ARCHITECTURE OF MODERN E-LEARNING SYSTEMS

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ABSTRACT

In the past two decades the area of e-learning was dominated by monolithic application silos. These e-learning platforms are usually vendor specific and do not provide the flexibility a learner needs, interoperability and pedagogical flexibility.

The concept of 'what an application is" is rapidly changing in the recent years. With the advances of Internet technologies, as well as social interactions online, there has been a shift from monolithic application silos toward service oriented approaches where flexible granular functional components expose services accessible to applications via loosely coupled standards-based interfaces.

This paper gives an overview of the existing trends in the design of modern e-learning systems emphasizing issues and challenges that will bring us to the sufficiently sophisticated eLearning system that will be able to adapt its behaviour depending on the learners knowledge, intelligently leading him to a particular goal by monitoring is progress.

I. INTRODUCTION

Back in history, knowledge has always been a main driver for economic growth and social development. The ability to innovate and create new knowledge has always been a main tool for creating well-being. Economic historians point out that nowadays growth of different countries have far less to do with their natural resources than with the capacity to improve the quality of human capital and factors of production: to create new knowledge and ideas and incorporate them in equipment and people [1]. As much as 70 to 80 percent of economic growth is now said to be due to new and better knowledge.

In the past several decades there has been fundamental reshaping of the global economy influenced by the advances of modern information and communication technologies. In an increasingly global economy where the capacity to use information in the right time and on right place gives advances on the market, knowledge has become the key resource. Knowledge has value, and creating value is about creating new knowledge and capturing its value. Innovation, which fuels new job creation and economic growth, is quickly becoming the key factor in global competitiveness

This economy, which emphasizes the importance of knowledge, where knowledge has become the key resource, is known as "knowledge economy". In this economy the knowledge of people, rather than traditional labour, are essential to growth and prosperity.

The emerging knowledge society and the Knowledge-based Economy signify a new era for education and training. Within this framework, knowledge and skills of citizens are becoming increasingly important both for the economical strength and social cohesion of the society, and the quality of citizens' life. Workers in the 21st century knowledge society will need to be lifelong learners, adapting continuously to changed opportunities, work practices, business models and forms of economic and social organisation.

The structural and functional society transformations raise the demand for major reforms in Education and Training, aiming at reducing the risks for knowledge gaps and social exclusion. High education institutions have the main role in the process of redefining the models for acquiring knowledge and skills. Technology is more often used in learning as a tool for lectures, delivery of materials, and assessment of student knowledge.

Typical demands include personalised training schemes tailored to the learner's objectives, background, style and needs; flexible access to lifelong learning as a continual process, rather than a distinct event; just-in-time training delivery; new learning models for efficient integration of training on workplaces; and cost effective methods for meeting training needs of globally distributed workforce [2].

In the past several years lots of reviews and analyses, predicted that eLearning will drastically change the way people acquire knowledge, sometimes giving optimistic numbers about its acceptance. Still, nowdays there are lots of reports that eLearning failed to fulfil these expectations. Variety of reasons are discussed and analyzed by experts. They all agree that the institutional and pedagogical reservations from one side and technical issues such as interoperability and security on the other are main barriers for broader uptake of eLearning systems [3].

Pedagogical considerations and business processes to facilitate learning, however defined, are of paramount concern in developing e-learning infrastructure [4]. Student-centered learning and constructivist approaches, are just some of the paradigms which emerged, and are being supported by technological advances.

Although technology has the potential to extend and improve educational and training activities, opposite results can be achieved "not because it (technology) wasn't effective, but because it … did not adapt to the way people wanted to learn." [5]. The potential of the technology can only be fully realized if the activities are built upon a stable and coherent technical infrastructure, and with existence of appropriate widely accepted standards.

The vast majority of the currently used web-based educational systems are powerful integrated systems, like Blackboard [6] or WebCT [7] that provide a large variety of support services to both learners and teachers, but lack adaptability, belonging to the class of Learning Management Systems (LMS)

Institution specific learning systems, unable for cross-institutional sharing of information are the most common problems with which Higher Education Institutions (HEI) are facing with. Those systems are usually vendor specific, lack interoperability and pedagogical flexibility. They do not provide the flexibility a learner needs. Normally centralized they offer courses with well-defined content instead of checklists. Learners do not have the ability to choose from content offered by different authors and styles within a course, and, moreover, the content is usually not selected and adapted to a learners needs at all.

