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A DISTRIBUTED E-LEARNING SERVICE FOR REMOTE AREAS

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Abstract

The cloud-compatible architecture of a distributed distance e-learning system which has been deployed and is being utilized in five remote areas in Eastern Europe (Finland, Poland, Bulgaria, Greece and Cyprus) is presented and discussed as a case study of e-learning. A series of e-courses is being conducted with a variety of learning tools and techniques: a Virtual World, Web 2.0 tools, a web conference platform and a learning management system. Emphasis is placed on the feasibility of the delivery of the integrated Distance Learning (DL) service through distributed web services; an architecture is proposed that extends the existing one by implementing the DL service in the form of a SOA in a hybrid cloud.

Keywords: cloud computing, distance learning, remote areas.

1 INTRODUCTION

The service out of an electricity plug, namely powering an electrical appliance, is provided by a transportation network fuelled from a large number of interconnecting power generating stations. The question "which station empowers my heater now?" is not only indifferent to the user and impossible to answer in practice, but possibly meaningless scientifically. Computing services, until recently, have been at a diametrically opposed pattern: users run programs, i.e. use computing services, in specific computers, be they their own personal ones, their organizations' servers, or even specific remote machines providing specific computing applications to specific users. Cloud computing is a new architectural paradigm in the direction of providing computing services through a "transportation network" (the Web), fuelled by a very large number of computing power providers in a way such that the question "which computers provide which (part of a) computing service at any particular moment" will be indifferent to the user, very difficult to answer in practice, and possibly meaningless to ask.
According to Weiss (2007), what distinguishes a "cloud" from a "bunch of machines" can be fuzzy. In the second section of this paper, the spectrum of definitions found in the recent bibliography is reviewed and the affordances and prominent characteristics of cloud computing are discussed, particularly in relation to education. In Section 3, we explain the rationale of using online, integrated web services for the delivery of the ongoing REVIT (Revitalizing Small Remote Schools for LifeLong Distance e-Learning) e-courses to remote areas, and we present the REVIT Distance Learning (DL) distributed system, in terms of its methodology and architecture. Finally, we conclude on the benefits and limitations of cloud computing in the present e-learning system and propose a hybrid cloud SOA architecture as a future extension of the present one.
The added value and the originality of the REVIT distance learning model stems from the idea of a pedagogy in a student-centered e-learning environment which combines:
(1) Multiculturalism (in terms of different roles, cultures, languages and perspectives) and
(2) Multiple intelligences (Gadner 1983). This theory defines seven types of intelligence we use for learning: logico-mathematical, linguistic, spatial, musical, bodily-kinesthetic, and inter/intrapersonal,. As an example in a classroom setting a lesson on the Trojan War would include in order to stimulate multiple intelligences: studying maps of the field of battle, listening to war songs, participating in a role play, devising a strategic plan for Trojan victory, reading Homer's 'Iliad' and watching a related movie (Brualdi 1996).
The instructional designers of REVIT have structured the e-courses so as to engage multiple intelligences. They used diverse ways of information representation and a wide variety of learning exercises: simulations in Virtual Worlds, presentations and synchronous discourse in web conference rooms, podcasts for reflection, assignments using a LMS, asynchronous –wiki and forum- and synchronous collaboration -chat. As an example, the REVIT ecology course, in order to stimulate multiple intelligences contains: a cartoon on waste segregation, role-playing in a simulation on choosing products based on their packaging, participation in web-conference lectures (including mini-presentations related to ecology and discourse), and a forum to reflect upon the issues discussed.
(3) Technically speaking, distributed web services and the underlying network infrastructure to serve learners are utilized in each remote area, where Internet remains underutilized for educational purposes.

