An e-learning platform according to the point of view of service-oriented architecture (SOA) is considered as a set of services that cooperate with each other to provide a set of functionalities to the actors of the platform. Once, one or several functionalities are exposed as a service, they become ready to be used locally and reused by other external learning platforms. Such an approach would save a lot of effort, cost and implementation time. Our objective through this work is to modernize e-learning platforms that are developed in technologies that are becoming increasingly obsolete (legacy system) through a new technology (SOA) that enables continuous and progressive evolution. To achieve this, we conducted an analysis phase of the various existing e-learning platforms. This allowed us to identify and bring out a set of services that could be shared and reused by e-learning systems. In order to provide quality services, we have conducted our identification process in such a way as to meet the essential criteria of the SOA, namely: autonomy, statelessness, loose coupling with external parties and strong internal cohesion. An experimental phase allowed us to test web services that have been implemented with different programming languages and hosted in different servers. Test results have enabled us to validate our approach and our choices.

Keywords: E-learning, Service Oriented Architecture, Service based e-learning platforms, Web service.

1. Introduction

With the widespread use of internet, people have become more and more addicted to computer tools. E-learning platforms are no exception, they are constantly proliferating. The global market of learning management system (LMS) is expected to increase from 5.05 billion USD in 2016 to 18.44 billion USD by 2025 [1]. The LMSs are trying to offer more and more features and functionalities in order to attract and seduce the largest number of learners. These functionalities are constantly evolving, which requires easy and fast implementation solutions.

Service-oriented architecture is emerging as a very agile and efficient alternative to facilitate the development and maintenance of learning platforms, regardless of technological changes and evolutions. It is a very effective response to the problems in terms of reusability, interoperability and reduce coupling between systems. Migration to SOA has become one of the most important modernization technic of Legacy Systems [2].

The advantage of a service-based e-learning platform is that its parts can be developed in different languages and distributed on different servers. Thus, each part exposed as a service can be used by several platforms. Such an approach would save a lot of effort, cost and implementation time.

Through this paper, we first outline the benefits of the integration of the SOA in e-learning systems, then we present related works, after that, we explain our approach to identify the architectural components of e-learning systems that can be shared as web
services. After that, we focus on the new resulting e-learning platform based on services, then we detail each identified service, and finally, we give an overview of our experience in the development of the described services.

2. E-learning systems and Service oriented architecture

Service oriented architecture is an architectural style that supports service orientation [3]. It is essentially a collection of services that interact and communicate. This communication may be a simple return of data or an activity (coordination of several services). The concept of service is better defined in business context than in a technical context. However, in an enterprise context, a service can be best described as a way to specify encapsulated business functionality independent from concrete implementations. In this context, a service is more of a business concept than an IT concept [4].

Integrating SOA to e-learning system can lead to several benefits as:
- **Modularity**: services are dynamically coupled; this makes it easy to add or replace services, even with a running system.
- **Interoperability**: Services communicate using standard protocols and are defined using standard specifications. This means that third-party specifications can easily be used with existing service-based systems.
- **Extensibility**: Because of their modular and interoperable nature, service-based systems can be easily extended, which reduces the danger of technology ‘lock-in’ [5].
- **Agility**: E-learning services can be offered by a variety of software providers. They are required to be discovered at run time, thus enabling flexible selection and use of appropriate services over networks, as users’ requirements are always changing.
- **Cost reduction**: During the e-learning services development process, reuse of existing services, rather than developing bespoke software components, enables organizations to use cost effective software [6].
- **Distribution**: The advantage of a learning platform based service is that its parts can be developed in different languages and distributed in different server. Thus each party exposed as a service can be used by different platform.

3. Related works

Since 1999, eLearning platforms have started to focus on sharing learning objects and have started to adopt the principle of "services", exposing some aspects of their functionality externally [7]. Since that time, the number of e-learning platforms, which are based on web services, has increased steadily [8][9], due to the need to share and reuse certain components or characteristics of e-learning platforms.

Several approaches and proposals have been made in this field, we cite as an example [10] where the entire e-learning system is broken down into loosely coupled components called services. From our point of view, claiming that all components of the eLearning system can be considered as reusable services is optimistic if we really respect the SOA characteristics for each component.

In [11], a multi-layer architecture was proposed, divided into presentation layers, E-Learning service layer, common service layer and resource layer.
A more detailed survey was presented in [12] where different architectures were proposed and classified.

![Multi-layer architecture for service base e-learning system](image)

Fig. 1. A multi-layer architecture for service base e-learning system [11]

### 4. Approach of modernization towards a Service Oriented Architecture

Existing approaches that improve e-learning systems towards SOA focus on the technical aspect. They are trying to redevelop new e-learning platforms where all components are technical services that communicate and use web service standards (XML, SOAP, WSDL, UDDI, etc.), without having to strictly comply with the fundamental criteria of SOA, and without the concern of having services that can really be reused by other external platforms. The main concern is to use web service standards which allow them to connect and disconnect services easily and replace services and maintain them at a lower cost and less time.

