS to support practical sessions of CSE using different approach [4-9].

Nowadays, SOA area is increased and many researchers are trying to use it to support plugin into LMS. However, there is a limitation in extending the LMS to support CSE using SOA or most of the researches propose some approaches without providing details on their implementation. Although, the current component-based development practice provides a tried and tested foundation for the implementation of Service-Oriented Architecture [10]. Therefore, SOA has become an active area of research and it provides integration to the e-learning by improving the legacy system. There are a lot of researches have studied adopting SOA into the e-learning using different LMSs to support the customization and extensibility. In 2003, Westerkamp proposed an approach to use the functionality of the e-learning system as web services [11].

In 2005, Teng Ma and colleagues presented an SOA-oriented integration Infrastructure for e-learning resources. They introduced new concept of the E-learning services. Their simulation results show that the model can effectively aggregate the service information improve the query response and low the cost of frequent dynamic updating [12].

In 2007 Zedan and Al-Ajlani were trying to analyze the development of some LMS (e.g. Moodle) using SOA. Also, they defined the concept of web services to satisfy the web-based academic system [13]. In the following year, they presented a new approach to extend the web services Architecture to meet the technical requirements of Virtual Learning Environment VLE (e.g. Moodle) [14].

In 2008, Qinghua and colleagues tried to implement SOA into e-learning and compared their work with traditional approach of developing the system. The comparison showed that the SOA approach is better than the traditional approaches according to the better reusability, collaboration, extensibility and integration of different components into the system [15].

In 2009, Gonzalez and colleagues analyzed some concepts and presented an architectural approach of adoption of SOA to the Moodle. They also presented and analyzed some important issues involved in the adoption [16].

In 2010, Fontenla and colleagues described a new architecture of LMS based on the integration of third-party tools accessible as web services into the LMS to support its functionality [17]. Furthermore, in the same year Jabr and Omari developed the e-learning system using SOA by using web services [18].

In 2011, González and Motz thought about providing more materials and activities in the LMS for teachers to achieve their teaching goals using web services technology [19]. Some other researchers tried to develop the whole software LMS using SOA concepts [20] and [21]. They developed e-learning systems using SOA in .NET environment and achieved the integration between different functions of the system of heterogeneous components.
In 2013, Huertas and Navarro discussed the integration of new functionality in the LMS using two approaches: the inclusion of Application Program Interface (API) and web services. Also, they provided the experiment of integration of the university virtual campus with more functionalities using both integration approaches [22]. This research showed that there is a limitation in implemented web services in the Moodle environment although it implements several communication protocols.

Nowadays, the researchers are trying to support the LMS with practical tool using cloud computing with SOA [23-25]. For example in 2008 the virtual computing laboratory was introduced to utilize the virtualization of the tools that were used in laboratory including computational storage and software resources [26].

The Software as a service (SaaS) is one type of the cloud computing that used to deliver particular software applications and services. Various types of applications such as word processing, presentations, spreadsheets, databases and more can all be accessed through a web browser, while the content is hosted in the cloud [27].

In 2013, researchers from university of Bigarde presented new approach to the integration of web services in e-learning through cloud computing infrastructure [28].

3. E-learning and Service-Oriented Architecture (SOA)

There are different ways for improving the functionality and extending the architectural design of LMS to fit the users’ need for virtual resources. Service-Oriented Architecture (SOA) is one approach of integration that is recently developed to improve the area of the software system. In this research the focus is on the usage of SOA to prepare and extend the virtual resources of the Computer Science Education in the Moodle environment.

3.1 Learning Management Systems (LMS):

E-learning is the new technology revolution in the education. It is organized and introduced using Learning Management systems (LMS) to be used by learners and instructors to support on-line education. There are two main categories of LMS: 1) Open source initiatives such as Moodle, Sakai, A tutor, etc., and 2) Commercial or property solution platforms such as: Blackboard, WebCT, Desire2learn, SharePoint, etc. Open source LMSs are typically built on extendable frameworks allowing developers to adjust and modify the LMS to suit their specific needs. Nowadays, current vendors of e-Learning Platforms are making their source code available for modification under various guises of open source license [29].

Moodle is the most successful LMS as an open source. This feature helped in facilitating the development and maintenance of it according to the users’ needs. On the other hand, it provides a research area to extend the software tools of CSE [30].

