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Architecture Solutions to E-Learning Systems Using Service-Oriented Cloud Computing Reference Architecture

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ABSTRACT

E-learning systems are moving away from monolithic applications towards more open, flexible components, capable of interoperating with other learning components. In spite of the diversity of learning environments, there is a lack of uniformity regarding their basic functionalities. Thus, the establishment of core functionalities represents an issue to the development of learning environments. In a different but related perspective, reference architectures have emerged as an alternative for promoting reuse of design expertise and facilitating the development of E-learning systems. Reference architecture increases the scalability, flexibility and availability of e-learning systems. The objective of this paper is to provide an architecture solutions to personalized e-learning systems using Service-Oriented Cloud Computing Architecture (SOCCA). SOCCA proposes high level designs to better support multi-tenancy feature of cloud computing The proposed architecture is called namely SOCCAPES, is designed to support maximum scalability and high service levels through virtualization and an optimized management environment. It enables new levels of scalability while providing a very cost-effective modular solution.

Keywords: Service-oriented, Cloud Computing, Reference Architecture, Personalized, E-learning Systems.

1.INTRODUCTION

The Internet and advances in Information and Communication Technologies (ICT) have changed the educational setting, both in traditional and distance learning. As a result, there has been a change in the way that educational content is designed, developed and delivered to learners. Faced with these transformations, in recent years there is an increasing demand for open, scalable and flexible learning environments [1].

E-Learning is a form of learning in which the teacher/instructor and learner are separated by *space* or *time* through the use of online technologies. With web-based learning, it is possible for the learners/teachers to learn from anywhere, anytime, at their pace. Web-based learning brings unprecedented level of accessibility to courses in remote area, courses prohibited by budget constraints, courses updated to recently discovered knowledge, qualified instructors, and instruction at any time. According to Ellis [2], E-learning environment has specific features concerning pedagogical, technical and management issues. More important, learning environments should integrate with other enterprise application solutions used by human resources and accounting, enabling the management to measure the impact, effectiveness and overall cost of training initiatives.

E-learning also needs personalized mechanisms to help learners learn more efficiently. To provide personalized learning strategy is urgently needed for most e-learning systems currently. And the system has to consider learner/user preferences, interests, and browsing behaviors when analyzing learner/user behaviors for personalized services. That is, the ability of individuals may be based on major fields and subjects. Therefore, considering learner ability can promote personalized learning performance [3].

With the increase in number of students, rapid growth of education content and changing IT infrastructure, the educational institutes are confronted with a dramatic increase in costs and a decrease in budgets which leads to the need of finding some alternative for their e-learning solutions. Also, the current e-learning systems are not scalable and do not lead to the efficient utilization of the resources. As a response to this increase in pressure and to increase the efficiency and availability of their current e-learning system, the educational institutes need more scalable architectures/approaches.

Taking in view the difficulty in maintaining centralized online learning systems, we need distributed, flexible and scalable approach in a plug-and-play manner. Many higher education institutions and corporate organizations are embracing e-learning as a means of providing learning and increasing training efficiency. From the viewpoint of consumer behavior and from organizational and management perspectives, many researchers of educational part and teachers want to apply virtualized technique to their educational program and learning system process.

1.1 Statement of the Problem

The current approaches to enabling real-time, dynamic infrastructure are inadequate, expensive and not scalable to support consumer mass-market requirements. Scaling is the ability of a system to handle elastic demand. E-learning systems are needed to handle heavier or lighter loads. A load could mean users, queries, transactions, servers, or services.

A scalable system has functionality that improves as capability is added or functionality that erodes as capability is reduced.

The current approaches like client-server computing and Peer-to-Peer computing have evolved to become a complex tangle of layered systems designed to automate E-learning System. These paradigms are ill suited for a world where customers are demanding communication, collaboration and commerce at the speed of light. Despite the diversity of existing learning systems/environments, a common weakness observed is the lack of uniformity regarding their basic functionalities. Actually, the establishment of core functionalities constitutes a significant issue to the development of such environments. The purpose of reference architecture here is to provide guidance for the development, standardization and evolution of system architectures of E-learning systems.

1.2 Solution to the Problem

It needs a more scalable approach with virtualization to provide dynamic visibility and control of services management to meet the rapidly growing demand for e-learning services.

Applying Service Oriented Architecture (SOA) to the E-Learning Systems provides better adaptive learning, a learner-centric single portal for learners, consistent service-level agreement across various related Learning Management Systems (LMSs), achieve better collaboration and facilitate life-long learning. The strength of SOC is *reusability* and *interoperability*. Also, the cloud computing offers e-learning is continuous availability, increases in efficiency and higher security. It increases in storage capacity that it affords educational institutions. The potential efficiency of using cloud computing in higher education has been recognized by many universities.

Providing reference architecture using Service-Oriented Computing and Cloud Computing Architectures (SOCCA) in E-learning Systems can increases the scalability, flexibility and availability more of e-learning systems. Hence, it is proposed to provide reference architecture using Service-Oriented Cloud Computing Architecture to Personalized E-learning Systems (SOCCAPES) for developing learning systems/architectures.

The main goal of SOCCAPES is to provide guidance for the architectural design of new versions of Personalized E-learning Systems as well as promoting a better reuse, evolution and maintenance of the existing ones. This architecture can be scaled, both horizontally and vertically, and the educational organization is charged according to the number of used servers that depends on the number of students or learners.

The proposed architecture addresses the limitations of traditional and SOA based E-learning Systems regarding interoperability, reusability, openness, flexibility, and limited tools for collaborative and social learning. It presents an integrated adaptive and collaborative Web-based learning environment.

