A MODEL FOR CLOUDIFYING E-LEARNING DELIVERY ENVIRONMENTS

By

Mashael Abdullah Mohammed Al-Sowaiel

A thesis submitted for the requirements of the degree of Master of Computer Science

Faculty of Computing and Information Technology

King AbdulAziz University - Jeddah

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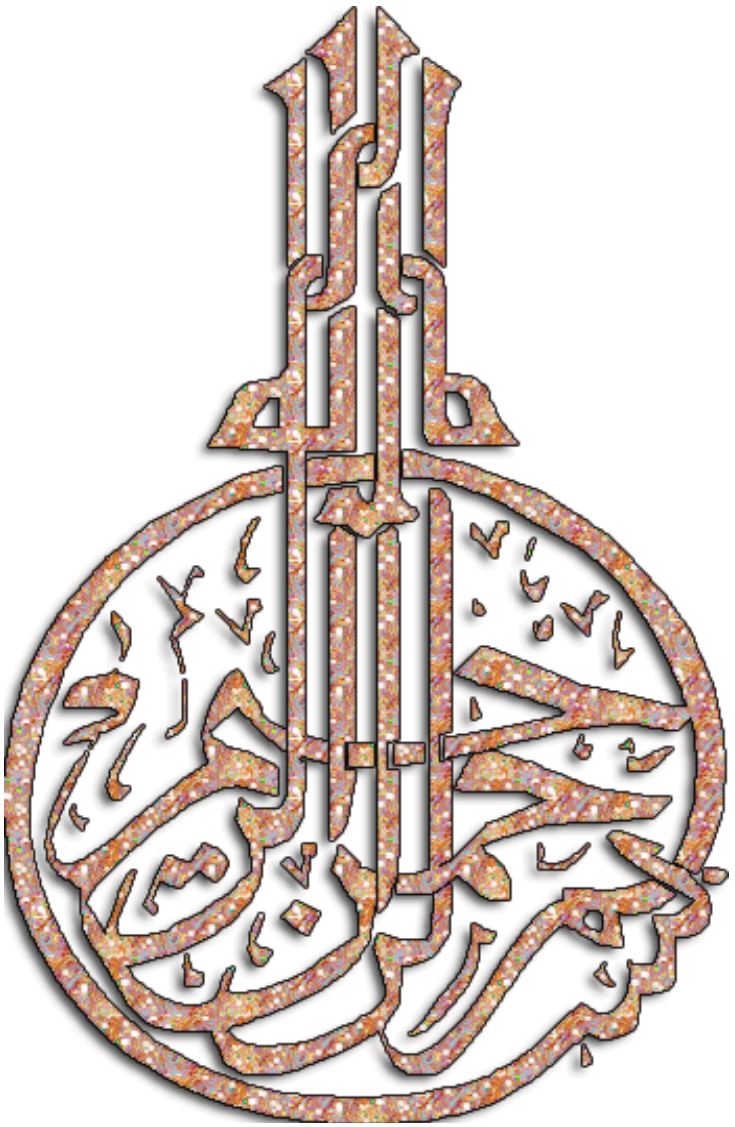

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This thesis has been approved and accepted in partial fulfillment of the requirements for the degree of Master of Science (Computer Science)

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Dedicated to

My Great Parents

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A Model for Cloudifying e-Learning Delivery Environments

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ABSTRACT

The need for e-Learning is becoming apparent due to the scarceness of resources in the traditional education. Therefore, many educational and training organizations became aware of the importance of adopting e-Learning. In addition, new purely virtual learning organizations start emerging intensively.

On the other hand, new technology—namely, cloud computing—has emerged. Business enterprises adopted this technology and have developed Cloud-based business models in which both infrastructures as well as software applications are offered for renting, which makes it possible to use expensive infrastructures and software applications without high setup expenses, yet at affordable low operating costs.

This research addresses how to employ Cloud Computing in e-Learning business. The different types of e-Learning organizations are identified and the e-Learning services offered by each type are classified. The Cloud Model that best fits the nature of each of these services according to the e-Learning organizations' affordability of resources as well as the abilities of the technological environment are discussed. Accordingly, taxonomy of Cloud Models mix is defined for each type of those e-Learning organizations and a rule-based expert consultant system (SCCeLE) is developed to aid them in determining the best cloud model mix that best fits their current situations and targets. On the other hand, this developed taxonomy, is believed, will encourage the Cloud Service Providers (CSPs) to conquer the business of e-Learning as it aids them in drawing a full picture on the e-Learning market and supports them in identifying their target market and in developing their e-Learning support business packages.

In addition, this research proposes another Cloud Model that offers e-Learning services in an economical way as it builds its service on top of freely available services that are offered to Internet users by other service providers for free. This newly proposed Cloud Model is named "Freeware as a Service (FaaS)". FaaS proposes a new technology in which e-Learning services can be implemented through building a customized user interface that fits the need for e-Learning, while interacting with the freely available Internet services as the engine of performing the real work, yet operating at the free service owner's servers. Therefore, FaaS helps in quickly and economically developing e-Learning software services that require no operational cost.

The expert system SCCeLE is implemented using Excel and Microsoft .Net platform. A survey and a questionnaire were conducted to understand the e-Learning market, organizations, services …etc. In addition, some prototypes were also implemented to experiment with the technology proposed by FaaS and to prove the idea.

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LIST OF ABBREVIATIONS

AOU	Arab Open University.
API	Application Programming Interface.
CapEx	Capital Expenditure.
CMS	Content Management System
CSPs	Cloud Service Providers.
DaaS	Data as a Service.
DDL	Deanship of Distance Learning.
EC2	Elastic Computing Cloud.
ELaaS	Education and learning as a service.
EMES	E-Learning Management Electronic System.
FaaS	Freeware as a Service.
FAQ	Frequently Asked Questions.
HaaS	Hardware as a Service.
HTML	HyperText Markup Language.
IAAS	Infrastructure as a Service.
Java EE	Java Platform, Enterprise Edition.
JSTL	JavaServer Pages Standard Tag Library.
KAU	King Abdulaziz University.
LCMS	Learning Content Management Systems.
LMS	Learning Management Systems.
OpEx	Operational Expenditure.
PAAS	Platform as a Service.

PBL	Problem-Based Learning Approach.
PC	Personal Computer.
PLE	Personal Learning Environment.
QoS	Quality of Service.
SAAS	Software as a Service.
SCCeLE	Smart Consultant for Cloudifying e-Learning Environment.
SDW	Software Development by Wrapping.
SLAs	Service-level Agreement.
SQL	Structured Query Language.
VLE	Virtual Learning Environment.
VMs	Virtual Machines.

Chapter One

Introduction

Chapter One

Introduction

1.1. Introduction

Educated and skilled human resources and workers are real assets and a key of success and power for both nations and organizations. Therefore, education and training play an important role in advancement. However, several challenges exist (Whitehurst, Powell, and Izatt 1998), which are mostly overcome by using the e-Learning technology that is believed to be the future of education. Universities and training institutions became aware of the power and advantages of e-Learning and had recognized how it can support their business in offering new more effective services that improve the learning efficiency. In fact, e-Learning offers various e-services to support all types of education and training systems; and most universities and training institutions have adopted some of these e-services as essential constituents of their education systems. Moreover, new purely virtual e-Learning-based educational organizations have emerged, which conduct all of their learning activities via the Web by using e-Learning services and technologies.

Although the adoption of e-Learning resolves many of the challenges facing traditional education including the need for large investments, yet, further reduction in needed investments is still required in order to encourage current and future learning organizations to adopt e-Learning, especially because of the increased demand on education and training.

The advent of cloud computing in recent years has sparked an interest from different organizations, institutions, and users to take its advantage (Masud and Huang 2012). It promises a shift from an organization required to invest heavily for limited IT resources that are internally managed, to a model where the organization can buy or rent resources that are managed by a cloud provider and pay per use.

Cloud Computing offers many advantages to business organizations, especially virtual and partial organizations. It offers investment reduction for the initial set up of IT infrastructure, fast time-to-market, and adaptable and balanced performance among many others. Similarly, we believe that it will be able to offer similar advantages to e-Learning organizations. Therefore, this research investigates the use of the Cloud Computing technology in the e-Learning business area.

Cloud Computing is a recent model that offers sharing computing infrastructures and application software in an efficient manner. It enables convenient on-demand network access to a shared pool of configurable computing resources, such as, networks, servers, storage, applications, and services. Commercially, new profitable business emerged in which three new service models took place so far—namely, IaaS (Infrastructure as a Service), PaaS (Platform as a Service), and SaaS (Software applications as a Service). Currently, all cloud computing service models are offered to generic type customers, meaning that Cloud Service Providers (CSP) deigned their services and products without a focus on any specific markets or business areas. In other words, the CSPs don't direct or customize their offerings to serve e-Learning organizations. This approach doesn't encourage serious educational organizations to think of the Cloud technology as an opportunity for implementing e-Learning services in acceptable investing expenses. To explain, the number of software services offered by e-Learning is large. Moreover, each of these services requires expensive specialized software, which makes building an e-Learning organization require relatively large investments and long time-to-market (long time before an organization can operate and offer its services to the market). Accordingly, CSPs are requested to resolve those issues if they want to attract e-Learning organizations among their clientele.

However, CSPs are currently not yet recognizing the importance of attracting and serving this new but promising business area—e-Learning. One reason for the ignorance of CSPs to serve the e-Learning business area might be due to the lack of having a full map of the e-Learning market, the services it requires, the nature of the e-Learning organizations, and the sizes and types of their needs, …etc. Therefore, the objective of this research is to aid both e-Learning organizations and CSPs to boost the e-Learning industry through cloudifying the e-Learning services as well as implementing less-costly e-Learning services on the Cloud.

One of the hypotheses of this research is: "Is it possible to use the S.W technology to boost e-learning business through encouraging both educational organization and CSPs to adopt e-Learning ?" The aim of this hypothesis was to develop a model of how e-Learning organizations can use the Cloud technology to boost their services and offerings, and, on the other hand, to look for ways that encourage the CSPs to consider serving the new promising business area.

To achieve this goal, many steps were followed. Firstly, a survey of many activities, such as interviews, literature review, and questionnaires, has been conducted to understand the business of e-Learning, the offered e-Learning services with their effecting criteria, and the expected service performance. This survey aided in developing taxonomy of five categories of e-Learning organizations, which categorizes the e-Learning organizations based on their intensity of adoption of the e-Learning technology and services onto their education systems. Secondly, the major services required for e-Learning organizations were identified by the survey to create a QoS (Quality of Service) map that defines the QoS of each e-Learning service as required by each category of the e-Learning organizations of the taxonomy. Thirdly, the criteria of operation and performance were defined for each required service and a set of rules were designed to recommend the Cloud Model that best suites those criteria. Unfortunately, these rules consider only the criteria of the e-Learning service; nothing about both the organizational and technology contexts was considered. Therefore, fourthly, another set of rules were designed to consider many other parameters, such as the organization's budget devoted to e-Learning adoption, time-to-market need, and QoS in terms of the

required features and performance; in addition to the availability status of supporting software for the target services. The second step of rules may upgrade or downgrade the initial recommended model to consider the organizational investment, marketing, and operational requirements as well as the technological environment status. Smart Consultant for Cloudifying e-Learning Environments (SCCeLE) is a rule-based expert system that was implemented to test the idea and to avail a useful tool for educational organizations to use to aid them in defining the most optimum e-Learning environment implementation strategy using a mix of Cloud models. Figure 1.1 demonstrates the inputs and outputs of SCCeLE.