Dagger [8] analyses the evolution of e-learning platforms regarding the interoperability. Three generation of e-learning platforms are identified where the last generation is the current one, which should offer complete federated exchange among services (information and control), various levels of interoperability (intradomain and interdomain), and service composition (orchestration and choreography).

The first generation of e-learning platforms (from roughly 1993 on) provided, in essence, black-box solutions. In terms of e-learning evolution, they provided a shift toward modular architectural designs and recognized a need for semantic exchange. In the second generation separates content from tools, and the learner information became more distinguished.

The next (third) generation will no longer be monolithic, one-sizefits- all solutions, but rather interoperable platforms and a range of e-learning services, letting consumers choose the right combination of services for their requirements.

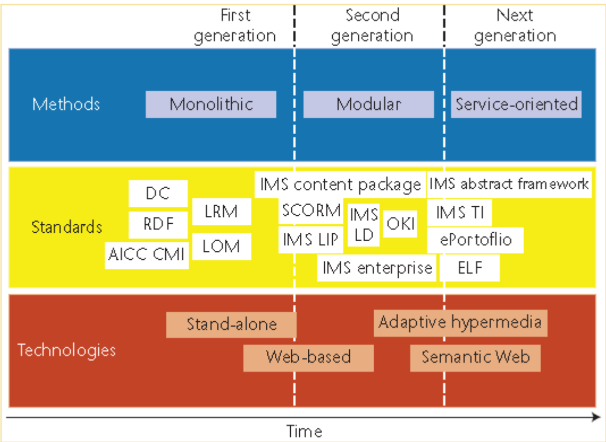

Figure 1: Evolution of e-Learning platforms[8]

Future framework of Learning Management Systems (LMS) will allow the exchange of the learner profile and learning resources with other legacy systems over the Internet. This will lead to the true individualization of media content to provide the next generation of personalized learning environments. However, the currently available LMS have several limitations. These include the weak reusability and interoperability between various systems at the course and learner levels. In addition, they lack the detailed tracking, a high level of interactivity, and search / retrieval features.

In order to stimulate industry agreement some high-level requirements are established for the development of the e-learning environments. The requirements are [9]:

- Accessibility: the ability to locate and access instructional components from one remote location and deliver them to many other locations.
- Adaptability: the ability to tailor instruction to individual and organizational needs.
- Affordability: the ability to increase efficiency and productivity by reducing the time and costs involved in delivering instruction.
- Durability: the ability to withstand technology evolution and changes without costly redesign, reconfiguration or recoding.
- Interoperability: the ability to take instructional components developed in one location with one set of tools or platform and use them in another location with a different set of tools or platform.
- Reusability: the flexibility to incorporate instructional components in multiple applications and contexts.

Recent standardization efforts in e-learning concentrate on the reuse of learning material, but not on the reuse of application functionalities.

Increasing flexibility demands on business processes and on supportive IT Systems have forced software providers to evaluate possibilities to assemble IT-supported functions on-demand. As a result of the standardization activities few detailed frameworks were developed. A common structural issue for which these organizations reached a consensus was the adoption of Service Oriented Architecture (SOA).

The potential of service-oriented software architectures had been recognized previously. Looking back at a history of distributed communication standards such as DCOM, CORBA or RPC, service-orientation is not a new architectural pattern in itself [10].

Still, the literature shows several differences between COA and SOAs. Component-oriented architectures (COAs), are more finely grained and tightly coupled than SOAs. Changes to individual components typically impact the software those components access, making COAs less flexible and extensible than SOAs.

II. SOA

Service-Oriented Computing is shift from a vision of a web based on the presentation of information to a vision of the web as computational infrastructure, where systems and services can interact in order to fulfil users' requests programmatic view. [11]

The Service-Oriented Computing (SOC) paradigm refers to the set of concepts, principles, and methods that represent computing in Service-Oriented Architecture (SOA) in which software applications are constructed based on independent component services with standard interfaces.

SOA is not a product, specific technology, application, specific standard or set of rules, but an approach for building agile and flexible business applications.