This research article is organized as follows: *Chapter 2* presented the basic information required to write this paper. Chapter 3 presented the literature survey and the related works in reference architecture using Service-Oriented and Cloud Computing architectures.

2.BACKGROUND TECHNOLOGY

E-learning or Online learning is a term that is used to refer to all forms of electronically sustained learning and teaching. E-learning is learning that takes place over the Internet enabled transfer of skills and knowledge to different geographical locations.. It uses Internet based technology as a primary means of communication between teacher and student. E-learning is inclusive of, and is broadly synonymous with Multimedia learning, Technology-Enhanced Learning (TEL), computer-based instruction (CBI), computer-based training (CBT), computer-assisted instruction or computer-aided instruction (CAI), internet-based training (IBT), web-based training (WBT), online education, virtual education, virtual learning environments (VLE), m-learning, and digital educational collaboration. These alternative names emphasize a particular aspect, component or delivery method.

E-learning includes numerous types of media that deliver text, audio, images, animation, and streaming video, and includes technology applications and processes such as audio or video tape, satellite TV, CD-ROM, and computer-based learning, as well as local intranet/extranet and web-based learning. Information and communication systems, whether free-standing or based on either local networks or the Internet in networked learning, underly many e-learning processes.

E-learning can occur in or out of the classroom. It can be self-paced, asynchronous learning or may be instructor-led, synchronous learning. E-learning is suited to distance learning and flexible learning, but it can also be used in conjunction with face-to-face teaching, in which case the term blended learning is commonly used [4]. Currently there are many e-learning systems available with open source and commercial licenses. The most popular e-learning systems are Blackboard, Moodle, Sakai and Adobe e-learning.

2.1 Personalized Learning System

Personalized E-Learning systems have a potential to advance distance education to a new level. This category of tools uses a range of approaches to adapt to the knowledge, interests, and preferences of individual students to deliver a superior level of support [5]. Many researchers have recently endeavored to provide personalization mechanisms for web-based learning. Therefore, personalized learning strategy is needed for most e-learning systems currently. Nowadays, most recommendation systems consider learner/user preferences, interests, and browsing behaviors when analyzing learner/user behaviors for personalized services. The personalization should consider different levels of learner/user

knowledge, especially in relation to learning. Therefore, considering learner ability can promote personalized learning performance [6].

Also most e-learning systems lack the presence and control of an instructor to the learning process to assist and help learners in these environments (also known as human touch). Thus modeling the behavior of the instructor and provide instant feedbacks is an important task in these environments [29]. Foltz and Dumais [30] present results of an experiment aimed at determining the effectiveness of four information filtering methods in the domain of technical reports.

2.2 Web Services Technology

Several standards for e-Learning currently exist, including IMS, SCORM (Sharable Content Object Reference Model), and ULF (Universal Learning Format) [7], which have been combined with XML based technologies to define and describe each e-Learning material as a learning object (LO). The different LOs can be inter-recognized to enable exchanges among different learning systems which support these standards. However, e-Learning systems suffer from several problems. E-learning resources are always distributed around several locations, making it difficult to integrate numerous e-Learning resources.

- Most e-Learning components are system-dependent and cannot be combine with other systems.
- Most e-Learning systems ask learners to use specific client devices to learn.
- Learners still cannot learn without time and place restrictions.

Because of the above problems, several researchers have proposed the use of web services to achieve learning object collaboration. Web Services is the most active and widely adopted implementation of Service-Oriented Architecture (SOA). Web Services technologies are being continuously standardized to ensure interoperability and security [8]. Web Services make calls to web methods exposed as a service by sending and receiving SOAP messages. Web Services are regularly being considered as one of the most advanced form of SOA implementation and usually one of the most matured as well.

2.3 Service-Oriented Architecture

The Service-Oriented Computing (SOC) paradigm refers to the set of concepts, principles, and methods that represent computing in SOA in which software applications are constructed based on independent component services with standard interfaces [9]. SOA leads us to understand it as an architecture which orients around services. *Services* are discrete pieces of software, implemented using well-defined standards and interface specifications. A service, once developed and tested is submitted to a directory or registry so that it is available to other developers. The registry also contains a repository, which contains details of the published service, such as how to construct the interface, what are the expected service levels, maintaining authority, etc. A typical SOA would look like in Figure 1.

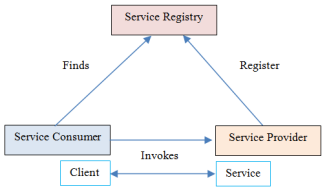

Figure 1: A Typical SOA

Communication among consumers and providers or services typically happens in heterogeneous environments. SOA services have self-describing interfaces in platform-independent XML documents. Web Services Description Language (WSDL) is the standard used to describe the services. SOA services are maintained in the enterprise by a registry that acts as a directory listing [10]. Applications can look up the services in the registry and invoke the service. Universal Description, Definition, and Integration (UDDI) is the standard used for service registry. SOA differs from existing distributed technologies in that most vendors accept it and have an application or platform suite that enables SOA [11]. SOA provides enterprises better flexibility in building applications and business processes in an agile manner by leveraging existing application infrastructure to compose new services. The purposes of applying SOA to the E-Learning Systems are as follows:

- to achieve better collaboration among related LMS's in order to perform learning tasks that are larger in scope;
- to provide consistent service-level agreement across various related LMS's during learning sessions or processes;
- to provide better adaptive learning across various LMS's
- to provide a learner-centric single portal for learners, which is capable of incorporating all of the learner's desired learning materials; all of the portal's capabilities should also be supported in this single portal;
- to facilitate life-long learning, where a learner will need to access many LMS's during his/her learning career and may wish to have consistent scoring, tracking, accessing, and/or learning methodologies during the life-long learning experience.