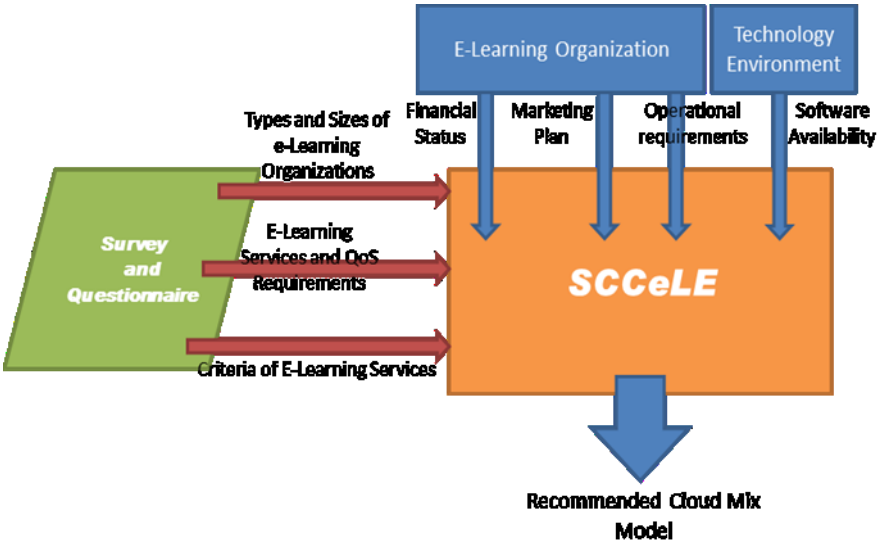


Figure 1.1. The SCCeLE's Model

Another hypothesis of this research is: "Are those commonly known three CSP service models—namely, IaaS, PaaS, and SaaS—the only possible; or it is possible that the technology opens a new opportunity for another fourth model that is economically more suitable?" This research suggests employing shareware or free Internet services, such as Chat and email services, in supporting the required e-Learning services. Unfortunately, those Internet services are not designed to serve e-Learning. Therefore, this research demonstrated that it is possible to wrap up those services in such a way that offers a more suitable look-and-feel for e-Learning environments, with a minimum cost of

development. We called this approach FaaS (Freeware as a Service) software development technique. Many prototypes were developed as a proof of concept to test the idea of FaaS development technique. For instance, a closed-list email service like that used by most e-Learning Management Systems (LMS) was developed using the Gmail service. In addition, a virtual Office Hours meeting room, a Collaborative conferencing meeting room, and a Virtual Classroom were developed on top of the Google's Hangout chat tool. This approach can be used by CSPs to develop less expensive e-Learning environments, though with less quality and limited features, but will quickly and economically overcome many of the challenges facing small e-Learning organizations. It is worth noting that FaaS is an economical approach not only for the development of the software but also in its deployment and operation as it usually runs on the servers of the service owner. Can we consider this approach and the services it offers as a fourth Cloud model? Figure 1.2 depicts the idea behind the proposed FaaS development technique.

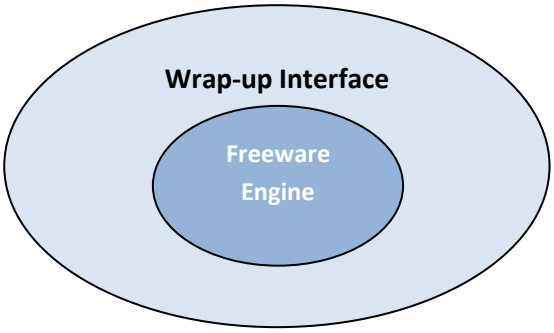


Figure 1.2.The Technology of Building the FaaS Model

Prototypes have been implemented to prove the ideas proposed in this research. SCCeLE is implemented using Excel (to ease the presentation and manipulation of tables) and the Microsoft .Net platform (for implementing the rule-based engine). Other prototypes were also implemented to experiment with the idea of the technology of developing FaaS's services. The prototypes implemented e-Learning specific scenarios, e.g., a closed circle e-mailing service on top of Google's Gmail. Also implemented are office hours chatting service, collaborative teamwork coordination meeting service, and

a virtual classroom service; all on top of Google's Hangout chatting service and Google Apps.

1.2. Research Objectives

The main objective of this research is:

" to aid both e-Learning organizations and CSPs to boost the e-Learning industry through cloudifying the e-Learning services and implementing less costy e-Learning environments on the Cloud"

The following is a list of our sub-objectives:

- Identifying the taxonomy of different e-learning organizations.
- Identifying the different e-Learning services that are required by different e-Learning organizations.
- Determining the services criteria and the guidelines affecting the selection of the most appropriate setup of the e-Learning environment on the Cloud.
- Identifying the different pragmatic circumstances affecting the organizational decisions when establishing an e-Learning environment.
- Designing an expert system that makes consultantions and recommendations to the e-Learning organization regarding building e-learning enviroment on the cloud.
- Devloping a prototype for the consultation expert system as a proof of concept for the suggested model.
- Investigating and suggesting methodology for developing e-Learning software economically, and applying this methodology in developing few e-Learning services to demonstrate the effectiveness of this methodology.

There are two Hypotheses in this research, which are as follows:

One of the hypotheses of this research is*: "Is it possible to use the Software technology to boost e-learning business through encouraging both educational organization and CSPs to adopt e-Learning ?"*

The second hypothesis of this research is: *"Are those commonly known three CSP service models—namely, IaaS, PaaS, and SaaS—the only possible; or it is possible that the technology opens a new opportunity for another fourth model that is economically more suitable?"*

1.3. Thesis Outlines

This thesis is organized into seven main chapters described as follows:

Chapter 1 is an introduction that describes the research motivation, the problem definition, and the approach of this research in tackling the problem as well as an overview on the achieved contributions.

Chapter 2 is a literature review of the previous researches on using cloud computing in e-learning.

Chapter 3 presents the necessary background about the cloud computing technology which includes the main concept of cloud computing, how it distinguishes from all the other concepts; enabling technologies; the main layers that make up the cloud computing architecture; types of deployment Models, and significant characteristics of Cloud Computing.

Chapter 4 explains the conceptual model and architecture for the Smart Consultant for Cloudifying e-Learning Environments (SCCeLE) rule-based expert system. Then, it describes the model's parameters, the inferencing process of two phases, and revealing the recommended cloud mix model for the e-Learning organizations and CSPs.

Chapter 5 intuitively demonstrates the idea behind the proposed approach FaaS (Freeware as a Service) software development technique through presenting examples and case studies of how this approach can be applied.

Chapter 6 describes the design and implementation of the prototype developed for SCCeLE rule-based expert system and the FaaS approach.

Chapter 7 concludes the thesis and identifies possible future work.

Chapter Two

Literature Review

Chapter Two

Literature Review

This chapter reviews the literature discussing the needs for cloud computing in elearning; the concept of cloud computing tecnology in e-learning; the usage of cloud computing in e-learning; and the great value that is added to e-learning. Finally, we will mention some the intitiatves of cloud computing aimed for the e-learning enviroment.

2.1. e-Learning Basics

People all over world search for knowledge. Knowledge can be gained through different kinds of education. Distance learning is one of the most common methods that derives its importance for the benefit it offers. That is, distance education works effectively with the students who are separated by time and space from lecturers (Zaıane 2002). There are different subtypes of distance education such as: paper-based correspondence education, videotape education, computer aided education (multimedia education, internet education or web-based education), etc. Currently, the most used is web-based education that allows students to conveniently learn via the Internet. Nowadays, many terms are used to refer to web-based education such as e-learning, e-training, online instruction, web-based learning, web-based training, web-based instruction, etc (Zaıane 2002). Concerning the types of web-based systems, they are classified into synchronous

and asynchronous, collaborative and non-collaborative, closed corpus and open corpus, etc (Zaıane 2002; Ai and Laffey 2007).

Network technology impacted learning environment and led to a new type of learning that is called e-Learning which grabbed people's attention. e-Learning is one of the most famous technologies offered to make the traditional way of learning easier with the help of software applications and virtual learning environment. The letter (e) means conducted electronically (Ma et al. 2010). E-learning comes through a network enabled computer and transfers the knowledge from the internet sources to end users' machines. E-Learning usually works with the help of software applications and the information (audio/video files, satellite TV, media disks) is usually transferred with the help of the internet. These materials can be in the form of text, image, animation, audio/video that can be used to deliver the learning materials to E-Learning users (Welsh et al. 2003; Pocatilu, Alecu, and Vetrici 2010)

Many universities, institutions and self-training companies are implementing the e-learning platforms for the students and employees to achieve their distance education programs. They also use it to enhance the ability of other educational degree programmes and to increase proficiency (Jindal and Singhal 2012). Broadly speaking, a good learning environment consists of an authoring system, and LMS (Learning Management System) and a learning object repository. Being the most important, the LMS delivers the target objects the time and the way it is required (Wang, Pai, and Yen 2011).

2.1.1. Benefits of e-Learning

The main factors of e-learning are re-use, resource sharing and interoperability. Moreover, there are other benefits such as (Vishwakarma and Narayanan, 2012):

1. Reducing cost of learning materials: One of the greatest benefits of e-learning is the reduction of the costs because the e-contents cost less money than the hard copies.
2. Enhancing learning technology: Sharing, storing, and manipulating the e-content over the network increases participation of academic institutes.

3. Clearness and attractiveness: Using animation and graphics in representing concepts and ideas stimulate accessibility and enhances learning outcomes.
4. Flexibility: E-learning users can select the courses, materials, and services in a flexible way.

2.1.2 e-Learning Environments

Virtual learning environment and personal learning environment are two important E-learning environments which offer a wide range of facilities to students through e-learning applications (Georgouli 2011).

- **Virtual Learning Environment**

Virtual Learning Environment (VLE) is simply another term used to represent the E-Learning systems, where the students are able to get face to face classroom environment through computer applications with the help of web sources. VLE is an enhanced application from the blended learning approach. The main objective of VLE is to provide the e-learning facility to large number of student communities to provide the virtual classroom environment. There are many terms which are very similar to virtual learning environment. These are Learning Management System (LMS), Content Management System (CMS) and Learning Content Management system (LCMS). Many universities and institutions use VLE to improve the intractable learning environment and break the interaction barrier on learning environment (Austin et al. 2013). The main advantage of VLE is that it is capable of storing many courses at a time, so it creates better environment for the instructor as well as the student when to move from one course to another. VLE provides some other provisions as follows (Kumar et al. 1998) :

1. Notice board for up-to-date course information.
2. Students can take their courses at any time and from any convenient place to them.
3. Students special needs and restrictions are able to use this kind of e-learning systems.
4. It provides geographically wide-spread education.

5. It offers education through the internet which helps students as its cost is effective and flexible.
6. Small universities that don't have many elective courses are able to provide a wide range of elective courses for their students in their institutions.
7. It enables more intractability among the students and lecturers.

- **Personal Learning Environment**

Personal learning environment (PLE) is a single user E-Learning system which helps the E-Learners to manage and modify their own learning. PLE offers a wide range of supporting features to their users, some of the important provision are as follows (Van Harmelen 2006) :

1. Users can fix their learning goals on their own in the e-learning system.
2. Users can manage the E-Learning systems including the learning materials and processes.
3. Users can communicate with other users in the same e-learning system during the learning process.

2.2. Cloud Based e-Leaning

Cloud computing has a clear and significant impact in many important areas in our daily lives. The concept of cloud computing means that the hardware and systems software are in the datacenters that deliver the services in best way to customers. Consequently, Cloud providers may provide a variety of applications to their customers and these applications may vary widely to offer several services in education, government, banking and healthcare (Armbrus, Fox, and Griffith 2009)

Over the few recent years, the majority of the research focus tends to apply cloud computing technology to the e-learning environment. In 2009, cloud computing is presented as a new computing platform to perform e-learning systems. Educational cloud became one of the most important and interesting applications of cloud computing. Cloud based e-learning is the sub-division of cloud computing concerned with the educational field of e-learning systems (Alshwaier, Youssef, and Emam 2012).

The so-called Cloud based e-learning refers to the integration of e-learning systems with cloud computing technology, and it is the future trend of e-learning technology and its new infrastructure (Laisheng and Zhengxia 2011). Cloud computing has a large value and a great effect in the field of education and learning applications. It is considered as a great opportunity for educational institutions to achieve different benefits. Cloud based E-Learning is a technology that took shape by enhancing the existing E-learning technologies and methodologies with the help of cloud computing technology (Fasihuddin, Skinner, and Athauda 2012).