2 BACKGROUND: DEFINITIONS AND CHARACTERISTICS OF CLOUD, CLOUD COMPUTING AND APPLICATIONS IN EDUCATION

There are no widely accepted definitions for the Cloud computing which is related to the fact that its enabling technologies (such as Web 2.0) are not stable and mature yet (Wang et al 2008). As long as users can connect to the Internet, they can potentially have the entire Web as their power PC. Cloud computing refers to the techniques that enable and facilitate this scenario: "a cloud represents all possible resources on the Internet, suggesting infinite power and capacity" (Voas & Zhang 2009).

Cloud computing can be defined as a style of computing where massively scalable IT-related capabilities are provided "as a service" (Dong et al 2009). It reduces the coupling between resources and applications, improves resource utilization and enhances the availability and scalability of applications. It has become a significant technology trend which could reshape the IT sector and marketplace (Voas & Zhang 2009). Typically, cloud computing providers deliver applications online which are accessed from a web browser, while software and data are stored on servers. The key of Cloud Computing lies in its component-based nature, i.e. reusability, substitutability (e.g. alternative implementations, specialized interfaces and runtime component replacements), extensibility, customizability and scalability (Vouk et al 2008).
Clouds render users with services to access hardware, software and data resources, thereafter an integrated computing platform as a service, in a transparent way (Wang et al 2008). In the recent bibliography, cloud computing is not only a ubiquitous infrastructure but is closely associated with:

- Software as a service (SaaS); In Basal and Steenkamp (2010) SaaS is presented as ideal for e-learning, especially for K-12 schools in developing countries: it offers the chance for fast implementation, focusing on "what really counts" than on maintenance and support of technical infrastructure, tools and systems, etc. The authors also express major concerns, such as the protection of user data.
- Platform as a Service (PaaS) and Infrastructure as a Service (IaaS); PaaS and IaaS were used as cloud service models in the case of the CloudIA (see below). IaaS is the service model proposed for the new REVIT architecture (Section 4).
- Cluster computing; In Díaz et al (2009), a cluster is defined as "a type of parallel and distributed system, which consists of a collection of inter-connected stand-alone computers working together as a single integrated computing resource" whereas in Grossman (2009) a cloud is defined as "a cluster of distributed computers". This description fits to the current REVIT architecture.
- Web 2.0; The usage of Web 2.0 tools is one the focal points in the REVIT methodology. These tools enable several capabilities (collaborative editing with the Wiki, article publishing with the blogs, etc). They can be offered as a service in a cloud computing framework (Section 4).

Cloud computing provides dynamically scalable infrastructure supplying computation, storage and communication capabilities as services. It offers service interfaces for transparent access to users and applications. Cloud computing is a promising infrastructure for E-learning services (Dong et al 2009). One application of cloud computing in e-learning is the case of the BlueSky cloud framework whose aim is to provide an e-learning platform for basic education throughout China (Dong et al 2009). This framework "combines cloud computing with traditional middleware features and delivers reliable IT services". In another case a project named CloudIA – Cloud Infrastructure and Applications was initiated by Hochschule Furtwangen Universisty (HFU), in which the targeted users are SMEs and HFU staff and students running e-Learning and e-Science applications (Sulistio et al 2009), aiming at building a private cloud for running these applications.

3 THE REVIT DISTRIBUTED DL SERVICE AND ARCHITECTURE

3.1 The REVIT project: Rationale, methodological approach, roles and culture, geographical distribution, languages

European citizens living in remote rural or insular areas are typically excluded from mainstream educational opportunities easily accessible to people living in larger cities or otherwise close to "centers". Fewer lifelong learning opportunities are available to both young pupils and adults. The small number of inhabitants renders it difficult, if not impossible, to offer local training courses suiting their particular interests, needs and opportunities. The REVIT project aims at revitalizing small remote schools by utilizing their premises, ICT infrastructure and human resources in order to provide the inhabitants with access to distance learning schemes. They are introduced into well structured, locally adapted ICT-based educational activities and materials. Courses organized include agriculturist, successful family functioning, cookery, foreign language learning, computer and internet skills.