However, a serious limitation of an SOA is that it does not make any assumptions regarding service deployment and leaves it up to the discretion of the service developer to make this deployment choice, which is a daunting task and often leads to failure. A dangerous "difficult-to-customize, one-size-fits-all" philosophy permeates SOA development leading to

brittle implementations where once an application is deployed it is bound to a particular infrastructure. In addition, traditional SOA-based application development concentrates on a kind of "big design upfront" where the prevailing belief is that it is possible to gather all of a developer's or customer's requirements, upfront, prior to coding a software solution. So despite its promises, SOA has so far failed to deliver promised benefits except in rare situations leading yet again to a software development crisis.

2.4 Cloud Computing

To address these serious shortcomings it is normal to turn our attention to Cloud Computing as it aims to provide both the economies of scale of a shared infrastructure and a flexible delivery model that naturally complements the service orientation of the SOA paradigm. However, there are several reasons why cloud computing is ideal for e-learning systems/applications [12]. The use of cloud computing in e-learning is raw computing power and a phenomenal increase in storage capacity that it affords educational institutions. Cloud computing brings higher security to e-learning systems. Many institutions are attracted to a cloud-based educational system is the degree of virtualization that it allows its users.

Cloud computing is rapidly emerging as one of the most important resources for the future of education [13]. Its ubiquity, convenience, and ease of customization let students and teachers have on-demand access to a vast pool of resources that can be shared among all participating individuals and institutions. The cloud offers e-learning is continuous availability, increases in efficiency and higher security. Cloud computing can practically replace every part of the traditional delivery. Mainly, three types of services from a cloud service provider are Infrastructure as a service, Platform as a service-service and Software as a service [14].

- *Infrastructure as a service* delivers computer infrastructure usually through a platform of virtualization. Instead of purchasing servers, software, network equipment etc., with cloud computing you are purchasing these resources as a total outsources service.
- *Platform as a service* delivers a computing platform as a service facilitating the installation and organization of applications. With this there is no cost of software and hardware to do this in a traditional delivery scheme. Development as a service provides clients and users with readily available apps that they do not require to create, update and maintain.
- *Software as a service* provides software as a service over the internet in which clients and users no longer need to install and run applications on their own computers.

A cloud environment can be broadly categorized into three types- public cloud, private cloud and hybrid cloud [15]. *Public cloud* is the most popular type of cloud system and is considered as a main-stream cloud system by cloud computing experts. In public cloud system a third party data center provide both disk space and computing power for all the application software like Amazon web and Google apps. *Private cloud* unlike public cloud, it needs to set up your own data center and also bear all the installation & maintenance cost, and have complete control of all the data. This system provides more security and privacy, but it is more expensive cloud solution to public cloud. The main advantage of using cloud computing facility is that learners do not have to pay for infrastructure installation and maintenance cost.

2.5 Cloud Computing Model

The cloud computing model allows access to information and computer resources from anywhere that a network connection is available. It provides a shared pool of resources, including data storage space, networks, computer processing power, and specialized corporate and user applications. The design uses layered web application architecture [29]. Figure 3 shows the proposed Cloud Computing Model [8] for E-learning systems which is derived from the Figure 2. It consists of Subscriber Tier, Service Tier, Application Tier and Storage Tier [19].

- *Subscriber Tier* - All the users or subscribers are exists in the Subscriber Tier. They are learners, teachers, content creators, publisher, administrator, etc. They connects to the Portal Server via Desktop, Laptop, etc.
- *Service (Demand) Tier* – The Service registry is existed in this tier. All the services discovered in the above section should be registered in the Service Registry. The registered users demand the necessary content to the EL Applications.
- *Application (Delivery) Tier* – All applications related to the ELS are placed in this layer. These applications perform registration, user identity, search or query, send alerts/ notifications, monitoring, remote connection management, etc.
- *Storage (supply) Tier* - All the data or content are available in Storage tier. They supply necessary data/ information to the registered users or subscribers. The data are available in the form of databases like user database, e-content database, e-mail database, message database, etc.

This cloud model promotes availability and is composed of essential characteristics, service models, and deployment models [16].

2.6 Cloud-Oriented E-learning Model/Architecture

Cloud-oriented e-Learning Model/Architecture (COLMA) introduces scale efficiency mechanism. The cloud-oriented environment supports the creation of new generation of e-learning systems, able to run on a wide range of hardware devices, while storing data inside the cloud. The COLMA would be one where full resource virtualization that takes into account the cost of resources, network connectivity, performance requirements, user geography, and so on. The

simplest model of cloud computing can be created using a pool of servers that have been "*virtualized*" using an application tool like the Web Services directory, UDDI or a network tool used for server load balancing. This can make multiple servers (real or virtual) appear as a single resource - *a cloud*. There are several reasons why cloud computing is ideal for e-learning applications. The main benefits that a cloud computing architecture can bring to an educational system [16] are as follows:

- It increase the storage capacity that it affords educational institutions.
- It offers e-learning is continuous availability.
- It brings higher security to e-learning systems.
- It increases the efficiency than traditional e-learning systems.