Cloud based e-learning can provide all hardware and software resources, and when using these resources, the educational materials for e-learning systems are virtualized in cloud servers, and these materials will be available on-demand immediately for usage to learners and other educational businesses in the form of rent base from cloud vendors or payment is based on the amount of used servers, and this follows the principle of "pay-as-you-go". It can not only reduce charges for schools and enterprises, but also for suppliers as it can also achieve economies of scale. This business model of e-learning system is called e-learning cloud model (Laisheng and Zhengxia 2011). Constructing a stuffiest cloud computing educational environment will help to achieve full usage of educational accessibility of cloud computing and to obtain all advantages of cloud computing for more valuable learning to learners (Ma et al. 2010).

2.2.1. Why Cloud Computing in e-Learning Environment

Currently, the need for education is continuously increasing, and with rapid growth of the technologies usage, the development and the improvement of informational education is necessary. Consequently e-Learning has become a very commonly popular way of learning in the educational field and it needs to keep the pace with the technology (Pocatilu, Alecu, and Vetrici 2010). In view of that, a lot of weaknesses and shortcomings are gradually discovered in the existing e-learning environment, and there are some of the important questions that haven’t got meaningful answers yet such as the following (Ma et al. 2010): Can the growing number of required massive learning resources find enough network storage system to fit accommodate it? These days, the variety of learning software require high terminal configuration, is it able to counsel the

learner's requirement as the low terminal configuration? For the learners who always need a variety and evolving learning software, are learners able to buy and renew its licenses continuously? Do all the educational institutes have capital that enables it to provide high-quality hardware and to purchase and renew licenses for new software, and also take the responsibility for everything related to maintenance?

Although e-learning systems have been applied widely over the recent years, there are some critiques and limitations such as the following:

- ***The quality of training materials does not improve and remains critical***. Despite the availability of modern tools, techniques and innovative technologies to improve and empower learning system but that did not achieve the required vision of a great modern e-learning system (Mariya 2011).

- ***Misunderstanding the pedagogic aspects and the requirements of the human learning process***. The pedagogical aspect refers to the interests of designing learning materials and learning tools. It means the service is provided to learners without taking appropriate consideration of the learner's background and knowledge level. (Lidan et al. 2006; Mariya 2011; Ko and Young 2011).

- ***Learners' isolation***. It is one of the most significant shortcomings which means that learners are not given the chance to take full advantage of education because it does not have facilities that build collaboration and interaction in e-learning environments (Fasihuddin, Skinner, and Athauda 2012).

- ***Expensive or unavailable***. It is a problem hinders enjoyment with technologies which are required in personal and daily lives (Ercan 2010).

- ***Technical perspective***. The users and resources are constantly increasing. Accordingly, e-learning systems need to be scalable in order to support this increasing. It is difficult to implement usual significant maintenance and development (Fasihuddin, Skinner and Athauda 2012).

- ***M-learning still requires more study to be improved and enhanced***. Learning materials used for e-learning including m-learning may require special considerations. It cannot be provided in some small devices and mobile devices have some limitations (Fasihuddin, Skinner and Athauda 2012).

Cloud computing appeared as a new technology that has been answered all these questions and overcame the problems and constraints faced by e-learning systems.

2.2.2 e-Learning Cloud Computing Business Model

In e-learning cloud computing business model, cloud service provider (CSPs) is fully responsible for building, maintaining and providing technical support to e-learning cloud. Cloud users pay to cloud provider for services offered by the e-learning cloud and services accessed on-demand (Laisheng and Zhengxia 2011). In Figure 2.1, during the cycle, servers support cloud users, funds support cloud provider, technologies support e-learning cloud, a business cycle is a virtuous cycle.

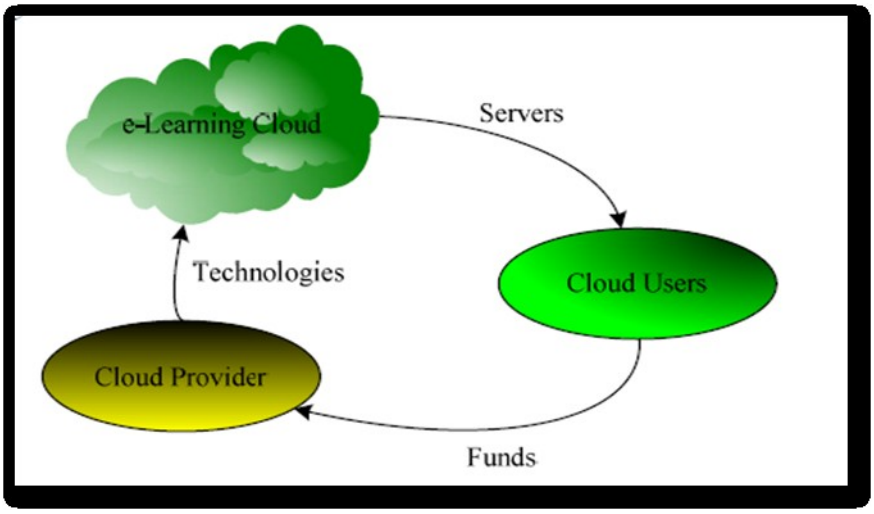


Figure 2.1. Business Model of e-Learning Cloud Computing (Laisheng and Zhengxia 2011)

2.2.3. e-Learning Cloud Computing Architecture

Cloud based e-learning architecture is mainly divided into five layers: hardware resource layer, software resource layer, resource management layer, server layer and business application layer (Laisheng and Zhengxia 2011). Cloud based e-learning architecture is explained in the Figure 2.2.

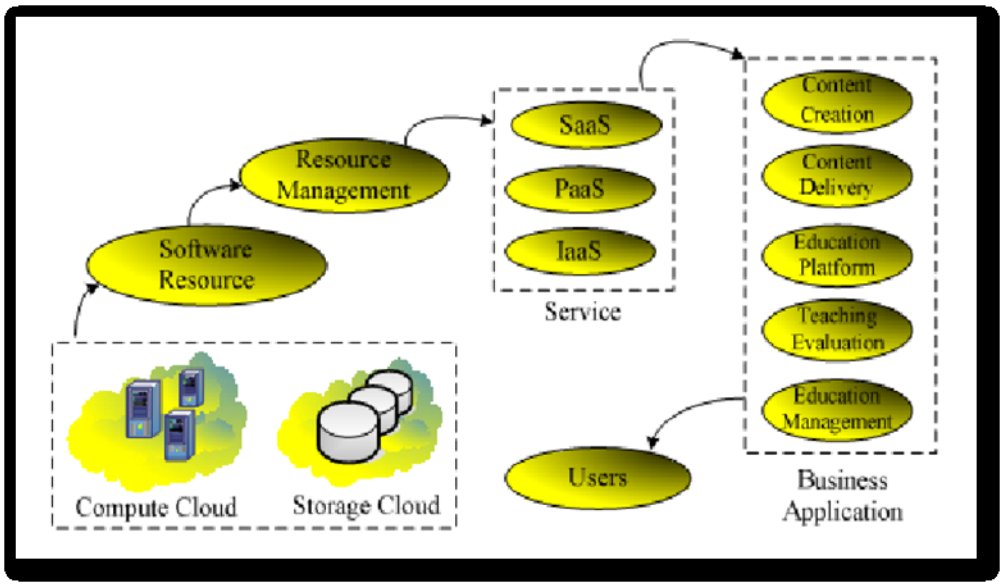


Figure 2.2. Architecture of e-Learning Cloud (Laisheng and Zhengxia 2011)

1. Hardware resource layer: This is the most bottom layer in the cloud service middleware where it handles the essential computing things like physical memory and CPU for the total system.

2. Software resource layer: This layer is created with the help of operating systems and middleware. With the help of middleware technology, many software solutions combine to offer the grouped interface for the software developers.

3. Resource management layer: This layer plays an important role on get loose coupling of software and hardware resources.

4. Service layer: Service layer is divided into three levels namely IAAS, PAAS, and SAAS. These service layers help to cloud customers to use the various forms of cloud resources for their products like software resource, hardware resource, and infrastructure resource.

5. Business application layer: Business application layer differs from all other layers in cloud based e-learning architecture, because this layer acts as important business logic of e-learning.

2.2.4. Key Benefits of Cloud Based e-Learning

There are several advantages when the e-learning is implemented with the cloud computing technology, they are as follows

- ***E-learning systems can make use of the following*** (Pocatilu, Alecu, and Vetrici 2009)
  - Infrastructure: use an e-learning solution on the provider's infrastructure.
  - Platform: use and develop an e-learning solution based on the provider's development interface.
  - Services: use the e-learning solution given by the provider.

- ***Lower costs***: E-Learning users need not have high end configured computers to run the e-learning applications. They can run the applications from cloud through their PC, mobile phones, tablet PC having minimum configuration with internet connectivity. If the e-learning services are used for a relative short time (several weeks, a quarter, a semester), the savings are very important. Using cloud computing instead of investments in datacenters (hardware and software licenses) will result in a shift from capital expenditure (CapEx) to operational expenditure (OpEx) (Al-Jumeily et al. 2010; Fasihuddin, Skinner, and Athauda 2012).

- ***Improved performance***: Since the cloud based e-learning applications have the majority of the applications and processes in cloud, client machines do not generate problems on performance when they are working (Rao, Sasidhar, and Kumar 2010).

- ***Instant software updates***: Since the cloud based application for e-learning runs with the cloud power, the software are automatically updated in cloud source. So e-learners always get updates instantly (Verma and Rizvi 2013).

- ***Improved document format compatibility***: Since some file formats and fonts do not open properly in some PCs/mobile phones, the cloud powered e-learning applications do not have to worry about those kinds of problems since the cloud based e-learning applications open the file from cloud (Boja, Pocatilu, and Toma 2013).

- ***Benefits for students***. Students get more advantages through cloud based e-learning. They can take online courses, attend the online exams, get feedback about the courses from instructors, and send their projects and assignments through online to their teachers (Pocatilu, Alecu, and Vetrici 2009; Youssef 2012).

- ***Benefits for teachers***. Teachers also get numerous benefits over cloud based e-learning. Teachers are able to prepare online tests for students, deal and create better content resources for students through content management, assess the tests, homework, projects taken by students, send the feedback and communicate with students through online forums (Verma and Rizvi 2013; Youssef 2012).

- ***Better services and maintenance***. Applying the cloud in the educational systems provides instant global platforms, resources utilization and real-time configuration, so any unexpected emergency cases can be processed very quickly, this is referred to as reliability (Fasihuddin, Skinner, and Athauda 2012).

- ***Access flexibility***. Using the cloud grants, learners and staff personnel have the opportunity to rapidly, widely, feasiblely, equitablely and economically access a variety of application platforms and resources through the web pages on-demand and it can be accessed anytime and anywhere using any a cheap access device (Boja, Pocatilu, and Toma 2013).

- ***Research collaboration***. Cloud computing provides research collaboration and data sharing, and it can be used as a shared environment for learners and users (Fasihuddin, Skinner, and Athauda 2012).

- ***Scalability & Availability***. It is scalable and available to e-Learning systems. e-Learning organizations can establish systems through these services in a simple way (Boja, Pocatilu, and Toma 2013).