There are many software tools could be prepared as part of CSE courses such as: simulator, programming languages compilers, digital library, virtual labs, office software tools and so on. The limited availability of these software tools in the e-learning application produces a gap in the e-learning against the traditional learning. These limitations could be solved by developing and making these tools to be part of the LMSs. So, users could use them anytime and anywhere. This solution could provide a way of making the e-learning more powerful and useful especially in Computer Science Education.

3.2 Service-Oriented Architecture (SOA)

Service-Oriented Architecture (SOA) is a structural model composed of standard components such as web services technology. SOA is defined as “an application architecture
with which all functions are defined as independent services with well-defined invokable interfaces which can be called in defined sequence to form business process” [15]. The service is the main entity in this architecture. It is well-defined and self-contained software entity with discoverable and invokable interface to provide certain capabilities over networks using standard protocols. It can be developed and its interface description can be published. Then, that service can be discovered and invoked using its interface.

Service-Oriented Architecture can be implemented through web services. Web service is a software application identified by a URI whose interface is described and discovered by using XML. Then the service interface is encapsulated by Web Services Definition Languages (WSDL). After that, it is published in the Universal Discovery Description Integration (UDDI) which is known as Broker or Registry. Next, the service can be transferred through message passing over HTTP [10].

It is based on the interaction of three roles: Service Provider, Service Broker and Service Requester [18]. In this research the following scenario is applied as shown in Figure 1:

- The **service provider**: course developer/teacher is deploying and publishing the description of its services to service broker, hosting these services and controlling access to them.

- The **services requester**: developer of e-learning platform works with the service broker to discover the optimal services that meet and satisfy the specifications of the user.

- The **service broker**: sends the services that have been found to the service requester.

- The final stage, service requester negotiates with the service providers to bind services after finding them.

![Figure 1. Three Roles in Service-Oriented Architecture (SOA)](image)

There are a lot of advantages of using SOA to implement or extend the services. These advantages are as following [20]:

The reusability of the service can be reached by reusable of any legacy system services or new services.

The collaboration between heterogeneous components achieved better by using SOA.

Achieves better extensibility for the system functionality.

Easy of the integration and the implementation is fully transparent.

It is loosely coupling which helps to build stronger application.

Facilitates the interoperability between integrated platforms.

Implementation and location transparency of the services.

Avoid incompatibility of data formats caused by different development platforms.

4. Extended Architectural Design of Moodle using SOA

The proposed approach as services aimed to extend the architectural design of Moodle to support the CSE and provide software tools to the online courses [16] and [13]. Figure 2 illustrates the process.

Extending the architectural design of Moodle is easier than other LMS because it is available as open source and it supports the external tool plugins. Also, it implements the web services in its platforms as a structure to facilitate the development of it using SOA. It follows both usability and functionality philosophy of web services. Therefore, Moodle implements different web services protocols since Moodle 2.0 and later. These protocols are [22]:

- XML-Remote Procedure Call (XML-RPC).
- Action Message Format (AMF).
- Representational State Transfer (REST).
- Simple Object Access Protocol (SOAP).

![Figure 2. The Overall Architecture of the Plugged in Services into Moodle](image-url)
In Figure 2, once students request the usage of the software tools, the LMS connects the students to the services (software tools) in the web and allows them to use them as shown in Figure 2. This way is more flexible in reducing the time needed and the load at the LMS since the real processing of the work is carried outside LMS servers. It is the most powerful solution as we noticed for extending the software tools in any Learning Management Systems (LMS).

5. The Model of Developing the Software Tools as Services

The model of developing the software tools as services and integrating them into Moodle environment follows the evolutionary approach as shown in Figure 3. This approach consists of four main phases with sub tasks. They are listed as follows:

- **Phase 1:** Define the required software tool for the CSE.
- **Phase 2:** Identify the software tool functionality and services.
- **Phase 3:** Develop the software tool service.
- **Phase 4:** Integrate the service into the LMS.

To develop the needed services there are some system requirements, which should be considered. These requirements include: Moodle v2.5, Windows Server 2008 R2, .NET environment of Microsoft, Learning Interoperability Tool (LTI) and the needed software tools for CSE such as: compiler.