European initiatives such as i2010: European Information Society 2010, supports the implementation of Service Oriented Computing. Also, all of DoD's major IT initiatives in the past years are based on the SOC paradigm, including the Army's FCS, the Navy's FORCEnet, the Air Force's JBI, and the OSD's NCES and GIG-ES. [12]

Although there are lots of definitions for SOA we will define it as "An approach for building distributed computing systems based on encapsulating business functions as services that can be easily accessed in a loosely coupled fashion."

[13]. SOA has many advantages, like reusability and flexibility of implementation, higher compatibility with the Grid, "lower overall costs, protection of legacy investment, lower cost of entry, rapid development, potential for business processes to drive technology" [4].

From an institutional point of view it enables collaboration between institutions, faster deployment of new functionality, and support for pedagogic diversity, and avoids lock in to single vendor solutions with the possible attendant costs.

From a technical point of view the open interfaces of the components make it relatively simple to connect components in novel and custom ways, encourage interoperability, and facilitate replacing one service with another to provide the same functionality in different ways.

In [14], Willson discusses the pedagogical aspects of SOA e-learning system analyzing 6 pedagogical choices in e-learning, and concludes that "'Brave New World' of web-service driven environments" offers much greater pedagogical diversity than the monolithic systems.

The comparison of abovementioned frameworks shows that they all have layered architecture consisting of a set of services which can be used in e-learning context and collectively realize required business objective.

A Service Orientated Architecture (SOA) will facilitate the rapid development of highly customizable systems that can be optimized towards a specific goal or pedagogical requirement. This framework will also make it easy to plug in extra components or combine services in novel ways to evaluate their effectiveness.

III. SOA IN E-LEARNING

As a result of the activities for creating a joint vision for common technical framework in e-learning area, and for defining international learning technology standards and specifications, several detailed frameworks were developed. These frameworks are identifying the needs to produce a coherent vision of how to integrate systems to support organisational and cross-organisational processes for enabling effective e-learning.

Some of the most successful and comprehensive technical frameworks developed are:

- JISC e-Learning Technical Framework (ELF) [15]
- IMS Abstract Framework (IAF) [16]
- Open Knowledge Initiative (O.K.I.) [17]
- LeAPP Learning Architecture Project [18]

A. *E-Learning Framework (ELF)*

E-Learning Framework (ELF) as one of most comprehensive frameworks, developed as a result of an Initiative by the U.K's Joint Information Systems Committee (JISC), Australia's Department of Education, Science and Training (DEST) and other partners. These organization in the past have been engaged in defining and developing similar frameworks (JISC Information Environment – JIE and LeAPP Learning Architecture Project).

The ultimate aim of the Framework was to produce an evolving and sustainable, open standards based service-oriented technical framework to support the education and research communities.

The framework provides a 'factoring' of all the possible functions that may be expected in an ideal e-learning system to provide and describes these as services, however it does not yet show how these might be combined in a real situation

The identified services in the framework are grouped into of two types (Figure 1). Common Services which can be used by other applications, and Learning Domain Services. The basic idea behind this is that anyone who wants to develop e-learning application can select services, integrate them and incorporate them into its application.

Standards play an important part in services, as they form the common contract between the provider of a service and anyone who wants to consume it. Tackling this issue, the project for each identified service, will reference one or more open specifications or standards that can be used in the implementation the service, and also will be able to provide open-source implementation toolkits such as Java and C# code libraries to assist developers in creating instances of the service.

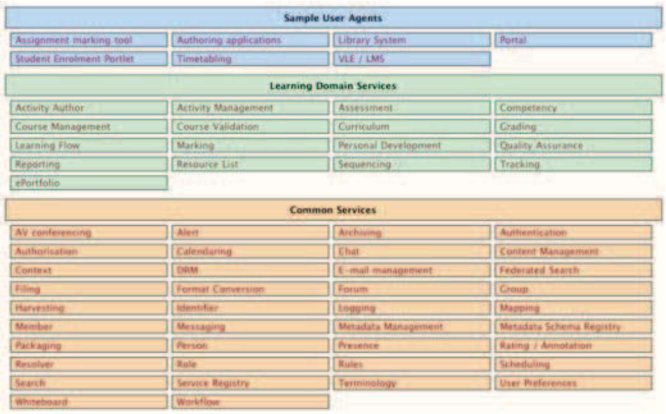

Figure 2: E-Learning Framework Architecture

After identification of the services, the project continues its work by identifying 5 particular areas of interest, and considering those services that will be relevant to that domain and how these could be selected and combined, the relevant standards that apply, and how they might be used. The areas identified are: Assessment, Learning Content, Enterprise, Personal Development Planning, Personal Learning Environments and Resource Repositories.