2.2.5. Current Challenges & Issues in Cloud Based e-Learning

While the cloud based e-learning has many advantages, still there are some disadvantages in cloud computing so as for e-learning applications. Figure 2.3 shows

those limitations in cloud based e-learning application (Laisheng and Zhengxia 2011; Ercan 2010):

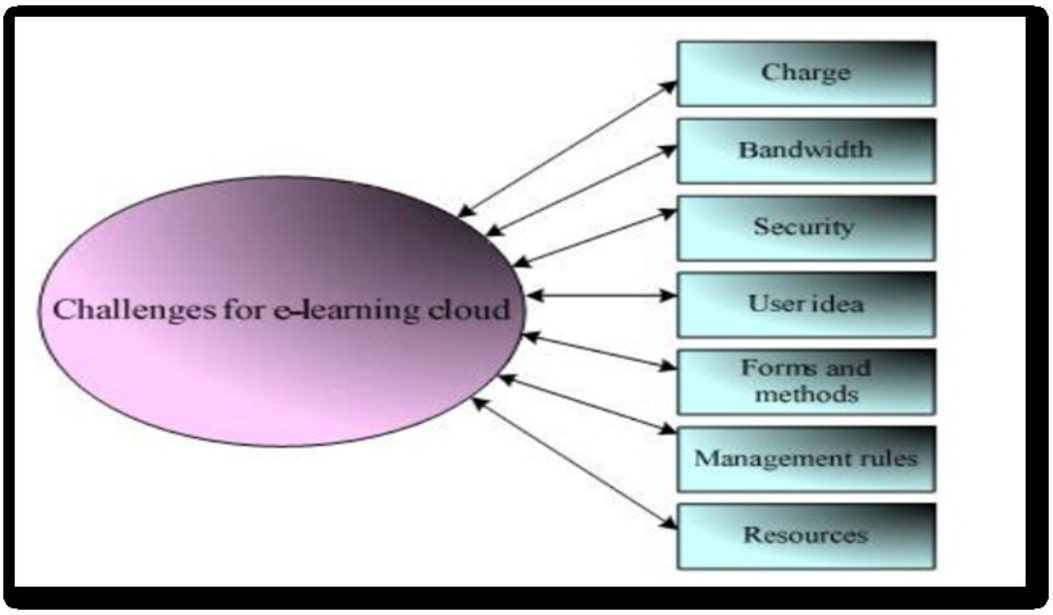


Figure 2.3. Challenges for e-Learning Cloud (Laisheng and Zhengxia 2011)

- ***Charge:*** When cloud computing is used for e-learning systems, charges are very crucial in the overall system - how the cloud vendors charge the schools and individuals.
- ***Bandwidth:*** Since the cloud based e-learning fully depends on the internet sources, bandwidth plays a vital role to deploy the data in internet servers.
- ***Security:*** Security plays a fundamental role as some of the e-learning materials are confidential. If the data is stored in cloud, the issue of security of this valuable data on unknown cloud servers arises.
- ***User Idea:*** Infrastructure of cloud computing, IT service delivery, and usage patterns used in cloud based e-learning undermines the traditional way of using computer technology.
- ***Educational Forms and Methods***: The main challenge for e-learning technology is the replacement of traditional educational forms and methods. The e-learning is entirely removing the importance of teachers in its technology.
- ***Education Management Rules***: we need suitable management rules are to be maintained for cloud based e-learning because when using cloud for e-learning

systems there may be a chance for new problems on learning environment through cloud based e-Learning.

- ***Resource Development***: In any technology, the stakeholders need to be involved in its development to bring the best outcome from its usage.

2.3 Review of Cloud Computing Intitiatves in Education / Related Work

There are different system architectures for e-learning systems based on cloud computing platform in the educational domain in literature. In this section, a review of the some of the recent research about Cloud Computing initiatives in education is reviewed.

Zhang and Liu introduced new architecture for cloud-based e-learning systems. It consists of three main layers, e-learning infrastructure layer, integration platform layer and access layer. The first layer, the infrastructure layer consists of two components, information infrastructure and teaching resources. Information infrastructure includes information management system and the system software and hardware. Teaching resources component is a mixture of different teaching materials that are distributed in different places. The second layer, the integration platform is to integrate the different resources that belong to different platforms in the infrastructure layer. Finally, the access layer consists of the applications that share teaching resources accompanied with some interactive tools that support the learning and teaching process (Zhang and Liu 2010).

Selvi and colleagues presented an architecture for applying problem-based learning approach (PBL) on e-learning system that is integrated with cloud computing technology. The PBL template consists of three significant modules which includes, understand the problem, explore the problem and resolve the problem. Within the group, learners discuss multiple solutions with the help of a discussion forum to determine the best solution. The cloud infrastructure in e-learning system is used to achieve scalability, accessibility, persistent storage, and efficient use of resources (Selvi, Kaleel, and Chinnaiah 2012).

Jinda and Singhal proposed an e-learning architecture based on Social Clouds. They blend the two important technologies, social networking and cloud computing. The social cloud provides the e-learning providers a common platform where they can share their information and make it universally accessible. This model will act as a social networking site among all the providers and learners. It also acts as knowledge search engine where all the contents of providers will be offered to the learner (Jindal and Singhal 2012).

Liao and Wang present a new model for collaborative e-learning called Collaborative Cloud. They apply the cloud computing and electronic commerce to connect learners and coordinate the resources in e-learning in a more effective way. The collaborator can request instructional services and the cloud system will advise and dispatch appropriate resources including text, audio, video files or the candidate list from the service provider to the requester based on the relations among requestor's knowledge status (their level of knowledge, price and historic service quality) (Liao and Wang 2011).

Jiao et al. introduce research that is based on the development of cloud computing technology and the application of online video resources. It aims to provide a perspective and practical references for the distance collaborative teaching and research in cloud computing environment. This process allows to teachers to transfer their educational activities to the "cloud" to enhance the quality of distance teaching and research and promote the professional development of teachers. The procedure of the activity is divided into three phases: preparation phase, implementation phase, and reflection phase (Jiao et al. 2011).

Vishwakarma and Narayanan proposed architecture model for the academic cloud and gives scheme focus on the e-learning as a service such as EduCloud and Education and learning as a service (ELaaS) and how the resources of organizations can be shared and connected together to perform all activities with greater flexibility. Academic cloud is the use of cloud computing in the academic institutions for enhancing the learning outcome, sharing of resources, and reduction in cost of maintenance. The whole

organizations can be connected for example the academic block, library, laboratory, bank, hospital and hostels. Whenever we need to access the resources, we can connect to the central system from the local servers. All the academic institutions can be connected globally and they can share the resources and e-contents for the e-learning process. It will enable the academicians, researchers, scientists and students who are working at various institutes and universities, to share their ideas and experiences (Vishwakarma and Narayanan 2012).

Jung and colleagues argue that the existence of simplified requisition interface with a method for estimation of cloud configuration is imperative such an interface allowing negotiations with cloud users. They, then, introduces *CloudAdvisor* as a Recommendation-as-a-Service platform designed to recommend an optimal cloud configuration for given user workload and preferences such as a maximum budget, a throughput expectation, the amount of input load estimated, and willingness to save energy (Jung et al. 2013).

Zhang and colleagues proposed a semi-automated, extensible, and simplified approach and a declarative system for cloud service selection, called *CloudRecommender* that transforms the cloud service configuration selection from an ad-hoc process that involves manually reading the provider documentations to a process that is structured, and to a large extend, automated. The system includes a repository of available infrastructure services from different providers including computing, storage and network services. The core idea of the CloudRecommender is to formally capture the domain knowledge of services using a declarative logic-based language, and then implement it in a recommender service on top of a relational data model. (Zhang et al. 2012).

Today, there is a growing number of cloud providers on the market claiming to offer Cloud infrastructures. Each of them describes their capabilities using their own terms, definitions, and goals. Nevertheless, there is a lack in the community for a common terminology, accompanied by a clear definition and classification of Cloud features. Prodan and Ostermann conduct a survey on a selection of Cloud provider to address this deficiency, and propose taxonomy of eight important cloud computing elements

covering service type, resource deployment, hardware, runtime tuning, business model, middleware, and performance (Prodan and Ostermann 2009).

Celesti et al. introduce The "Vertical Supply Chain" scenario where a Cloud service provider begins to build their services using cloud-based services offered by other service providers. This means a cloud service provider is able to arrange its own services IaaS, PaaS, or SaaS to target business, on top of "generic" IaaS using the IaaS(s) provided by other clouds. More specifically, that approach is based on the eXtensible Resource Identifier (XRI) technology which enables a cloud service provider to manage the whole composed services, retrieving information about them from the IaaS(s) on which they are deployed. Therefore, through this approach, each Service Provider is able to satisfy all SaaS allocation requests and also able to achieve an efficient use of the hardware resources, consequently minimizing costs (Celesti et al. 2011).

D'Agostino and colleagues introduced the context of an Italian research project aimed to transfer ICT advancements from research centers towards ICT SMEs. Their research focuses on the design of a brokering tool for hybrid clouds capable of adequately responding to specific Quality of Service (QoS) constraints. Aimed to satisfy the highest number of user requests while trying maximizing the profit of the private provider, and to fulfill the actual requirements according to the agreed SLAs, in the context of a posted price economic model, the proposed brokering algorithm may apply different allocation policies, based on the reservation of a quota of private resources to high-level QoS applications. The brokering tool will transparently manage the allocation of the requested service to the public or to the private Cloud infrastructures, depending on the QoS expectations and the workload of the private Cloud resources (D'Agostino et al. 2013).

Alhamad, Dillon and Chang developed an approach that characterizes the key aspects of the trust relationship between cloud providers and users. The notion of trust involves several dimensions. These dimensions include: the scalability, availability, security, and usability parameters of IaaS, PaaS,SaaS, and DaaS. Moreover, each of the trust

dimensions will be represented within a fuzzy framework, and measures along each dimension will be developed. In addition, an overall figure for trust value will be developed for the cloud providers. In this research, the focus is on how to evaluate the trusted cloud providers in such a way that users of cloud can easily understand and start to build a trusting relationship with the service providers (Alhamad, Dillon, and Chang 2011).

Although there is an increased attention on Cloud Computing in the academic literature in the recent years, most research works focus on technical aspects of cloud computing. Research on consumers' preferences for cloud services is limited to studies from consulting and industry companies. Koehler and colleagues introduced an approach intended to explore consumer preferences for service attributes and show possibilities of second-degree pricing discrimination in the cloud computing field. Conjoint attributes are: Provider Reputation, Required Skills, Migration Process, Pricing Tariff, Cost compared to intern Solution and Consumer Support. The results help both practitioners and academic researchers to better understand the prerequisites of a successful market introduction of cloud services and to design appropriate services (Koehler, Anandasivam, and Dan 2013).

From this review the following is found:

- Many of these researches proposed architecture of cloud-based e-learning system, and described the main layers which constitute this system. Also many of these researches presented e-learning architecture based on Clouds integrated with other technology. They blend two or more important technologies with cloud computing such as: social networking, problem based learning approach (PBL), application of online video resources and/or electronic commerce.

- All the research used cloud infrastructure in e-learning system to achieve one or more of following features; scalability, accessibility, persistent storage, and efficient use of resources, share their information and make it universally obtainable, collaborative e-learning and/or to enhance the quality of distance teaching and research.

- Most researches proposed model of academic cloud and provide scheme focuses on the Education and learning as service such as EduCloud and (ELaaS). They aim to build e-learning organizations on cloud and take the advantages of the cloud infrastructure. The resources and e-contents for e-learning organizations can be shared and connected globally.

- Some researches introduce recommender systems such as; CloudAdvisor and CloudRecommender as a Recommendation-as-a-Service platform designed to provide interface allowing negotiations with cloud user and recommend an optimal cloud configuration based on the users' preferences and captured knowledge of CSPs.

- The taxonomy of important cloud computing elements to select the target and the best CSPs in the market claimed to offer Cloud infrastructures are: the service type, resource deployment, hardware, runtime tuning, business model, middleware, and performance. Also there are several dimensions that build a trusting relationship between service providers and users including: the scalability, availability, security, and usability parameters.

- Acceptable number of these researches aimed to provide the context of a posted price economic model satisfying the highest number of user requests while trying to maximize the profit of the providers and minimize costs. These contexts are achieved by using the IaaS(s) provided by other clouds or using brokering tool for hybrid clouds.

- The results (conclusions) show that Cloud based E-Learning is a technology that took shape by enhancing the existing E-learning technologies and methodologies with the help of Cloud Computing technology and that it provides the great infrastructure for an e-Learning environment on the cloud.

It is noticed in this review that there are some limitations as follows: these researches aimed to use the cloud services in provision of the required e-learning services for e-learning organizations, but not all e-learning services are available on the cloud computing, and these reviews did not provide a method about how the e-learning

organizations can select the most appropriate cloud service for each required service. The recommendations offered by recommender systems were not accurate and they are limited to the recommendations on specific CSPs, and they consider the user's preference without considering the technical aspects or vice versa. There are also some important business aspects which have not been taken into account such as technology environment status and time to market.

Current research works do not look for effective ways to develop CSPs to attract and serve e-learning business area since all CSPs are now offering services to generic consumers, and they do not focus on a specific domain. One reason for the ignorance of CSPs to serve the e-Learning business area might be due to the lack of having a full map of the e-Learning market.