In distance learning, educators have been creative in providing learning experiences characterized by access, choice, flexibility and mobility options for students. Currently, e-Learning 2.0 deals with new innovation challenges following Web 2.0 developments (Howell et al. 2003, Porter 2006).

The methodological approach allows the learners from five characteristic remote European areas participating in the REVIT project to (Egarchou et al 2009):

- Participate via web or video conferencing in lessons coordinated by a remote instructor, interacting through specific ICT tools, with the instructor and other learners (synchronous distance learning).
- Watch pre-recorded lessons delivered as podcasts.
- Work on their own using appropriate educational material and software on the school's computers or at home (asynchronous distance learning).
- Communicate, cooperate and construct new knowledge with their peers in other participating countries, using the modern tools and communication spaces provided, through well designed and structured educational activities.
- Utilize existing infrastructure and use modern ICT tools, such as distance learning platforms and e-Learning 2.0 tools (e.g. blogs, wikis, 3D virtual environments, social networking software, etc.) in the learning process. The DL methodology used, allows the creation of user generated content during the implementation stage (e.g. user blog content, podcast recordings, etc.), which enriches the e-course initial content.

In order to engage all learners it is best to vary the way information is communicated (Gardner 1983). REVIT methods include: small (5 - 6 persons) - and large-group discussion, role-playing, lecturing, case studies, games, questioning, and varying technology (e.g. media, video etc).
As a specific example, role-playing technique is implemented through study on ecology. This technique is used both in a synchronous mode (participants actively participate in the scenario-learning by doing approach) and asynchronously (participants watch the simulation as a video in an embedded media player- advisable for the visual learners); small group discussion will take place through the use of chat rooms etc.
Focus is on the separation of the processes from content development/provision, course design and development and course delivery, through the methodologies for designing, developing and delivering the REVIT e-courses.
Roles: Beyond the traditional roles of the learner and tutor, the REVIT methodology includes: (1) the domain expert (responsible for content development/provision), (2) the course designer, (3) the course developer (who creates a course, given specific content and instructions) and (4) the local moderator. The role of the domain expert is separated (in principle and in function, even when more than one roles are enacted by the same person) from that of the course designer and developer as well as from the role of the tutor and the local moderator.
The Local moderator is a person (one per remote area) who is in charge of and facilitates the learning process, but is not an expert in the subject learned. This role is usually undertaken by one of the school teachers, so the Local Moderator is also referred to as the Local Teacher. The Local moderator/teacher is responsible for the coordination and support of the students during the e-courses playing an "intermediary" role between the learners and the tutor/distant teacher.
The Tutor is the remote teacher who is familiar with the subject matter and conducts the REVIT e-course from a distance. He plays the role of the 'classroom' teacher and handles the e-course objectives and tasks as well as the time-schedule of the e-course. He cooperates with the local moderator.