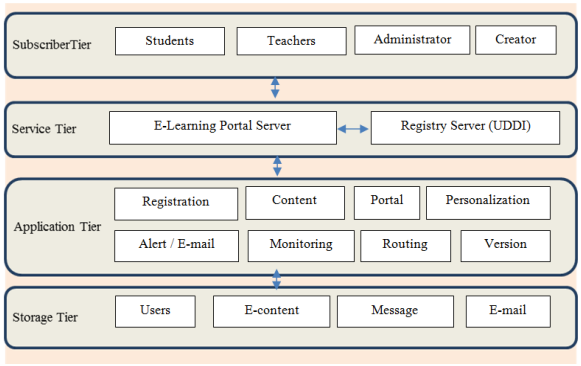

Figure 2: Cloud Computing Model for E-Learning Systems

Cloud computing and SOA have important overlapping concerns and common considerations. The most important overlap occurs near the top of the cloud computing stack, in the area of Cloud Services, which are network accessible application components and software services, such as contemporary Web Services. Both cloud computing and SOA share concepts of service orientation. Services of many types are available on a common network for use by consumers. Cloud computing focuses on turning aspects of the IT computing stack into commodities that can be purchased incrementally from the cloud based providers and can be considered a type of outsourcing in many cases. However, cloud computing is currently a broader term than SOA and covers the entire stack from hardware through the presentation layer software systems. SOA, though not restricted conceptually to software, is often implemented in practice as components or software services, as exemplified by the Web Service standards used in many implementations. These components can be tied together and executed on many platforms across the network to provide a business function.

2.7 Service-Oriented Cloud Computing Architecture

Service Oriented Cloud Computing Architecture (SOCCA) [23] is the other architecture proposed by researchers. This is a theoretical architecture that is not implemented but discussed in the paper. This architecture is similar in many ways to CCOA and different in others. This is another architecture that attempts to take advantage of the goals and views of SOA. SOCCA has four layers that make up its architecture. They are cloud provider layer, cloud ontology mapping layer, cloud broker layer, SOA layer and application layer.

- The *cloud provider layer* is the layer at which each individual cloud provider has their own hardware and software. In this layer all the cloud providers take care of their own resources and virtualization. Each provider has to figure out how much resources they will need and if they need to cut down on the amount that they are using or increase the amount they have.
- The *cloud ontology mapping layer* is the layer of SOCCA that hopes to mask the differences between separate clouds. This layer is to help the transfer of data from one cloud to another which fulfils one of the key goals of SOA. Each cloud provider shares information in the same way.
- The *cloud broker layer* is the layer that deals with information - such as pricing, hardware, software, and services provided for each cloud provider. The core components of this layer is cloud provider information which is the information above.
- The *SOA layer* deals with the ideas of SOA and implementing them into the SOCCA architecture. The key idea of SOA is multi-tenancy.
- The *Application layer* is the specific applications of integration the teaching resources in the cloud computing model, including interactive courses and sharing the teaching resources. This layer mainly consists of content production, educational objectives, content delivery technology, assessment and management component [24].

The potential benefits of service-oriented cloud computing e-learning architecture include decentralized, cost effective, virtualized, flexible, personalized and scalability. The advantage of cloud computing is that the application can be continuously updated by the application provider. Each time the user logs in to the site, the user will get the latest version

of the application. The application provider is also offering a very scalable web application using a multi-tiered web architecture, implemented on a considerable infrastructure.

2.8 Service-Oriented Cloud Computing Reference Architecture

Reference architectures can play a fundamental role in this perspective, aiming at guiding the building of learning environments. Basically, a reference architecture refers to a special type of software architecture that captures the essence of the architectures of a collection of systems in E-learning systems.

Service-Oriented Cloud Computing Reference Architecture (SOCCRA) is a process that systematizes the design, representation and evaluation of service-oriented cloud computing reference architecture [5]. The process comprises four basic steps.

i. Firstly, the main information sources are selected and investigated. These sources must provide information about services that can be supported by software systems of the E-learning application domain. SOCCRA highlights people and software applications as the most relevant information sources to be considered.
ii. Secondly, the architectural requirements of the reference architecture are identified, describing the common functionalities presented in E-learning systems. It identifies system requirements (functional and non-functional) and establishment of the reference architecture requirements (architectural requirements).
iii. The third step consists of establishing the architectural description of the reference architecture. To build this description, well-known architectural styles and patterns (e.g., client-server and three-tier architecture) as well as a combination of them and other styles can be considered. Besides that, SOCCRA proposes some architectural views like module view, runtime view, development view and conceptual view to describe reference architecture.
iv. Finally, an evaluation of the resulting architecture is conducted by means of a checklist-based inspection approach. The checklist is composed of questions. The main idea is to guide reviewers on detecting defects in the documents related to the reference architecture design.

3 LITERATURE SURVEY AND RELATED WORKS

Arch-int et al. [6] proposed a reference architecture to promote interoperability of existing learning systems by means of web services. Still regarding interoperability, Habraken [17] described a reference architecture in which learning components from different suppliers could be integrated into one e-learning solution for a customer. Anido et al. [18] proposed a reference architecture that identifies common, standardized software services for distributed e-learning systems. In the same perspective, Palanivel and Kuppuswami [19] designed a service-oriented reference architecture for personalized e-learning systems. In Schmidt's work [20], a layered reference architecture for context-aware learning support systems was defined. Li et al. [21] also presented a layered reference architecture for learning environments, aiming at building scalable environments to support an arbitrary number of users, while providing them with a personalized environment.

It is important to point out that reference architectures for developing learning environments are still very specific, sometimes considering only one type of environment, for instance, e-learning systems. Besides that, SOA (Service-Oriented Architecture) [22] has been the basis for almost all architectures, such as [6], [19], [20]. Also, the SOCCA has not been widely investigated for the learning domain. Last but not least, none of the proposed architectures was developed by using a process for designing, representing and evaluating them. Thus, addressing such issues by adopting a systematic process to the establishment of a more general, SOCCRA for developing learning environments is the focus of our work.