All attempts conducted in cloud computing to obtain an economic model were not successful as required because it involved resources from other and external CSPs, therefore they need the agreement from all sharing CSPs.

In this research, we will try to overcome these limitations through developing a system to avail a useful tool for educational organizations. It suggests a suitable Cloud Computing model for each of the identified e-Learning services based on both the technical aspects of service criteria requirements and the circumstances for each individual e-Learning organization. On the other hand, it looks at ways for encouraging the CSPs to consider serving the new promising business area. It also aids them in drawing a full picture on the e-Learning market and supports them in identifying their target market.

The second contribution of this research consists in providing a great economical and quick solution to all CSPs by developing e-Learning services through wrapping around freely available Internet services that were designed without e-Learning in mind.

Chapter Three

Cloud Computing

Chapter Three

Cloud Computing

In this chapter, the researcher will try to show what cloud computing technology is, and provide sufficient knowledge of the basic concepts it contained in, and how it distinguishes from all the other concepts.We will be also identify the most important (types, features, significant characteristics), and main layers that make up the cloud computing architecture. The main problems in cloud computing will be explained in the following chapter.

3.1. Cloud Computing

Many computing resources, including hardware and software such as distributed computing software, computer clusters, storage devices and network infrastructure are hidden behind what is called ‘cloud computing platform’ (Bai et al. 2011). The concept of delivering computing resources through a global network had its roots since the sixties. In 1999, Salesforce.com arrived to be one of the first milestones for cloud computing (Sosinsky 2011). In 2002, Amazon Web Services provided a suite of cloud-based services, including storage, computation and even human intelligence. In 2006, companies and individuals were allowed to rent computers on which to run their own computer application (Fasihuddin, Skinner, and Athauda 2012).

Obviously, it can be declared that August 24, 2006 can be considered as the birthday of cloud computing because on this day Amazon launched the initial test version of its

Elastic Computing Cloud (EC2) to the public. In 2007, the term "Cloud Computing" first became popular in the English Wikipedia. Consequently, Dell tried to trademark the word mark. In 2008, there was a great development of active parties in the significantly popular fields of Cloud Computing. It is noteworthy that Google was the pioneer to propose the concept of cloud computing (Ma et al. 2010). Today the most significant contribution to cloud computing was from technology giants such as Microsoft and Google. These firms delivered services in a reliable and easy way that created a wider-general acceptance of online-services (Sosinsky 2011). Eventually, it can be declared that the sparkle of the concept of cloud computing was first enlightened by Sun Microsystems, implying: The network will be the computer.

3.1.1. Cloud Concept

Over the last half century, significant advances in Information and Communications Technology caused rapid emerging of cloud computing as the new information technology platforms. (Mousannif, Khalil, and Kotsis 2012). Cloud computing can be considered as a new era of computing technology. After mainframe, personal computer, client-server computing and the Web, cloud computing has been ranked as the fifth generation of computing (Fasihuddin, Skinner, and Athauda 2012). Clearly, cloud computing is beneficial as it changes the traditional personal computer-based production model and definitely changes the way people obtain information , share content, and communicate with each other (Bai et al. 2011).

Through cloud computing, the computing infrastructure and data storage goes out of the users' hands to the cloud and consequently used as a service on-demand over the internet (Fasihuddin, Skinner, and Athauda 2012; Ercan 2010). This implies that the user's data is saved in the internet data center, and not stored locally in their personal devices. Thus, cloud computing providers become responsible for the management of effective data processing and guaranteeing strong computer skills and sufficient strong space available for customers (Ma et al. 2010). The main idea of cloud computing is a "pay-as-you-go" model that delivers the cloud services according to customer’s needs and depending on the amount paid (Mousannif, Khalil, and Kotsis 2012).

3.1.2. Cloud Definition

There is no exact definition for cloud computing till now. However the work of National Institute of Standard and Technology provided a general definition of cloud computing: *"Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.*" (NIST 2011; Mell and Grance 2011).

Another definition is given by (Vaquero et al. 2009): *"Clouds are a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms and/or services). These resources can be dynamically reconfigured to adjust to a variable load (scale), allowing also for an optimum resource utilization. This pool of resources is typically exploited by a pay-per-use model in which guarantees are offered by the infrastructure provider by means of customized SLAs."*

3.1.3. Cloud Computing Main Actors

Table 3.1 briefly lists the main actors defined in the NIST cloud computing reference architecture. The general activities of the actors are defined in this table (NIST 2011).

Table 3.1. The NIST Identification of Cloud Computing Actors

Actor	*Definition*
Cloud Consumer	A person or organization that maintains a business relationship with, and uses service from, *Cloud Providers*.
Cloud Provider	A person, organization, or entity responsible for making a service available to interested parties.
Cloud Auditor	A party that can conduct independent assessment of cloud services, information system operations, performance and security of the cloud implementation.
Cloud Broker	An entity that manages the use, performance and delivery of cloud services, and negotiates relationships between *Cloud Providers* and *Cloud Consumers.*
Cloud Carrier	An intermediary that provides connectivity and transport of cloud services from *Cloud Providers* to *Cloud Consumers*.

3.2. Differences with Similar Concepts

When comparing the cloud idea to the existing clusters or supercomputers that are offered from IBM and other technology companies (IBM 2009), it is obvious that clouds are located globally and are made of heterogeneous and mostly anonymous computer networks (Foster et al. 2008). According to Foster et al. (2008) cloud computing and grid computing are the same when it comes to the vision, which aims to decrease the costs of computing while increasing the flexibility, quality and reliability by outsourcing a service to a third party.

However the scale of how things were ten years ago and how things are now, is different. The data that need to be analyzed nowadays is huge and generate therefore even more computing demand. With virtualization and the huge investments of large companies such as Amazon, Google, and Microsoft it creates “real commercial large-scale systems containing hundreds of thousands of computers” (Foster et al. 2008). In other words, cloud computing has put distributed computing into another stage. Now it needs just a simple bank account to access on-demand computers that are located in datacenters all around the world which are able to compute a massive amount of data

just-in-time (Foster et al. 2008; Carr 2008). That makes cloud computing new and exciting for companies to invest in.

3.3. Enabling Technologies

There are two technologies that made the way of distributed computing and therefore cloud computing realizable: virtualization and load balancing.

3.3.1. Virtualization

Virtualization is the technology that tends to present an abstract computing platform and covers up the physical characteristics of the computing platform from the users. Virtualization shows up a single physical machine that can function as a set of a variety of Logical Virtual Machines (VMs). Through virtualization, it becomes allowed to run and host multiple operating system environments totally separated from one another. Therefore, virtualization provides extreme flexibility to use different partitions of resources on the same piece of hardware to different certain requirements of service requests. Thus, it can be comprehended that a cloud functions as a pool of virtualized resources through the internet that provides pay-per-use service to satisfy user requests on the provisioning/deprovisioning of virtual machines (Armbrust et al. 2009). That is, effective virtualization significantly supports sharing of complex systems and separation of data/application (Mousannif, Khalil, and Kotsis 2012).

3.3.2. Load Balancing

One and the most important characteristic of Cloud computing is vitalized network access to a service. It does not matter where you are and how you can access the service, you will be directed to available resources. The technology used to distribute service requests to resources in efficient and fast manner is referred to as *load balancing*. It is a complementary technique for the vitalization concept, and it is the key to the achievement of cloud architectures. Using load balancing technology, we can increase performance and availability since resources can be used proficiently, and the cloud can gain all these advantages through dependence on this technology. Load balancing is capable of distributing the working processes consistently and equally between 2 or

more computers. The initiative of load balancing is run by an application, so a load balancing solution is regularly used in internet services (Rimal, Choi, and Lumb 2009).

3.4. Cloud Computing Characteristics

There are five essential characteristics for cloud computing, which are as follows (Mell and Grance 2011; Fasihuddin, Skinner, and Athauda 2012; Jula, Sundararajan, and Othman 2014):

1. ***On-demand self-service.*** Whenever the customers require any services, they can get them automatically without any need of human help from the providers.
2. ***Broad network access.*** The network (internet) makes the services available and accessible by a heterogeneous client platform (e.g., Smartphone, tablet, PC and other).
3. ***Resource pooling.*** The pool of physical and virtual resources that constitute cloud computing serves a variety of consumers using multi-tenancy model.
4. ***Rapid elasticity.*** Based on consumers' demand, the resources of cloud computing are provided and released automatically and immediately.
5. ***Measured service.*** The resources' provision and usage are automatically controlled and optimized by a cloud computing system based on metric capacity that fits different provided resources. Also, for more transparency in services for both; the consumer and the provider, resource usage for individual consumer is monitored and reported.

3.5. Cloud Computing Architecture

There are three main layers or service models that make up the cloud computing architecture. They are IAAS, PAAS, and SAAS. These layers provide a variety of services to the customers from cloud providers as shown in Figures 3.1 and 3.2 and as follows (Hofer and Karagiannis 2011; Mousannif, Khalil, and Kotsis 2012; Mell and Grance 2011):

- **IAAS**: Infrastructure as a Service provides resources from the cloud providers to their clients. These resources include: storage, hardware, servers, networking components. The cloud providers are responsible for the maintenance of these hardware resources. The clients pay money only when they need to use the resource. Also, they do not have to pay after the work finishes. Moreover, the client is able to resize or extend the kind of service from their cloud providers according to their needs. The IAAS facility is provided with the help of virtualization.

- **PAAS**: Platform as a Service derives its importance from the fact that it provides the development environment for building, testing, and delivering software applications or any other services through cloud. In this case, the user only needs the required service without any download or installation of applications on the cloud user's machine. The following illustrations show that in action.

- **SAAS**: Software as a Service enables the customer to enjoy the software like Word Processor through the cloud for almost free or low price. Thus, cloud allows the user to use certain software applications without the need to get license, and accordingly, it saves a lot of money. In some cases, the users can access certain software applications like MS- Excel in offline mode, and once they come to online, the data processed in that application are synchronized with the cloud.

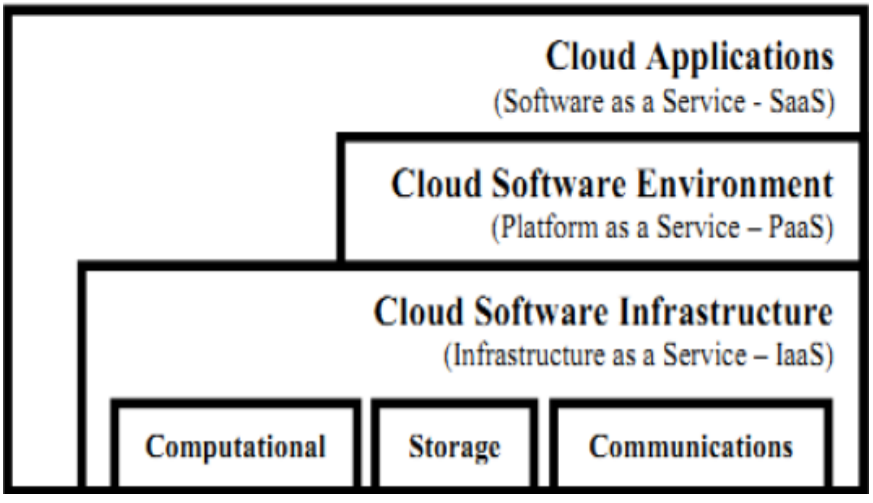


Figure 3.1. Cloud Computing Architecture (Al-Jumeily et al. 2010)

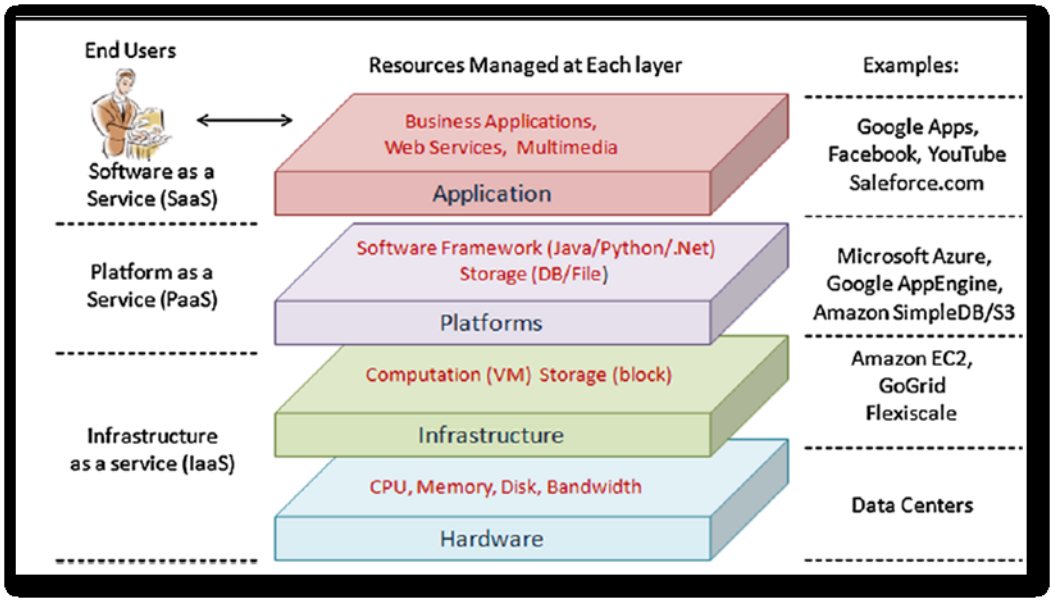


Figure 3.2. The three Main Categories of Cloud Computing Services (Hofer and Karagiannis 2011)

After deeper studying of the types of services, the following illustration in Figure 3.3 shows the three of the most famous companies that currently offer three technology capabilities and solutions under the name of cloud computing.