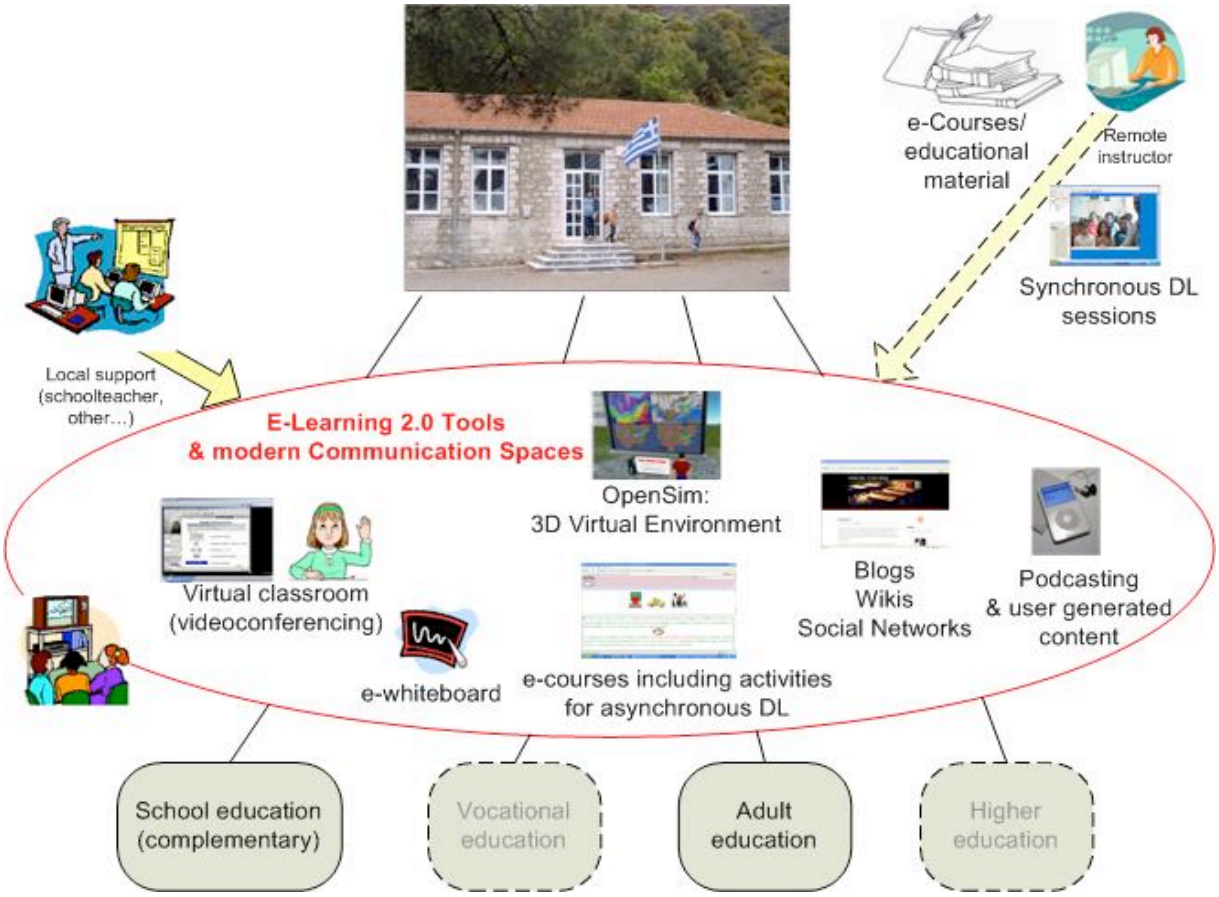

Figure 1. The REVIT Distance Learning Educational Services System

Geographical distribution, language: According to (Schlosser & Simonson, 2006), one of the major components of the definition of the distance education is the concept of separation of the teacher and the student. Most often, separation is thought of in geographic terms- teachers and learners are in different locations. Sometimes, implied by the definition is the separation of teachers and learners in time in an asynchronous distance education framework, which is also involves the means of communication.

In the REVIT DL framework, special effort is being put for having as much as possible "mixed" learner groups, including learners coming from more than one partner countries (inter-country course), where the circumstances allow such an approach (e.g. common communication language, common interests etc.). One example of such "mixed" groups includes EFL teachers from various partner countries (GR, FI, PL, BG) attending the "EFL Teachers e-Course using web 2.0 tools" delivered in English by tutors from Greece and Cyprus (Egarchou et al 2009).

The school computer lab is the place where learners go and use the existing infrastructure in order to participate to the distance learning sessions. The school acts as a central place in the REVIT framework where all people participating in the REVIT e- courses (tutors, local moderators, learners) get together for their delivery.

3.2 The REVIT architecture: services, platforms, infrastructure

Based on the previous goals, the REVIT Distance Learning Service System consists of three main software sub-systems: Portal Engine, Collaboration System and e-learning 2.0 System.