In this proposed architecture we have to consider the interoperability between the tool and the LMS not only to the content but to a wider scope of features and services that the learning application can offer. Therefore, in 2005 IMS Global Learning Consortium published new tools for the integration between tools and LMS which is Learning Interoperability Tool (LTI) or as known as Basic LTI. It is composed of two main elements: a Tool Provider (TP) in the tool side and a Tool Consumer (TC) in the learning platform side [31]. As shown in Figure 4, the communication between TC and TP can be activated through using REST protocol of the web services and the negotiation can go through providing three main information from TP to TC which are: URL of the tool, Key, shared secret between both applications.
5.1. **Phase 1:** Define the required software tool for the CSE

The needs of the software tools for the Computer Science courses have to be determined according to the learning goals. The requirement of the courses and the needed tools should be defined. Programming Languages Compiler is one of the most important tools for both the students to practice the programming languages online and the teacher to evaluate the code of submitted assignments or quizzes.

5.2. **Phase 2:** Identify the software tool functionality and services

The tool functionality and the required services must be identified. The functionality of the compiler tool should be defined. This tool is a single service which takes the code as input, processes it in the provider side, and then returns back the output which either is the result of the code or the error if there is any.

5.3. **Phase 3:** Develop the software tool service

According to the type of the tool service provided from previous phase, the way of development of the tools must be identified. The following are the two ways of developing the compiler service:

1. Developing a new service using any programming language and registering it in the broker. Then, invoking it using WSDL in the Moodle environment. The preparation and development of the tool is described as following:
   - Design and Code the Service.
   - Implement the Service Endpoint Interface.
   - Write a Configuration File.
   - Generate the necessary Mapping Files.
   - Package and Deploy the Service.
   - Integrate the service API using web service plugin in Moodle.
   - Prepare the link for the required service in the specified course.
   - Allow users to use it. The data will be passing as a message.

2. Searching for existing service and integrating it to the Moodle by its interface description. The preparation of the tool is described as following:
- Search for existing service in the UDDI registry from different enterprise Provider [.NET environment for Microsoft, WebSphere for IBM, CISCO system and Oracle].
- Use the web service to access service API
- Build web application to contain that service with needed functionality.
- Integrate it to the LMS using LTI.
- Allow users to access it as web application in the Moodle through the provided link.

Nowadays, there are many service providers that assist software developer commercial software infrastructure products such as Microsoft and IBM by their environment .NET and WebSphere lines respectively [10]. In this research, the second approach is applied. After defining the tools which is the compiler and define the development approach, the tool development process is started. By searching in different tool provider, there are a set of compiler services that are offered by Microsoft in .Net environment. They define new concept which is Compiler as Service or “Hosted Execution”. In 2012, Microsoft published “Roslyn” which is compiler as a service. It processes code on-the-fly and get the result directly. It aims to bring powerful new features to C# and visual basic with set of API’s that developers can use it to fine tune their code.

5.4. Phase 4: Integrate the service into the LMS:

The integration must be defined either by using Learning Tool Interoperability (LTI) so the integration of that application could be done in the Moodle environment or by using its WSDL immediately to the Moodle. For the integration of those services into the Moodle, the “Execute” interface from scripting API’s is used for the development of the compiler tool as shown in Figure 5. This interface is responsible for executing the code at runtime.

![Figure 5. Using the service API](image)

Figure 6, shows the overall architecture and layers of the development process for the service (e.g., compiler).
6. Conclusion and Future Work

This paper proposes the extension approach of the needed software tools as services in the Moodle environment to better support the practical sessions in the CSE. The proposed approach uses Service-Oriented Architecture (SOA) to support the functionality and extend the architectural design of Moodle. It was found that there are no much available services that facilitate development of the software tools for the CSE. Therefore, the best alternative is to develop that service as a software then publish it in the cloud and integrate it in the LMS. On the other hand, since the security criterion in this approach is important, it is achieved by using LTI which implements Single Sign-on (SSO) features, which allows the user to:

- login to Moodle session and software tools application with one username and password.
- work secure by encoding the shared secret between LMS and software tool.
- remain logged in while Moodle session is open.
- log out of identity provider and all other services at the same time.

As a future works, cloud computing facilities could be used to enhance the e-learning environment.
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References


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