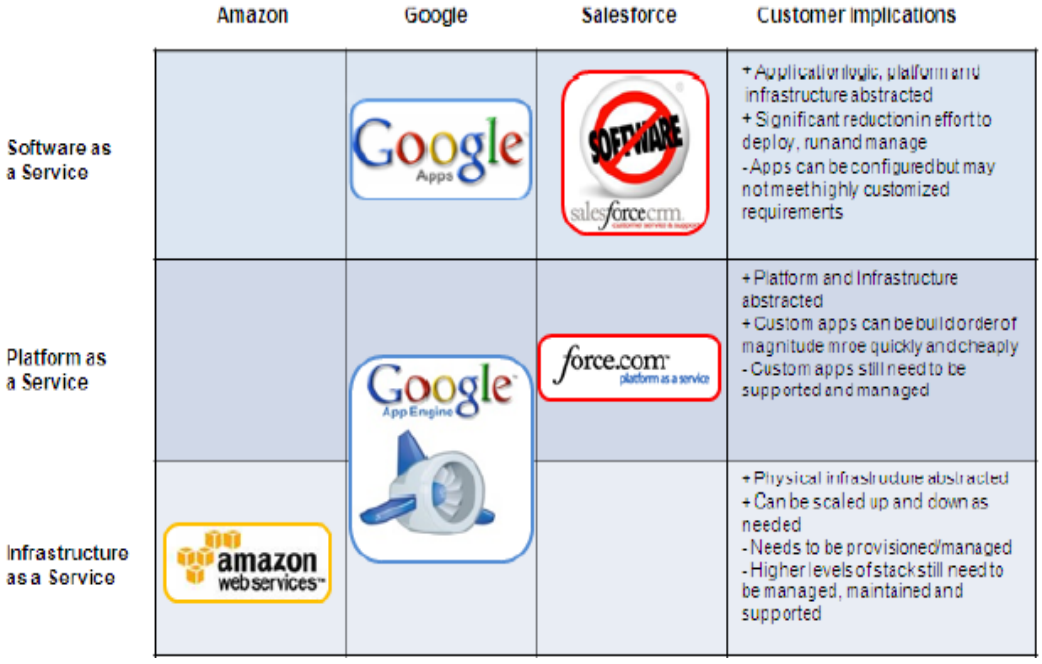


Figure 3.3. Technology Capabilities for Cloud Computing (Narasimhan 2009)

3.5.1. The Ownership in Different Service Models

A Cloud taxonomy is a way of categorizing and comparing cloud solutions based on their degree of control, methods of provisioning and delegation of operations. Figure 3.4 shows a diagram of where the responsibility typically lies with the types of cloud computing, and it demonstrates the owner responsibilities and cloud provider responsibility (Rady 2012; Gurkok 2014).

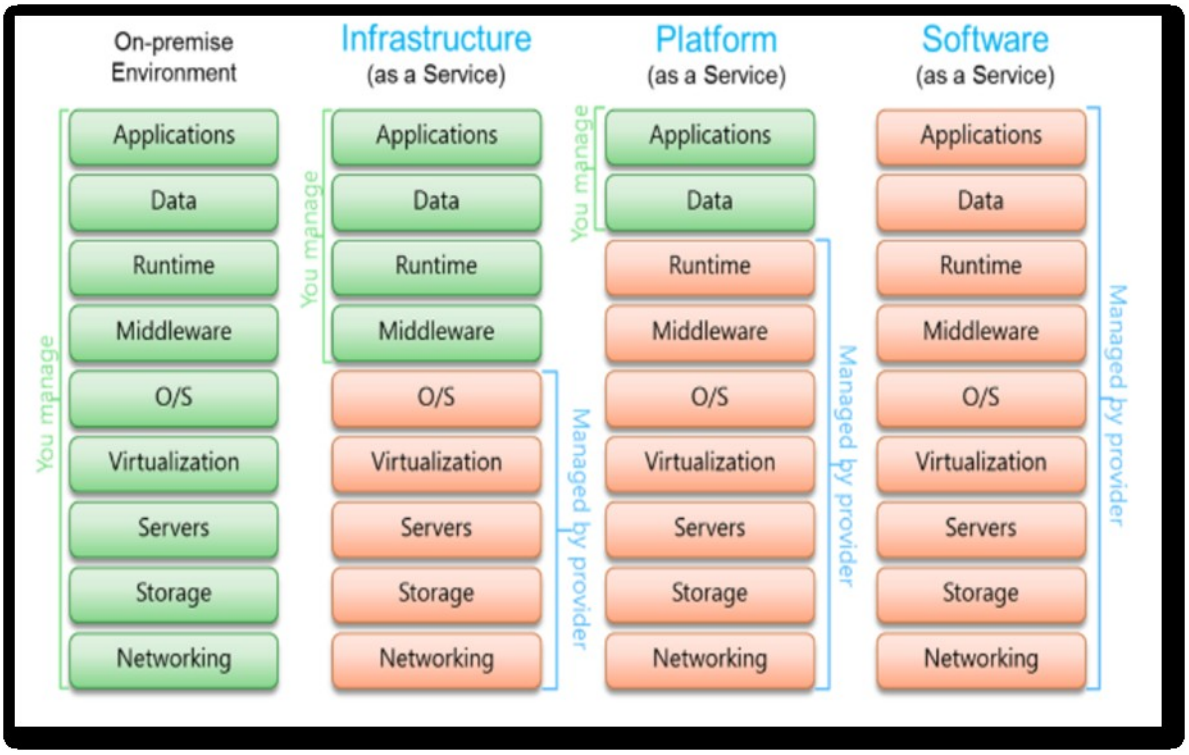


Figure 3.4. The Ownership in Different Service Models

3.6. Cloud Computing Deployment Models

There are four main different types of clouds in cloud computing which differ on their modes of deployment of computing. They are Public Clouds, Private Clouds, Hybrid Clouds and Community Clouds as shown in Figure 3.5.

- **Public Clouds:** The idea of a public cloud involves the traditional concept of cloud computing in the way that it offers the chance to use computing resources from anywhere in the world. Public cloud uses pay-per-use method. That is, the user pays

transaction fees only for the resources being used (Mell and Grance 2011; Armbrust et al. 2009; Rimal, Choi, and Lumb 2009).

- **Private Clouds**: They are internal clouds. That is, they are normal data centers used in a private network. It can be declared that private clouds are more secure than the traditional public clouds for the fact that they restrict the undesired public to access the data existing in the private data center. However, there are still worries about the system's purchase, building, and maintenance (Mell and Grance 2011; Armbrust et al. 2009; Rimal, Choi, and Lumb 2009).

- **Hybrid Clouds**: A hybrid cloud is a mixture of both private and public cloud. In these clouds, there are two kinds of portion. One kind of portion is private as it can be accessed only internally while the other kind of portion is public as it can be accessed only externally. The following illustration shows that explained (Mell and Grance 2011; Rimal, Choi, and Lumb 2009)

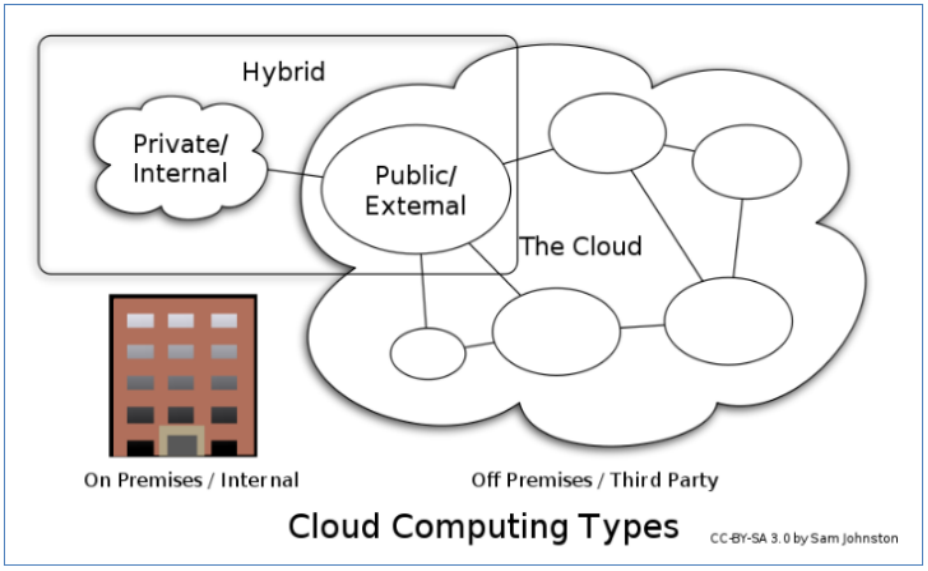


Figure 3.5. Cloud Computing Types (Giacomo and Brunzel 2010)

- **Community Clouds:** Many companies that have the same requirements share this kind of external private clouds. This kind of clouds is offered by third party providers, but only the companies that operate in this community can access it (Mell and Grance 2011).

3.7. Problems in Cloud Computing

There are issues in cloud computing environments as follows (Mezgar and Rauschecker 2014; Avram 2014; Kumar and Chelikani 2011):

- ***Security and privacy problems***. The organization using a cloud service will be held in a shared environment. A shared environment is implicitly less secure than a non-shared one, delegating the storage and processing of data do not relieve the organization of its legal and regulatory obligations around this data, and critical points among others are raised around trusting the vendor's security model.

- ***Reliability***. Each aspect of reliability should be carefully considered when engaging with a CSP, negotiated as part of the SLA, and tested in failover drills. Additional costs may be associated with the required levels of reliability; however, the business can do only so much to mitigate the risks and the cost of a failure.

- ***Interoperability and standardization***. Every new cloud service providers have their own way on how a user or cloud application interacts with their cloud leading to cloud API propagation. Cloud adoption will be hampered if there is not a good way of integrating data and applications across clouds.

- ***Economic Value.*** As usage expands and interoperability requirements for the business process become more onerous, a new approach is needed. This evolution may be the most cost-effective approach; however, there is a risk that the business transition costs from one solution to another may change the cost and benefit equation, and hence the solution that should be employed.

Chapter Four

SCCeLE: Conceptual Model and Architecture

Chapter Four

SCCeLE: Conceptual Model and Architecture

This chapter intuitively demonstrates the model of **S**mart **C**onsultant for **C**loudifying **e-L**earning **E**nvironment (SCCeLE) by providing the methodology of how the rule-based expert system is built. The e-Learning service criteria and the e-Learning organization circumstances which dictate the rules of this expert system will be presented. The benefits of recommended cloud mix model to e-Learning organizations and CSPs will be also highlighted.