4 PROPOSED ARCHITECTURE: SOCCAPES

The solution is to investigate and design a scalable reference architecture to Personalized E-learning Solutions using SOCCA. The proposed reference architecture is called SOCCAPES, a layered architecture that it consists of demand layer, supply layer and delivery layers. This architecture provides several benefits. Because it includes a SaaS approach for data along with PaaS option and even an IaaS offering, the data can be stored based on the security, consistency, and other properties desired.

The architecture is designed to support maximum scalability and high service levels through virtualization and an optimized management environment. It enables new levels of scalability while providing a very cost-effective modular solution. This enables institutions to start with a cost-effective small pilot and then grow and expand over time to support an enterprise-scale online learning environment. Some of the critical design factors [25] are flexible infrastructure, building services, scalability of users and contents, and caching the data.

4.1 Source Investigation

It began the design of SOCCAPES by choosing a set of E-learning systems to be considered as information sources in E-learning domain. The selection was based on the first initiatives on learning systems with specific features, such the use of ontologies and adaptive issues on learning. Additionally, it also conducted a systematic review in order to identify publications addressing characteristics, functionalities and requirements of architectures of learning systems. At the end, it was able to get considerable knowledge about the learning systems. This knowledge acts as a basis for the design of SOCCAPES. Here, we take the design considerations based on functionality.

1. *User performance*: The learners can interact with multiple channels such as mobile, Laptop, or online. Some of the content that must be retrieved when a user approaches the DL server are how frequently the user comes back and what are the interests of the user
2. *Security*: All E-learning transactions are always critical and should be secured so security as service will enable security requirements including multi-factor authentication.
3. *Scaling of User systems*: The administrator should enhance the number of systems available for users.
4. *Common infrastructure*: Identify the common functionalities and provide them with a common infrastructure for better coordination and implementation
5. *Collaboration Services*: Design E-learning applications for collaboration services like sharing the information on common utilities, information, attractive provisions offers, etc.
6. *Load balancing*: Handle load balancing using Infrastructure as a Service

4.2 Architectural Requirements

Based on the knowledge obtained from source investigation, it is able to identify the functionalities/services with respect to learning systems. The various services are content, assessment, communication, adaptation, storage, semantic, publish/subscribe, interface, versioning, file transfer, etc. Each service was divided in subcategories and, for each of them, a set of functionalities was identified. From the architectural requirements, it is able to determine the main concepts related to the learning systems. Among all functionalities analyzed, personalization are generally spread for several parts (modules) of a learning systems and personalization can occur as needed by the user.

The SOCCAPES is to reduce cost and improve performance. SOCCAPES should provide mechanisms to support *data portability & system portability*, *service interoperability*, *security* and *privacy* [14].

- *Portability* - For portability, customers or users are interested to know whether they can move their data or applications across multiple cloud environments at low cost and minimal disruption. From an interoperability perspective, users are concerned about the capability to communicate between or among multiple clouds. This can be d*ata portability* and system portability.
- *Interoperability* - Service interoperability is the ability of cloud consumers to use their data and services across multiple cloud providers with a unified management interface.
- *Security* - Security in cloud computing architecture concerns is not solely under the purview of the Cloud Providers, but also Cloud Consumers and other relevant actors. Cloud-based systems still need to address security requirements such as authentication, authorization, availability, confidentiality, identity management, integrity, audit, security monitoring, incident response, and security policy management.
- *Privacy* - Cloud providers should protect the assured, proper, and consistent collection, processing, communication, use and disposition of personal information in the cloud [14].

4.3 Services Identified

The services identified during design of SOCCAPES are Registration, Portal, Alert/Notification, E-learning, Monitoring, Remote Connection service, etc. The services can be specified as a set of messages of a XML. The Services Layers implement the necessary functionality to transform the request from a service consumer application to a suitable format, communicating with the application/product implementing the functionality and returning the result. A brief description of the services is as follows

- **Registration Service** - It enables an application to register as a participant. The Registration service provides methods for collecting the information required to build the User personal details. The tasks have to be covered by registration are registration process, sending e-mails to the registered users, conform registration and enable/disable of users account.
- **Portal Service** – It provides role-based portals and interfaces. They enhance the user experience for designing, building, and consuming private and public cloud services. Among the interfaces It provides consumers of services, service designers, service assurance, and IT administration.
- **Alert/ Notification Services –** The learners receive an e-mail or SMS alerts or notifications whenever adding/updating content to the E-learning Server. The chief function of the notification service [26] is to notify the users with the latest information they are interested in automatically without any users' information retrieval and request. The users only need to do is to register the kind of their subject. The information types to be notified are subject information, subject navigations, course information, course navigation, the digital magazines/book, and the news/circulars/notification, new services provided by LMS.
- **Personalization Services** - The personalization services [27] in a E-learning environment would help the users to find information resources available in a digitally chaotic world. The reasons of developing a E-Learning include increasing access to information serving and users' needs and bringing organization to the unstructured universe of electronically available information.

- **Security or Identity Service** - Security service offers authentication, authentication, access control and confidentiality [28]. The *authentication* handles the authentication requests sent to the DL portal. It is passed log-on credentials for a user and returns an authentication certificate. *Authorization* follows authentication and that is, once a user or system has be authenticated. The *confidentiality* is the security service for ensuring non-disclosure of sensitive information traveling through networks.
- **Remote Connection Service** – This service offers establishing connection to the EL Server from a remote place. It accepts the requests from the authorized users and allow them to upload the contents to the EL server.
- **Monitoring Service** - Monitoring Service can be implemented as support to predict, track and remediate site problems in a timely and efficient manner. This secure service will interpret events and activate the proper response mechanism with user defined notification rules, including e-mail or SMS. The user friendly E-Learning Web Portal gives users easy access to up-to-date contents such as e-books, e-journals, e-theses, etc. and dynamically generated reports.