Each subsystem provides distinct functionalities, but sub-systems are fully integrated. They interoperate by exchanging well-defined information, regarding user metadata as well as data that have been produced by users according to their roles and their corresponding privileges: as a project partner, as a trainee, as a trainer. The design of the Distance Learning framework for adult education

in the context of REVIT also contained technical specifications derived from the usage of open standards such as SCORM and educational metadata standards for Learning Objects and Learning Activities included within REVIT e-Courses.

REVIT interoperability is based on learning objects being designed and exported in SCORM v1.2 format (using the open source software eXe XHTML editor) and imported and used in the asynchronous learning platform (Moodle). This has the added benefit of enabling to track content and users actions throughout their interaction with the platform: the log files of the learners' interaction with the platform can be as an important parameter in the evaluation phase. SCORM (Sharable Content Object Reference Model) is a set of standard web-based technologies and protocols that allow application developers to share content and learner data between diverse learning management systems. SCORM provides a common technical framework for the development of reusable learning objects for web-based learning.

The two sub-systems other than the portal engine consist of a set of software tools. The collaboration system consists of:

- an internet based bulletin board system,
- a collaborative editing system and
- a document management system.

The e-learning 2.0 system consists of:

- a synchronous e-learning system (Elluminate Live!^{TM} , a web-conferencing platform),
- an asynchronous e-learning system (Moodle v1.9.4, an open source LMS), incorporating Web 2.0 tools (such as Wikis, Blogs, Podcasts with RSS feeds) and
- a synchronous 3D Virtual Environment (OpenSim, an online Virtual World).

The implementation of the REVIT Portal is based on a Content Management System and is considered to be a member of REVIT DL Services System because it acts as:

- end-users access control mechanism for all the tools participating in the REVIT Distance Learning System, and
- as the means for publishing certain information to educational community.

All the selected tools getting involved in DL System are web-based, available online applications, so they can be accessed via a simple web browser over the Internet. Most of these tools are mature Open Source. They offer to the developers the possibility to modify the source code in order to make the appropriate adjustments for the software integration.