4.1. Overview on the SCCeLE Model

When organizations provide e-Learning in fully virtual or partial virtual way, they often face with the dilemma whether they should go for hosted cloud computing or an on-premise solution. There is really no right or wrong answer but e-Learning organizations need to assess their needs for e-learning services and their circumstances before taking the decision. The fundamental point is that not all solutions for e-learning services work best on the Cloud or on-premise option, and the choice often requires a trade-off or a balance between the organizations' circumstances and the nature of the required e-learning services' to optimize the hosting infrastructure and obtain the best solution.

Figure 4.1 depicts the model behind the Smart Consultant system for Cloudifying e-Learning Environments (SCCeLE). SCCeLE is a rule-based expert system that takes few parameters as inputs and makes recommendations as an output. These recommendations represent the most appropriate set up of the e-Learning environment on the Cloud. In other words, they suggest the most appropriate Cloud mix for all the required e-Learning services as defined by the e-Learning organization.

Survey was conducted to understand the nature of the e-Learning environment in the market. Many educational organizations of different types were visited, interviews were arranged, and questionnaires were distributed. This survey identified many aspects of the model: the types and sizes of the available e-Learning organizations in the market, their needs and the expected QoS of the different e-Learning services. In what follows, the different elements used by the rules to make the recommendation are discussed in more details.

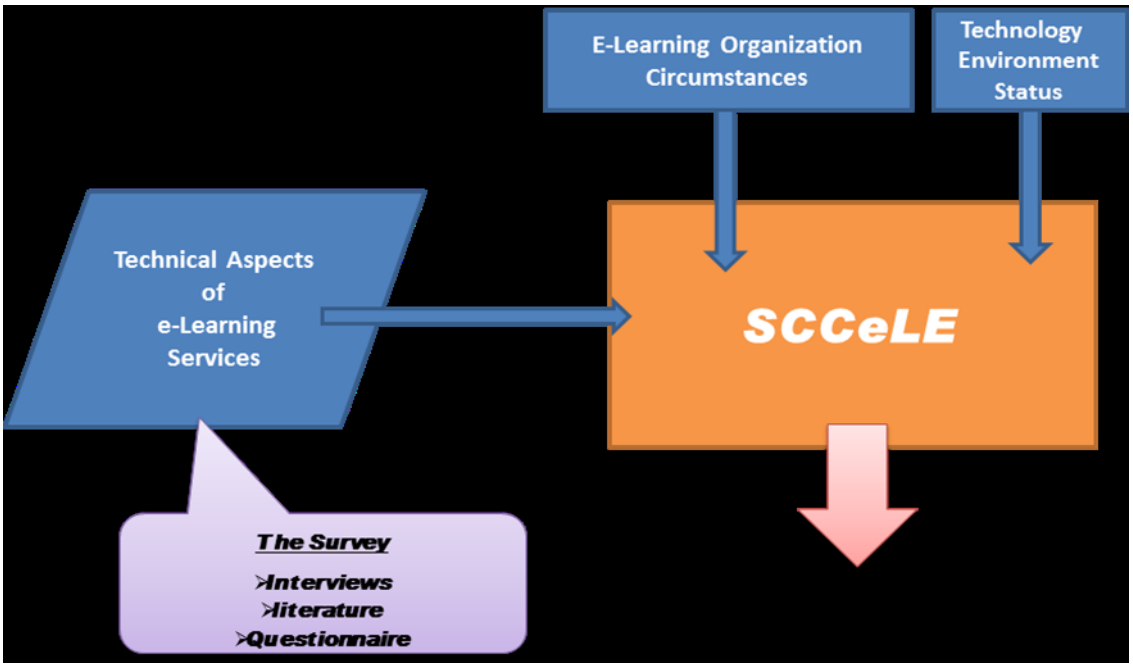


Figure 4.1. The SCCeLE's Model

The benefits of the SCCeLE rule-based expert system include:

SCCeLE rule-based expert system was implemented to test the idea and to avail a useful tool for e-Learning organizations to use in defining the most suitable e-Learning environment implementation strategy using a mix of Cloud models that best fit their current situations and targets.

SCCeLE also makes consultations to CSPs where it encourages the CSPs to conquer the business of e-Learning as it aids them in drawing a full picture on the e-Learning market, and supports them in identifying their target market.

4.2. SCCeLE Inference Process

In its process of recommending the most appropriate Cloud Model Mix for a certain educational organization, the inference process of SCCeLE goes through two phases; the first of which is purely academic and considers the technical aspects of the e-Learning services, while the second step considers the business aspects of the e-learning organization, as depicted by Figure 4.2.

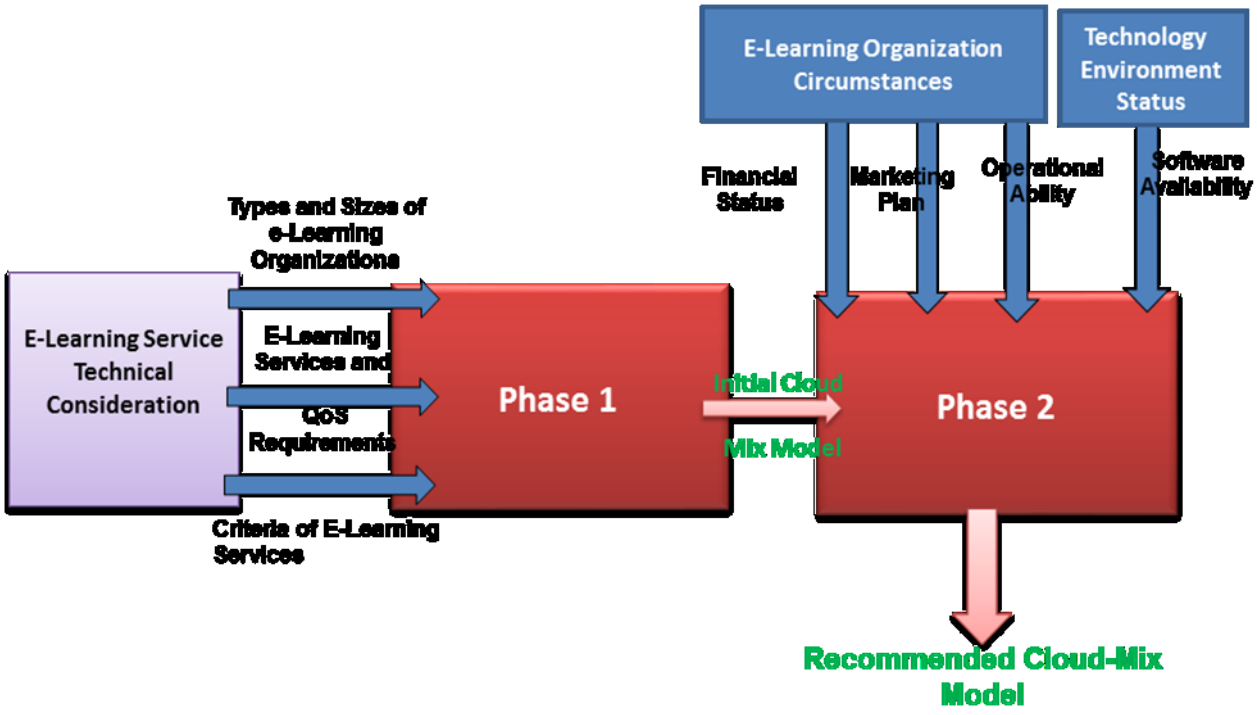


Figure 4.2. The SCCeLE Inference Process

4.3. The SCCeLE's First Inference Phase

The first phase of SCCeLE is purely technical, and considers the technical aspects of the e-Learning services. It depends solely on three main parameters as input which are; type and size of the e-Learning organization, e-Learning services and QoS requirements, and the e-Learning service criteria. These parameters are obtained from the survey which consists of three tools; interviews, literature reviews and the questionnaire. After that, this phase will show the initial cloud mix model based on the rules of cloud configuration as depicted in Figure 4.2.

The parameters of SCCeLE's First Phase are explained in detail as follows:

4.3.1. Taxonomy of e-Learning Organizations

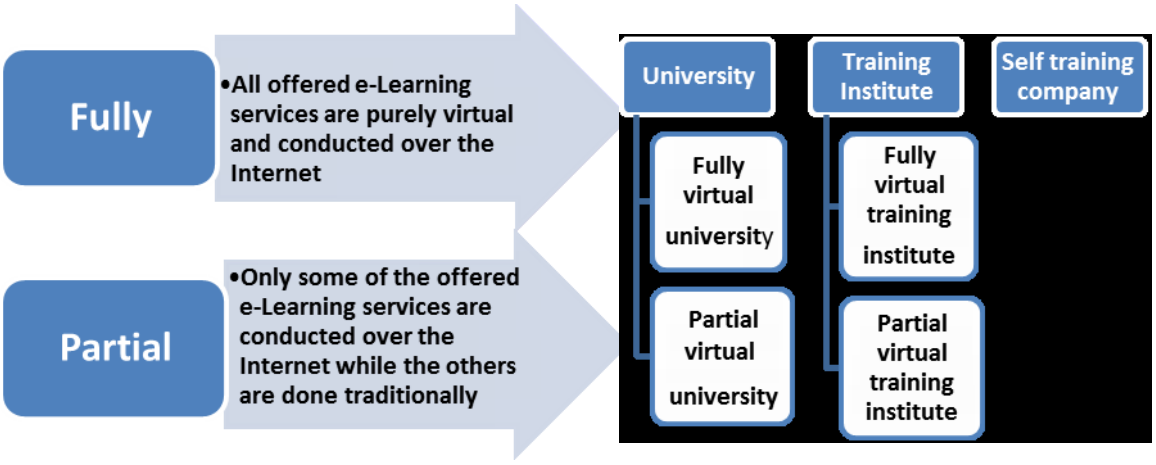
In our study, we dealt a wide spectrum of e-learning organizations .We divided the educational organizations into three main types to include all types of educational organizations that deal with e-learning services, and also to cover all sectors of e-learning environment including : universities, training institutes and self-training companies. After that, we made three levels of classification on these types of e-Learning organizations. The first one is the fully and partially virtual classification. This classification is only for university and institute organizations. The fully virtual refers to everything offered by e-Learning services which are purely virtual in nature and are conducted over the Internet (Haywood 2000; Hui 2007; Kumar and Chelikani 2011). The partially virtual refers to only some of the offered e-Learning services which are conducted over the Internet while the others are done traditionally. The organizations here provide these services to support the traditional learning.

The second classification is based on the size of the educational service provided by the organization. We determine the size of each organization by *Nominal values* that are based on using scale ranging from 0 as ‘very small’ and 10 as ‘very large’. Here are some examples of the organizations classified based on this scale : Fully virtual university can be classified into *Very Large*, Partial virtual university can be classified into *Large,* fully virtual training institute can be classified into *Medium*, Partial virtual

training institute can be classified into *Small* , and self-training company can be classified into *Very Small*.

The third classification is at the level of each type of organization where each type is classified into three sizes: *large (L), Medium (M), and small(S)* based on the size of e-learning services provided or based on the size of their usage or dependability on electronic services for education. We make this division in this study in order to be *more accurate, more detailed and to tackle the topic in more depth*. At the end of the study on organizations, we get fifteen types of e-learning organizations.

Figure 4.3 depicts the taxonomy of the educational organizations as currently identified in terms of the level of e-Learning adoption. In the SCCeLE model, the size of the e-Learning organization plays a role in the recommendation.



(a) Fully/Partial Virtual Organizations **(b) e-Learning Organizations**

Figure 4.3. e-Learning Organizations' Taxonomy

4.3.2. e-Learning Services

The survey as well as the literature reviews helped identifying the different possible e-Learning services. We dealt in this research with the most important and most frequently e-learning services that are used in the e-learning processes. We also considered whether these services are for instructors, administrators or students, and whether they are before, during or after the e-learning process. They can also be viewed

from three different perspectives; administration, awareness and assessment perspectives (Shih, Chang et al. 2000; Haywood 2000). Summary of the most commonly used services as revealed by the survey are as follows:

1. **Closed Circle Mailing System/Closed Mailing List System.** A Closed Mailing List for each Section members including the instructors and assistants.