The above identified services are registered in the services registry. The registry manager can either start/restart or stop the services.

4.4 Reference Architecture Design

Considering the architectural styles and patterns, it is chosen to build SOCCAPES based on well-known and consolidated architectural styles of interactive systems and Web systems - the multi-tier architecture. Besides that, SOCCAPES proposes some architectural views to describe reference architectures:

i. module view: shows the structure of the architecture in terms of packages, classes, containment, specialization/generalization and relationships;
ii. runtime view: shows the structure of the systems (that will be built based on the reference architecture) when they are executing;
iii. deployment view: describes the hardware, the software system or subsystems that are installed on that hardware, and the network connections, if they exist; and
iv. conceptual view: describes the understanding of each domain concept or term used in the reference architecture.

The module view is composed of three tiers/layers. Figure 3 shows the proposed SOCCA Model for E-learning Systems which is derived from the Figure 2.The request for PES functionality, which comes from the PES users over network, is passed to the Service or Demand Layer. The Demand Layer implements business processes for the different modules, including batch processing and report generation. The Identity Service includes authentication and authorization. It authorizes the user for every request made by the user.

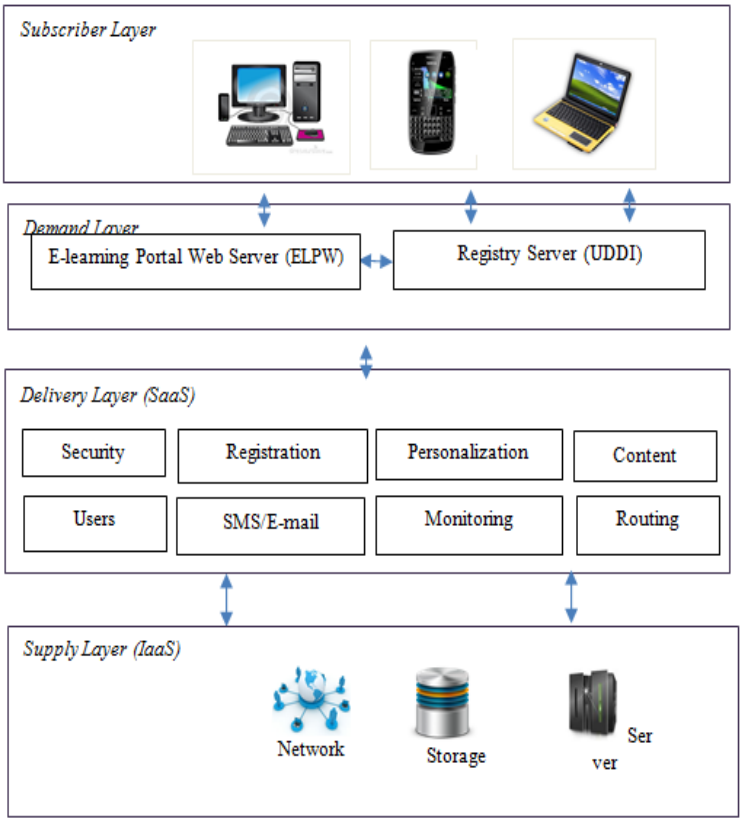

Figure 3: Generic High-level Architecture of E-Learning System

Figure 3 depicts a generic high-level architecture [15] and is intended to facilitate the understanding of the requirements, uses, characteristics and standards of cloud computing. The cloud computing reference architecture defines the actors: *cloud consumer*, *cloud provider*, *cloud carrier*, and *cloud broker*. They are described below:

The *cloud consumer* (example Student, Teacher, Guests) is the principal stakeholder for the cloud computing service. A cloud consumer browses the service catalog from a cloud provider, requests the appropriate service, sets up service contracts with the cloud provider, and uses the service. A *cloud provider* (E-learning Applications, SMS, Notification, E-mail, Monitoring, etc.) is the entity responsible for making a service available to interested parties. A Cloud Provider acquires and manages the computing infrastructure, runs the cloud software, and makes arrangement to deliver the cloud services to the users through network access. A *cloud broker* is an entity that manages the use, performance and delivery of cloud services and negotiates relationships between cloud providers and cloud consumers. A *cloud carrier* acts as an intermediary that provides connectivity and transport of cloud services between cloud consumers and cloud providers. Cloud carriers provide access to consumers through network, telecommunication and other access devices.

Each actor is an entity (a person or an organization) that participates in a transaction or process and/or performs tasks in cloud computing. The cloud computing infrastructure and its impact on critically important areas to IT, like security, infrastructure investments, business application development, and more. This requires multiple skills for using applications on the cloud computing environment. These layers have made it easier for the users to define the roles and responsibilities and the skills demanded by the users at each level. The above four key layers of a cloud computing environment will help understand the functionality and the technical skills required, in order to understand the system as well as perform tasks more efficiently.

4.5 Layered Architecture

SOCCAPES consists of various layers like supply layer, delivery layer and demand layer and their functions are explained below:

Consumer Layer – The consumer are students, teachers, guests designer and administrator. The consumer layer is more strictly and carefully separated from the services and service provider to allow pooling and substitution of cloud services or providers. This end layer is more about the data consumers. As these data consumers use a different kinds of protocols and APIs, Enterprise Search Layer and Data Manipulation Layer appropriately exposes the services for them to be consumed.