Several projects are financed in these areas where reference models are produced with the aim to give answers who is involved, what are the assumptions, what kinds of information is involved, what kind of process is involved and what would the practice look like.

B. *IMS Abstract Framework (IAF)*

The IMS Abstract Framework is a project lead by the IMS Global Learning Consortium which is one of the largest organizations in the world dealing with the development of the standards and specifications in the e-learning area.

The IMS Abstract Framework loosely identifies and represents the core components and interfaces of an e-learning system. It is a device to enable the IMS to describe the context within which it will continue to develop its eLearning technology interoperability specifications. This framework is not an attempt to define the IMS architecture, rather it is mechanism to define the set of interfaces for which IMS may or may not produce a set of interoperability specifications. In the cases where IMS does not produce a specification then suitable specification from another organization will be adopted or recommended.

It is the intention of IMS that this Abstract Framework and the associated IMS specifications produced to realize the exchange of information between the identified services will be adopted in a manner suitable for a particular system requirement. The Abstract Framework is represented as a layered model, as shown in the figures below; this approach was derived from an extensive survey of the state-of-the-art for eLearning architectures.

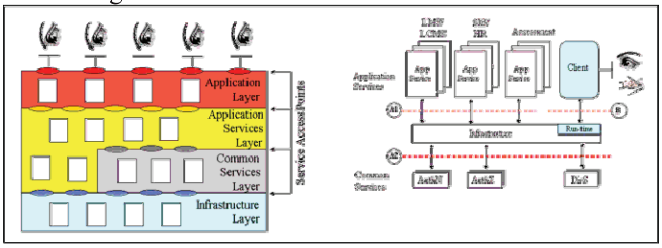

Figure 3: IMS Abstract Framework Architecture

The core features of the framework are:

Application layer - the set of systems, tools and applications that are constructed from the suite of application and common services to provide a particular set of eLearning functionality;

Application services layer - the set of entities that provide the eLearning specific services e.g., course management. It is these services that constitute the primary focus for IMS specification development;

Common services layer - the set of entities that provide the generic services to be used by the application services e.g., authentication;

Infrastructure layer - the underlying services that enable the exchange of the data structures in terms of physical communications, messaging and corresponding transaction needs;

Service access points - the access points, or interface, to the corresponding service. Each access point provides access to one service capability;

Entities - the processes that are used to represent a particular service. The realization of an entity with its service access points is termed a component and its abstract representation is called a Class.

C. *Open Knowledge Initiative (O.K.I.)*

The Open Knowledge Initiative (O.K.I.) is defining an architecture that precisely specifies how the components of a learning technology environment communicate with each other and with other campus systems. By clearly defining points of interoperability, the architecture allows the components of a complex learning environment to be developed and updated independently of each other. This leads to a number of important benefits:

Learning technologies appropriate for a range of teaching and learning requirement scan be integrated together into a common environment. The needs of the Math department are not those of the English department, and tools that work well for new users may not be adequate for seasoned users.

Learning technology and content can be more easily shared among schools and departments. This provides a catalyst for cooperative and commercial development.

There is a lower long term cost of software ownership because single components can be replaced or upgraded without requiring all other components to be modified.

Modularity makes learning technology more stable, more reliable, and able to grow with increased usage, and allows components to be updated without destabilizing other parts of the environment. O.K.I. is based on technologies that have proven to be scalable and dependable in large scale enterprise computing environments

The architecture offers a standardized basis for learning technology software development. This reduces development effort and encourages the development of specialized components that integrate into larger systems.

At the core of O.K.I. is a set of application programming interfaces (APIs) that realize the O.K.I. architecture. O.K.I. is providing Java versions of these APIs. These Java APIs are provided for use in Java-based systems and also as models for other object-oriented and service-based implementations. O.K.I.'s partners and developer community are providing open source examples and reference implementations of learning technologies that make use of the APIs.