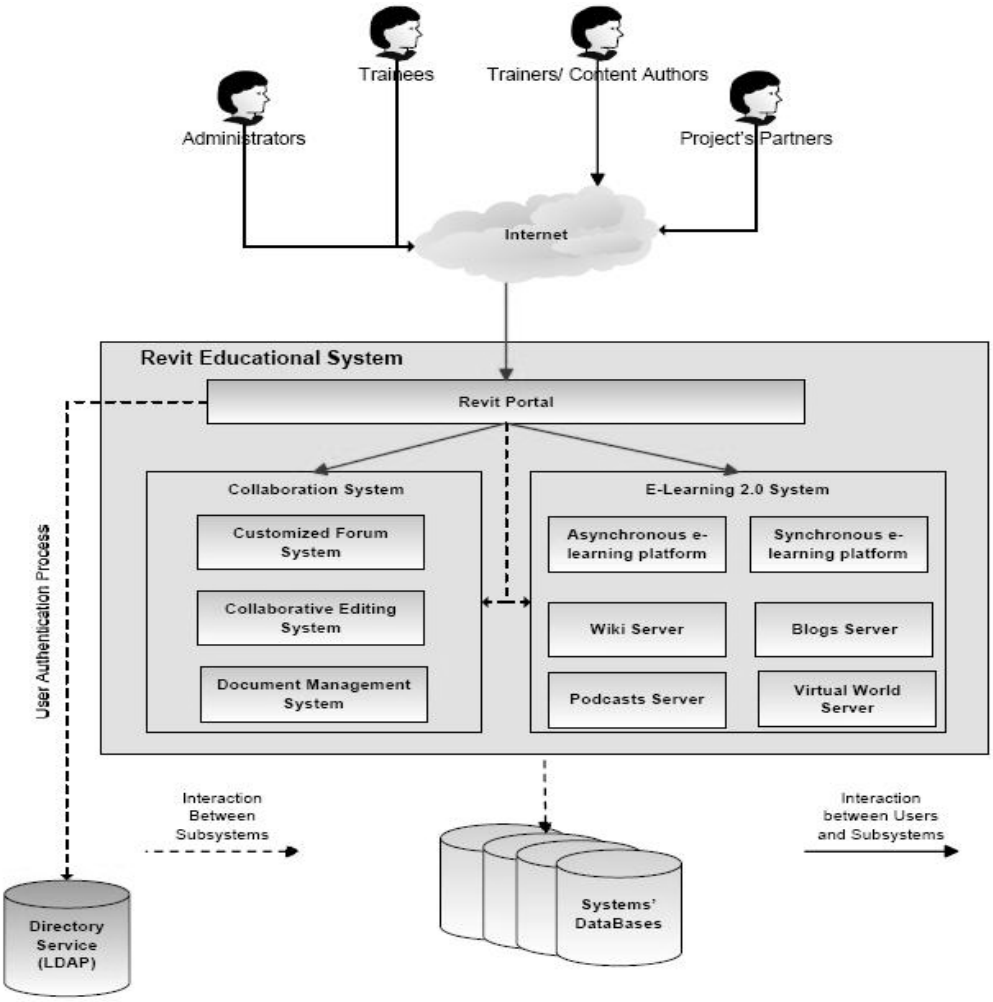

Figure 2. The REVIT Distance Learning Educational Services System

4 CHALLENGES AND SOLUTIONS

The current REVIT architecture is a cluster in which the infrastructure is decoupled from the application layer. For example, when the infrastructure concerning the REVIT synchronous learning platform changed (the web- conferencing service was originally offered through the data centers owned by a hosting provider -allocated in the UK- and at a certain moment in the timeline of the project, when the Open University -located in Cyprus- decided to run the service through its own servers, the change was transparent to the users of the web-conferencing service). Moreover, in the REVIT distributed systemno single point of failure actually exists, since the various REVIT services are autonomously implemented by web servers owned by different organizations.

Despite the flexibility of the REVIT architecture for building 3rd party or ad hoc solutions, the creation of new computing, storage and application services is not provisioned dynamically, but is provided semi-automatically by the administrators. There is a clear need to tackle with this problem. For example, when the need for more extensive use of the web-conference service was present, extra 'meeting rooms' were created by the local administrator of the service in order to host the online meetings for the various groups of users. Similar examples may occur for the other services of the REVIT DL system. The challenge of dynamically provisioned computational resources can be tackled through the proposed architecture described below.

In the current REVIT architecture the consortium that has the collective responsibility of the operations, is the service provider and the participants from the remote school are the clients of the integrated REVIT e-learning service. Web applications (such as content delivery and video streaming)

are particularly well suited to the Cloud paradigm (Díaz et al 2009) and the fact that the REVIT system is comprised exclusively of web applications and services makes it suitable in embracing cloud computing in its fullest sense, in which resource requirements scale dynamically up or down –if such requirements arise in the future.

However, a key goal of the project is to study the following through a scalable example: Is it possible and economically feasible in actual practice to substantially supplement the meagre and sometimes irrelevant educational opportunities typically available to residents of remote regions in Europe through modern ICT-based distance education? Can the existing and often growing ICT infrastructure at otherwise declining schools be utilized towards revitalizing their operation and make them multi-purpose local learning centers accessible to all?

This is why scalability (let alone, dynamic scalability) in this specific e-learning case was not an important issue, since the number of participants of a specific e-course in remote areas is relatively limited. But, if the provision of e-courses to remote areas using the REVIT DL model is to be initiated in a large scale by a national policymakers, then scalability will be an issue. There would be a number of on-line services, each accessed by large amounts of national users at all times. The traditional approach would suggest the addition of new resources when receiving high workloads and this would have unacceptable overhead concerning resource management (Dong et al. 2009). This is another case in which dynamically provisioned computational resources might be a vital solution.