Demand layer - Cloud Service Automation also provides the portal services for the demand layer, where consumers or business users can request services. The Demand layer exposes services and products to the consumer through a user portal. It maintains a catalog of all internal (provided by the Delivery layer) and external (aggregated) services available to end users. The Demand layer authenticates end users to determine their authority to create or modify services, generates service billing and settlement information, and provides visual feedback on customers' Quality of Experience and Service Level Agreement compliance.

Delivery layer - Above the supply layer is the delivery layer, where Cloud Service Automation software enables and manages the delivery of application services. User interfaces allow infrastructure design, for specifying what assets will be available, and service design, where a service designer can add to and manage service catalogs. It also selects the most appropriate Supply layer to use, based on policies, the Demand layer requested, and Supply layer availability. The Delivery layer also monitors consumers' and customers' service usage.

Supply Layer - The supply layer provides for service delivery of infrastructure elements such as compute, network, storage, and other resources both physical and virtual. These infrastructure elements may be hardware and virtualization, or they may be provided by a customer's existing infrastructure or by third parties, including public clouds. The Supply layer isolates the Delivery layer from physical resources by providing customer-facing service abstractions. It performs all governance and orchestration necessary to ensure that the resources deliver the desired service. This layer also monitors resource utilization and generates usage data records.

As more functionality moves to the internet cloud, every provider and user is needs to develop set of skills required. As time progresses, these layers will shift, blur or might even disappear entirely.

The Registration as-a-Service

Registration provides an easy-to-use web interface for potential users of an application to "register" themselves and request sign-in credentials. Administrators receive requests and decide whether to grant them or not. When a user is registered, a credential is created on his behalf and used whenever he uses the Library application. The *Registration–as-a-Service* (RaaS) combines certification authority with a back-end database and ELWP to automate user registration requests. The registration interface solicits basic data from user, including a desired ID/password combination. Requests are forwarded by email to an administrator and the data from the requests are stored in a database. The administrator uses administrative functions in the web portal to process requests. Users receive email notification when their accounts are ready for use. When an account is created, the portal generates a credential for that account automatically. This credential is issued by the application administrator, so it is most likely only "valid" for use with the specific application and no others. When a user logs into the ELWP portal, the application obtains a certificate from the security service using the

user's ID/password, and the application can then use this security to authenticate to any other service that recognizes credentials issued by the application administrator.

E-Learning as-a-Service

E-learning as a Service (eLaaS) is a platform that provides a comprehensive range of learning and teaching services to staff and clients / associates remotely over the internet (e-learning). The teaching materials are sent to clients / associates via the internet, an intranet within the company or an extranet. E-learning Software as a Service providers deliver and manage e-learning applications and services from remote data centers to multiple users via the Internet. Obtaining your e-learning application from an outside supplier is a cost effective solution to the demands of systems ownership, namely up-front capital expenses in facilities, hardware and software, implementation challenges, staffing for a complex computing infrastructure, and a continuing need for maintenance, upgrades and customization.

Notification as a Service

Managing notification and problem resolution continues to be increasingly challenging and critical for enterprises of all sizes, academic institutions, government entities and other large organizations throughout the world. Notification as a service allows enterprises to take maximum advantage of the growing trends toward Software as a Service (SaaS) and to leverage on-going improvements in notification technologies, while minimizing operating costs and avoiding future forklift upgrades.

This Notification Service [23] provides a single notification client to all applications, support synchronous and asynchronous interface to the Notification Application Server. The Notification Application provide capability to send notification like instant /short messaging, and e-mails through multiple channels. The Notification minimizes the knowledge of different notifications produces in order to facilitate a loose coupling of services. Here, the Notification Application Server sends instant/short messages and e-mails to the learners/teachers/content creators whenever adding a new contents or updating the existing digital content to the E-learning Server.

Notification Application Server perform extremely well even if the application must support thousands or millions of subscribers/learners. In all applications that send notifications, the basic requirement is to evaluate subscriptions at the right times, either when an event related to the subscription is available, or according to a schedule.

Query as a Service (QaaS)

Query as a Service is an application that allows the users to quickly create queries and publish them as web services. It has a client component that creates queries from universes, and a server-side web service that allows developers to create web services from specific objects queries.

ELPS need to present data in a tabular format to the learners/users. The ELPS server delivers the data to learners/users in a tabular format. The functionality provided by the query (search) service [24] are dynamic query generation based on learners/users input, sort order, joins, etc. In order to make the changes in the architecture as transparent as possible to the user, SOCCAPES provides a list of the services references if such functionality is activated. There are multiple ways to invoke the query service according to users' preferences. One straightforward way to access the service is by an embedded URL. For example, the learners/users want to search a digital content/ object related to Computer Science, then they have to type 'Computer Science'. By activating the link on the query interface, it can obtain the extra services exposed by other providers. The advantages of the storing the results in XML format while avoiding the disadvantages of increased data volumes and reduced query performance caused by the enrichment process.

Security as a Service (SaaS)

Security-as-a-Service solutions for the cloud protect E-Learning Web Applications against the most common threats and attacks. Security-as-a-Service solutions for the cloud provides solutions to secure the application and infrastructure stack. It delivers both critical Web protection and cost effective management. Security-as-a-Service solutions for the E-Learning includes Information, Data, User Account, Access Rights, Intrusion & Detection, Firewalls, Virtual Private Network, RFID, etc. Security component offers authentication, authentication, access control and confidentiality [18, 30]. Figure 6 shows that how the security module works in SOCCAPES.