Our approach is distinguished by the strategy we have followed.

- a) We have begun to identify the fundamental characteristics of a service in SOA, namely: loose coupling, autonomy, statelessness, distribution, accessibility, reusability, etc.
- b) Then, we analyzed the e-learning platforms, which allowed us to identify and highlight the autonomous components (which seem to be willing to be shared by e-learning systems) as web services.
- c) Finally, we verified that these components can be put in the form of reusable modules while respecting the quality criteria of an SOA service.

We can say that our approach is a gradual approach in the sense that we develop the main part of the e-learning system as a consumer service and the rest of the shareable functionality as provider services added in a gradual and incremental way. Consumer service being the main part and the access point for users includes all the information of the
different actors (administrator, learner, tutor, and teacher), the profiles and traces of learners, local courses and tools that cannot be shared.

Provider services can be added as needed progressively or even replaced by more efficient ones.

5. Identification of e-learning services

The analysis of the e-learning platforms allowed us to identify and highlight the autonomous components (which were willing to be shared by the e-learning systems) in the form of web services [13]. We took care to take as candidate services only those components that were completely autonomous, stateless and in loose coupling with their environment in order to best meet the requirements of the SOA.

We present below (Fig.2) the global architecture of our e-learning system that consists of the local part (customer service), the layer that ensures the smooth running, the connection between the system and the distant reusable services and the different web services.

Thus, four types of web services could be identified, namely:

- Course Web Service: provides access to remote courses and seamlessly integrate our platform or other similar platforms.
- Cognitive level Test Web Service: allows assigning a cognitive level to each learner.
- Collaboration Web Service: that enables collaborative work between learners of the same group.
- And finally, the Tutoring web service: which we describe the features and characteristics in the following.

![Fig.2. Global Architecture for e-learning system based web service.](image-url)
6. The tutoring web service

The role of the tutor in an e-learning platform is more than necessary; he has a great role in orienting and supporting learners. Without the tutor many learners will find themselves disoriented and over time they will risk abandoning the learning process.[14] Highlights the fact that infinite freedom of e-learning services causes dropouts.

The Tutoring Web Service (TWS) is an independent tool, which we developed as a web service, it provides all the necessary features to the tutor to follow and assist the learners. It provides a dashboard that groups and synthesizes all learners' activities in graphical and easy-to-use forms (Fig 3.).

![Fig. 3. The dashboard of activities of each learner.](image)

In order to preserve the autonomy of the web service, the TWS does not contain any information locally, all the learner's information is transferred instantly when needed. In return, it provides all necessary treatments. The necessary information is duplicated from the database of the eLearning platform to a partial temporary database (PTDB) accessible by the TWS. Fig. 4.

![Diagram of the Tutoring Web Service](image)

In order to minimize data transfer as much as possible, the PTDB only contains the information of the learners forming the group followed by a tutor (usually 4 learners). The PTDB is created at the beginning of each work session and erased at the end of the session.

We proposed this solution, in order to avoid access by the TWS to the main DB and to guarantee TWS stateless and autonomy.
6.1 TWS functionalities

We have designed the TWS to support two types of processing:

1. Internal functionalities:

These are all treatments that require interventions in the e-learning platform (consumer service). It concerns all processing operations that involve modifications to learners' data. These data are recorded by the TWS in the partial database, and then retrieved by the client platform to be reflected on the database of the learning platform, and finally exposed to the tutor. Such as:

A. Updating the learner's level:
   According to the results of past tests, the learner's initial level can be raised or reduced in order to offer him/her courses more adapted to his/her real level. The level is calculated from a formula that allows to have an average of the last three scores acquired following the passing of the proposed tests at the end of each learning unit.

B. Appointment management:
   The tutor and learners can set up appointments to discuss problems encountered, propose orientations, etc. At the end of each online meeting, the tutor evaluates the meeting by a satisfaction rate with the objectives of the meeting. The TWS updates the remarks on each appointment. All these remarks will be summarized in a meeting-tracking table that contains the learner's absence rate, the meetings proposed by the tutor and the one requested by the learner, the satisfaction rates, etc.

2. External functionalities:

These are all the features offered by the TWS that do not require updates on the eLearning platform's BDD. The client Platform allows the opening of a remote web page managed by the TWS and integrated in an iframe in the tutor space. The TWS displays the various statistics in graphical form or in the form of a readable and easily exploitable summary table.