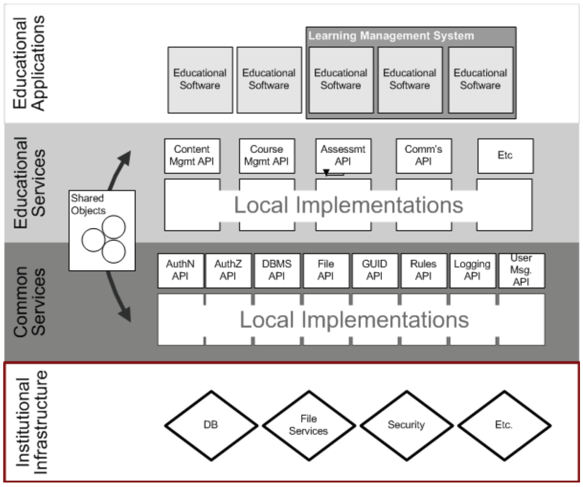

Figure 4: Open Knowledge Initiative Architecture

D. *Learning Architecture Project (LeaP)*

LeAP is a project of the Tasmanian Department of Education (Australia) witha goal to implement Web Services in an Education Environment. The LeAP project has guiding principles of interoperability and the use of standards for data and infrastructure.

The application architecture model has a preference for the use of “service based infrastructure” which is also supported by IMS specifications.

Where data must be provided to more than one application, data may be replicated either continuously (live) or on a scheduled basis.

The diversity of products within the educational computing environment makes it impossible to take an ideal or single track approach to application architecture. Good practice in this situation would be to have level of preference:

- Common Services Approach: Use existing common services and create new services as application development progresses.
- Replication Approach: Integrate application into the replication framework which, where appropriate, also links to the related common services.
- Self Contained Applications: Data is replicated through other means or is re-entered manually or semi manually.

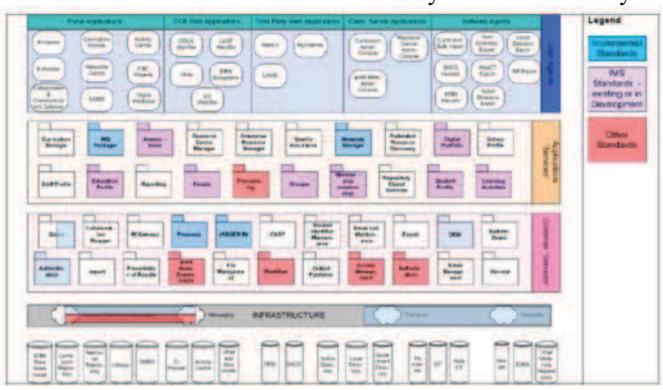

Figure 6: Learning Architecture Project Arhitecture

IV. SUMMARY AND FUTURE ISSUES

A common structural approach for all the mentioned frameworks above and about which above mentioned organizations reached a consensus, was the adoption of a service oriented approach to system and process integration.

The importance of the cross-institutional sharing of information lead to modularizing of the functionality of the e-learning systems and identifying sets of services which combined together can realize particular e-learning goal.

A common issue in all frameworks that they are layered and usually are defining following groupings:

- sets of applications (such as LMSs);
- application services (finer-grained services, such as quizzes and simulations, with which the user directly interacts);
- educational services (usually revolving around education administration such as course management and scheduling);
- common services (functionality that the user isn't directly exposed to but that is essential, such as authentication, file sharing, logging, and database management); and
- infrastructure (the backbone of the services, including HTTP, SOAP, and XML).

JISC as organization developing the E-Learning Framework (ELF), has gone further that the others in their efforts to define the e-learning domain. Following its strategy for creation of Reference Models for number of domains and identification of sub services in each domain, identified as one of the 5 prioritized domains in ELF, the next steps of JISC is financing of real implementation projects which should prove the theoretical findings.

Recent frameworks and reference models developed are still on an abstract level and have little support in practical implementation. For example, in the assessment area, there isn't yet a complete product. Because of that, research on standards and development work is underway in order to see what will be results from the implementation of the proposed models. A number of projects were funded in this domain in order to develop part or services as whole.

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