The *authentication* handles the authentication requests sent to the ELPS. It is passed log-on credentials for a user and returns an authentication certificate. *Authorization* follows authentication and that is, once a user or system has be authenticated. Authorization means making a decision about whether an authenticated or even an authenticated identity is allowed to access a resource. The *confidentiality* ensures non-disclosure of sensitive information traveling through untrusted communication networks. Information at rest includes security, user, and application information. It is commonly rely on ton cryptographic techniques such as encryption. *Single sign-on (SSO)* is mechanism can permit user to access all resources without the need to enter multiple passwords. Single sign-on reduces human error, a major component of systems failure and is therefore highly desirable but difficult to implement.

The security services enhance both security and performance. This increase website performance, no installation of firewall, anti-virus software, remote access, etc.

Monitoring as a Service (MaaS)

Application monitoring tools pursues with all or at least a part of E-Learning application. A monitoring tool that is itself delivered as a service so that it can log onto one central web based dashboard which is hosted by the vendor of the

monitoring service and see what is going on with all of EL applications matter where they are located. Monitoring as a Service is referred as MaaS. The extensive monitoring, tracking and auditing capabilities of ELAs help administrators identify and react to misuse due to malicious intentions, undetected compromises, policy gaps, errors or oversights. They also provide extensive support for compliance with corporate policies, and with security and privacy regulations.

Monitoring-as-a-Service is an outsourced service to provide security mainly to platforms that are run on the Internet for conducting classes. Monitoring involves protecting ELs from cyber threats, in which a team prepared is crucial to maintain the confidentiality, integrity and access to IT assets. However, time and resources constrain the limits of security operations and their effectiveness for the vast majority of companies. With this, it is vital to continue vigilance on security infrastructure and information.

This service monitor and manage the quality of service of the architecture, including its performance, security, and manageability. This service also includes building blocks such as performance managers, security managers, and notification managers.

Storage as a Service

Storage as a Service is generally seen as a good alternative for a small or mid-sized business that lacks the capital budget and/or technical personnel to implement and maintain their own storage infrastructure. SaaS is also being promoted as a way for all businesses to mitigate risks in disaster recovery, provide long-term retention for records and enhance both business continuity and availability. Cloud storage is a service model in which data is maintained, managed and backed up remotely and made available to users over a network (typically the Internet).

It facilitates cloud applications to scale beyond their limited servers. SaaS allows users to store their data at remote disks and access them anytime from any place. Cloud storage systems are expected to meet several rigorous requirements for maintaining users' data and information, including high availability, reliability, performance, replication and data consistency; but because of the conflicting nature of these requirements, no one system implements all of them together.

The types of storage layers for Infrastructure-as-a-Service (IaaS) include capabilities such as web or virtual machines, storage for online file sharing, backup or archiving, database, search and development tools. These capabilities enable cloud providers themselves or third parties to create customized solutions by combining the various cloud functionalities or layers with services provided. SaaS cloud storage solutions include file, document, music, photo and video sharing and backup/restore along with archiving capabilities. Other cloud storage options include database, cloud drives and other applications exploiting back-end cloud storage. Cloud storage solutions also extend to products and solutions used for deploying public, private and hybrid clouds.

Demands for storage bandwidth continue to grow due to rapidly increasing client performance, richer data types such as audio and video. For storage subsystems to deliver scalable bandwidth linearly increasing application bandwidth with increasing numbers of storage devices and client processors, the data must be striped over many disks and network links. The *file manager* provides naming, directory hierarchies, consistency, access control, and concurrency control. The storage manager redirects clients to the underlying component NASD objects. The *storage manager* (possibly co-located with the file manager) manages mappings for striped objects and supports concurrency control for multi-disk accesses. The *object store* binds blocks into variable-length objects and manages the layout of these objects in the storage space offered by the device(s).

Scalability and flexibility are highly valuable advantages offered by SOCCAPES, allowing stakeholders to react quickly to changing IT needs, adding or subtracting capacity and users as and when required and responding to real rather than projected requirements. Customers benefit from greater elasticity of resources, without paying a premium for large scale.

5 EVALUATION OF SOCCAPES

Aiming at evaluating SOCCAPES, it is conducted an inspection on its architectural views using questions. It evaluates quality characteristics of the reference architecture: maintainability, performance, security, usability, portability and reuse. Examples of questions are as follows:

- Is the RA develop based on the domain terms that are widely used and well-understood?
- Are the architectural views sufficient and adequate to represent all elements of the domain?

The results achieved from this preliminary evaluation suggest the adequacy of SOCCAPES with respect to the learning systems. The consistence among the architectural views of SOCCAPES was also verified.

6 CONCLUSION & FUTURE ENHANCEMENTS

A scalable E-learning systems will be possibly to facilitate the development of information technology in education and should support multi cloud environment for ensure the further improvement of the quality of teaching and learning activities for changing the pattern of learning and teaching. The various limitations concerning Cloud are availability of services, data lock-in risk, reliability of data, data transfer bottlenecks, performance unpredictability and software licensing are raised. The adoption of Cloud and SOA results in a service full cloud computing environment that enables highly dynamic and effective organizational collaborations. In such collaboration each of the participants behaves according to the predefined and mutually agreed upon business logic and service level agreement.

SOCCA is a promising idea could possibly be made into SOA. The concept of a CCA has all the best properties would be amazing feat, but is still far away and needs more effort invested into it before SOA can become a realization. Though from operation and maintenance point-of-view cloud computing is a great cost-effective IT solution for business of any magnitude, but it has at least two major concerns-technical developments, *security* and *privacy*. Since cloud computing is relatively a new technology, it still has lots of scope of becoming a mature system as a reliable and cost-effective computing technology. Like any new technology, the adoption of cloud computing is not free from issues. All these challenges should not be considered as road blocks in the pursuit of cloud computing. It is rather important to give serious consideration to these issues and the possible ways out before adopting the technology.

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