As an example of this type of processing operations provided by the TWS, we can mention:

A. Collaboration and communication statistics:

Information about the collaboration between the tutor and the learners, and the interaction between the learner and his/her peers (Towards forums, mail, and chat) (Fig.5.). The TWS can also provide statistics on the archive of working sessions with the tutors, the archive of tutors' remarks, etc. All these in a visual interface that is
easy to use.

B. Progression statistics:

Graphical representations, and various statistics relating to the learner's evolution, such as the number and dates of access to the system, progress in courses (Fig.6), evaluation results, etc.

C. The risk of drop-out:

Studies show that, the dropout rate among online learners is not to be ignored and achieved, up to 40-80% of students [15]. For example, the dropout rate in the UK Open University has dropout rates of around 45-50% for new students on their first course and around 65-70% to its first degree. Another example, the Korean National Open University, apparently has dropout rates of up to 90% to a degree [16].

Having a clear idea of the risk of drop-out is very important, it will allow the tutor to intervene at the right time to encourage the learner and motivate him to avoid dropping out permanently. In our case, the risk of drop-out is considered the most important information to provide to the tutor in the foreground, it is displayed in the form of a traffic light (red: high risk, yellow: medium risk, green: low risk).

It is calculated from all the learners' activities in the learning platform to predict whether the learner is beginning to have a tendency to drop out. Thus, a learner who has not accessed the course, who does not collaborate with other learners, who does not communicate with platform actors for a sufficiently long period of time (e.g. one month), is assigned a high risk of dropping out (red). In this case, the tutor should go into the details of the statistics provided about the learner and should arrange a meeting to discuss possible problems.
many other statistics are provided by the TWS to facilitate the tutor's work, such as the number of attempts to pass a test, the rate of progress in relation to expected progress, a session manager working with the tutor which records the learner's reactions...etc.

7. Courses Web service

Courses Web services are courses developed as web services to enable to share their contents so that they are accessible by a multitude of remote e-learning platforms, they will also allow access to exercises that relate to a given chapter for evaluate and then retrieve the results of the evaluation to safeguard in local profile data base. To retrieve a chapter, we need the identifier of the learner and his cognitive level. Similarly, if we want to recover the exercises, so we need the code of the concerned chapter.

8. The Cognitive level Test web service (CLT WS)

The content of this web service is developed under the direction of psycho pedagogues, educators and researchers in the humanities. It contains questions of intelligence, education, language..etc. After recovering the test questions and pass the test by the learner, the system communicates with the WS to get the result of the evaluation. This web service allows assigning a cognitive level to each learner; it allows the system to adapt courses to learners. The web service can be requested at any time in order to update level.

9. The collaboration web service

Collaboration is not something new in e-learning. Discussion forums, chats, video conferencing, whiteboards were and still are available technological tools in almost all learning management systems [17].

This web service is a collaborative tool that enables learners of the same group to work together, to discuss and implement the solution of a given work online. The WS also
captures statistics and traces on the progress and the collaboration of each learner; these statistics and information will be available for the tutor and allow him to consider them in the orientation of the learner.

![Collaboration WS diagram]

**Fig.9.** The basic input /outputs operations of the collaboration web service.

10. **Experimentation**

In order to validate the proposed architecture, an experimentation e-learning system was developed as part of a final project of a graduate student of computer science department.

The main part e-learning platform (Consumer service) has been implemented with PHP / MYSQL, Web services courses where developed using the PHP language which will be interpreted in remote servers. To be a client of a remote web service, we have integrated the "nusoap" library for web services, it defines rights and way of communication with web services, it is developed as classes in PHP. It also helps to treat all types of errors that can suspend communication between the server and client service.

To test interoperability between web services, we chose to implement the CLT WS with java language.

In our experience, the entire web services worked very well despite they was installed in different remote servers.

11. **Conclusion**

We proposed in this paper an e-learning platform based on web services. The eLearning platform consists of two parts; the first is the one with the local part which is responsible for managing the local database with all the spaces of the different actors (learner, teacher, tutor, administrator), and the second representing the remote part in the form of web services, and which is composed of 4 types of web services: Course web services, Cognitive level testing web service, Collaboration web service and finally Tutoring web service.

The proposed approach is based on a gradual integration, that is to say, that we have the local part of the e-learning platform (consumer service), and we plug in progressively new options and features as web services. We can add an unlimited number of web services without influencing the basic eLearning platform. So we can make the necessary maintenance and improvements with the lowest possible cost and effort

Our approach is distinguished by the strategy we have followed. We began to identify the fundamental characteristics of a service in SOA, namely: loose coupling, autonomy, stateless, distribution, accessibility, reusability, etc.... Then we identified the components that may be shared while respecting the criteria for the quality of a service. Each candidate service can be integrated to the main platform, as it can be used by other remote platforms.
References