On the other hand, security and privacy issues in the public clouds are important concerns, since their data policies remain unknown to the users (Rimal et al 2009, Grossman 2009). Taking into account all the above, an optimal solution would be a hybrid cloud (i.e. an environment consisting of multiple internal and external service providers), as a collaboration of a private (managed by the consortium) and a public or hosted (managed by external service providers, for example Amazon or Google) cloud.

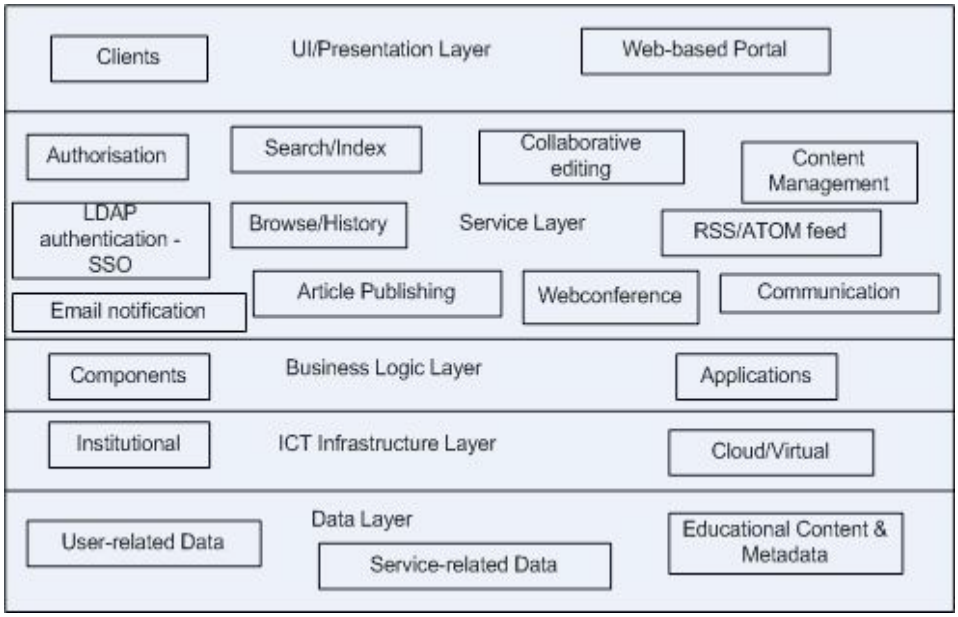

Figure 3. REVIT -2 Architecture: SOA in a hybrid cloud

The figure above suggests an architecture for REVIT (REVIT-2) that supersedes the existing one by deploying a Service Oriented Architecture (SOA) in a hybrid cloud. In our case cloud computing delivers Infrastructure-as-a-Service (IaaS). "A SOA does not preclude using portals and in fact, it is agnostic about how the rest of the enterprise is configured, which is why it makes it a good approach for integration in heterogeneous environments" (Wilson 2005). The core of hybrid is found in the ICT infrastructure layer, where the instructional infrastructure (private cloud) will provide common, internal services (LDAP authentication, authorization, search/index,…), whereas the virtual cloud will provide additional resources (extra storage when needed,…) dynamically. Another issue is the coordination of information coming from multiple sources, not all of which are under the control of

the same organization (as shown in the ICT infrastructure layer). Information exchanged between the various layers is likely to be encoded in some variation of XML (Hayes 2009).
Finally, the efficiency and effectiveness of the present approach is being evaluated through semi-structured interviews and reflective questionnaires from all the participants (tutors, learners, local moderators and other external evaluators) aiming to reveal the actual levels of (1) efficiency (in terms of labor intensity and cost of the method) and (2) accessibility (how easily learners and staff can access the learning facilities).

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