2. **Office Hours Management.** Managing and administrating Office Hour sessions for instructor and their students, e.g., scheduling, notifications, etc.

3. **Office Hours' One-On-One Chatting System.** An online synchronous communication service through which the student can have a one-to-one session with the instructor through an online chat room.

4. **Discussion Group (Forum).** An offline discussion service providing a medium where ideas and views on a particular issue can be exchanged. It allows students to discuss various topics amongst each other, or with their instructor, and they can hold conversations in the form of posted messages.

5. **Collaborative Team Work (e-Meeting).** An online synchronous service that allows a team of students to collaborate in doing things together without the need for physically attending meetings.

6. **Virtual Class Room.** An online simulation of a traditional classroom in which lectures are virtually and synchronously conducted where each individual (instructor and students) is located differently.

   The virtual class room service includes some important communication tools as follows:

   a) **Floor Control Tool.** It allows the instructor to control who to speak in a virtual class**.**
   b) **Audio Communication Tool.** It is essentially necessary and it allows transferring the audio between the instructor and the learners in the class room. One possible solution is to use internet phone.

c) **Video Communication Tool.** A video conferencing type of tool should be provided to the instructor and students. It allows transmitting the sound and images together between the instructors and learners in the class.

d) **Chat Room Tool.** It allows the instructor and students to communicate via text in the virtual class.

e) **White Board Tool.** It allows the instructors and students to share drawings of simple graphics objects on the same board at the same time in the class.

7. **Lecture Recording & Playback.** Recording virtual classroom lectures synchronously and then later allowing for offline and asynchronously replay of the recorded lecture.

8. **Lecture-on-Demand (Delivery).** The presentation of a web document can be incorporated with a video record, which is synchronized to the navigation on the web document. This service allows an instructor to navigate a web document and record video at the same time.

9. **Course Development/Course Authoring.** Web-based multimedia learning material can be developed using this service.

10. **Student Assessment and Exams.** An on-line service for both student assessment and self testing.

11. **Quiz.** An on-line service for student initial assessment which offers some questions concerned with what has been studied and then asking students to answer them. It often contains a few questions offered at periodic intervals.

12. **Self Testing** An on-line service that allows any student to evaluate themselves by answering a series of questions related to a particular topic.

13. **Learning Process Analysis.** It is an off-line service that offers analytical information regarding a course, section, instructor, students...etc.

14. **Virtual Library.** An off-line service that maintains storing, searching, and retrieving learning materials, such as e-books, research articles, recorded multimedia, etc.

15. **Personal Student Notebook with Annotation Facility.** This service allows students to take notes while attending a class .Similarly, students need a tool to cut and paste course materials that they think are important. This editing tool allows students to edit various types of multimedia information, such as text, figures, audio, and even video recordings.

16. **Courses Resume (Syllables).** It is a service that displays a summary or a brief description about the course and all the topics that will be taught in this course.

17. **Assignment.** An offline asynchronous service that helps managing assignments among the instructor and the learners.

18. **FAQs (Frequently Asked Questions)**. An offline asynchronous service that is used to answer student's administrative and course questions without the need of human involvement. Students use keywords and other mechanisms to retrieve questions and answers. This service, if used properly, should be able to reduce the load on both instructors and administrators.

19. **Files Download (Download Center).** An Off-line asynchronous service that allows the instructors and students to exchange files, such as assignments, syllables, learning materials…etc.

20. **On-line Registration and Course Selection.** This service allows learners to register on the web and select courses.

21. **Student Record Maintenance.** The administrator needs web-based tools to maintain student academic records, such as the application records, the transcript records, etc.

22. **Course Catalog Maintenance.** Available courses of virtual university and course syllabuses should be maintained on a web site, which can be accessed by both learners and instructors.

23. **Curriculum Schedule Maintenance.** On-line courses can be scheduled using this tool. The scheduling tool should consider load balancing among the synchronous communication servers and the course on demand servers.

24. **Transcript/Diploma Inquiry.** Transcripts and diploma can be requested from the web. After verification, these documents can be sent to learners.

25. **Accounting.** The accountant general needs a web-based tool to maintain the account balance of students, payroll of academic stuff, and other issues.

26. **Public Announcement.** The administrator can put out a public message to different groups of members using this tool (e.g. to learners, or instructors), either through an e-mail system, or via on-line audio/video broadcasting).

27. **Certificate / Certification Issuance**

    This administrative service allows administrators to issue the educational certificate for learners when they have completed the educational period.

4.3.3. Educational Organizations' Need for e-Learning Services

In the survey, the different interviewed educational organizations were asked to identify the e-Learning services they use as well as the importance of each service to their educational system. In this research, a table has been created based on the results obtained from the questionnaire for some of the identified e-Learning services. It aims to study the relationship between the e-Learning organizations and the e-Learning services through identifying the needs of each category of the e-Learning organizations taxonomy for each of these e-learning Services. (In terms of the importance of their existence in the e-Learning organization or the size of usage for this service).

Table 4.1 shows the majority of organizational need, as identified by the questionnaire for each service in terms of one of three choices: "needed", "optional", or "not needed".

- ✓ This means the service is needed or essential for the organization
- o This means the service is optional for the organization.
- ☒ This means the service is not needed for the organization.

In other words, the essential option it consider the important of the service for the organization, and we should provide them with the appropriate hosting platform with the required specifications that make them function properly. It is possible to develop this platform to obtain the best specifications and performance in case the organization's circumstances permit. However, we give a little importance to the optional option because it is possible to be provided or not. Therefore, we provide a hosting platform that makes them functional with the simplest specifications and prices. Accordingly, there is no need to develop this platform as long as it is not essential or necessary. Not needed service means that the organizations don't need them, and therefore we do not give them any importance in the hosting platform.

Table 4.1. Educational Organizations' Need for e-Learning Services

Organization Types /Services Types	Fully virtual University			Partial virtual University			Fully virtual training Institute			Partial virtual training Institute			Self Training Company		
	L	M	S	L	M	S	L	M	S	L	M	S	L	M	S
Closed Mailing List	✓	✓	✓	✓	✓	○	✓	✓	✓	○	○	☒	○	☒	☒
Office Hour Management	✓	✓	○	○	☒	☒	✓	○	○	☒	☒	☒	○	☒	☒
Office Hour Session (On-line Chat Room)	✓	✓	○	○	○	☒	✓	○	○	○	☒	☒	○	☒	☒
Discussion Group (Forum)	✓	✓	○	○	○	○	✓	○	○	○	○	☒	○	☒	☒
Collaborative Team Work / E-Meeting	✓	✓	○	○	○	☒	✓	✓	○	○	☒	☒	○	☒	☒
Course Development /Course Authoring	✓	✓	○	○	○	☒	○	○	☒	○	☒	☒	☒	☒	☒
Lecture-on-Demand(delivery)	✓	✓	○	○	○	☒	✓	✓	○	○	☒	☒	✓	✓	○
Virtual Class Room	✓	✓	✓	○	○	☒	✓	✓	✓	○	☒	☒	✓	○	○
Virtual lecture Playback & Recording	✓	✓	✓	○	○	☒	✓	✓	✓	○	☒	☒	✓	○	○
Assignments	✓	✓	✓	○	○	☒	✓	○	○	○	☒	☒	○	☒	☒
Student Assessment and Exams	✓	✓	✓	○	☒	☒	✓	○	☒	☒	☒	☒	○	☒	☒
Quiz	✓	✓	○	✓	○	○	✓	○	○	○	☒	☒	○	○	☒
Self Testing	✓	✓	○	✓	○	○	✓	✓	○	○	○	☒	○	☒	☒
Learning Process Analysis	✓	○	○	○	○	☒	✓	○	○	○	☒	☒	☒	☒	☒
Virtual library	✓	✓	○	✓	○	○	✓	○	○	○	○	☒	○	☒	☒
Personal Student Notebook Tool with Annotation Facility	✓	✓	○	○	○	☒	✓	✓	○	○	☒	☒	○	☒	☒

4.3.4. The QoS Map That Defines the QoS of Each e-Learning Service

In the survey, the different interviewed educational organizations were asked to identify the e-Learning services they use as well as the expected QoS (Quality of Service) of each service to their educational system. This table is created to study the QoS map that defines the QoS of each e-Learning service as required by each category of the e-Learning organizations Taxonomy. The quality of service intended here is defined as follows:

QoS= (Amount of Services/Number of Features) + Performance

This table contains two main fields as follows:

A. **Operational Environment (QoS) field**: it means identifying the expected QoS of each service to their educational system, and it takes two values; H means High QoS, and M means Moderate QoS. Whereas the essential need of the service takes two values H (high QoS) and M (Moderate QoS). The optional need takes only M value.

B. **Technology Environment (Commonly High Available Software) field**: that means the software that supports the service is commercially available and commonly used in the current environment, and it takes the values; N (No) which means that the software is not available, Y (Yes) which means that the software is available with high features, and NS (not satisfactory) which means that the software is available with low or not satisfactory features.

Table 4.2 shows the expected QoS (features and performance) of each e-Learning services for each organizational type as either “high” or “moderate”, as revealed by the survey.

Table 4.2. The QoS for e-Learning Services as Expected by the Educational Organizations

Organization Types / Services Types	Technology Environment	Operational Environment (QoS)															
		Fully virtual university			Partial virtual university			Fully virtual training institute			Partial virtual training institute			Self Training Company		
		L	M	S	L	M	S	L	M	S	L	M	S	L	M	S
Closed Mailing list	N	H	H	H	H	M	M	H	M	M	M	M	☒	M	☒	☒
Office Hour Management	Y	H	H	M	M	☒	☒	H	M	M	☒	☒	☒	M	☒	☒
Office Hour Session (On-line Chat Room)	Y	H	H	M	M	M	☒	H	M	M	M	☒	☒	M	☒	☒
Discussion group (Forum)	Y	H	H	M	M	M	M	H	M	M	M	M	☒	M	☒	☒
Collaborative Team Work / E-Meeting	Y	H	H	M	M	M	☒	H	M	M	M	☒	☒	M	☒	☒
Course Development /Course Authoring	N	H	H	M	M	M	☒	M	M	☒	M	☒	☒	☒	☒	☒
Lecture-on-Demand(delivery)	Y	H	H	M	M	M	☒	H	M	M	M	☒	☒	H	H	M
Virtual Class Room	N	H	H	H	M	M	☒	H	H	H	M	☒	☒	H	M	M
Virtual lecture Playback & Recording	Y	H	H	H	M	M	☒	H	H	H	M	☒	☒	H	M	M
Assignments	Y	H	H	H	M	M	☒	H	M	M	M	☒	☒	M	☒	☒
Student Assessment and Exams	N	H	H	H	M	☒	☒	H	M	☒	☒	☒	☒	M	☒	☒
Quiz	N	H	H	M	M	M	M	H	M	M	M	☒	☒	M	M	☒
Self testing	N	H	H	M	H	M	M	H	M	M	M	M	☒	M	☒	☒
Learning Process Analysis	N	H	M	M	M	M	☒	H	M	M	M	☒	☒	☒	☒	☒
Virtual library	Y	H	H	M	H	M	M	H	M	M	M	M	☒	M	☒	☒
Personal Student Notebook tool with Annotation facility	N	H	H	M	M	M	☒	H	M	M	M	☒	☒	M	☒	☒

4.3.5. The Effective Criteria of e-Learning Services

This research investigates those criteria that impact the selection of the most appropriate cloud model. Literatures as well as specialists' opinions (through the survey) were the sources for the identification of the most effective criteria (Buyyaa et al. 2009; Monfort et al. 2010; Dong 2009). In this research, a table consisting of the general criteria and main type of e-learning service has been created. It aims to study the nature of each service individually and abstractly and from the technical aspect in the E- learning environment depending on some criteria and specifications. This table is considered essential in this study because it has a strong influence in determining the initial recommendation of the hosting platform for each e-learning service. In this study, each service is studied based on these criteria on two different levels of QoS; High and Moderate. Table 4.3 shows the recognized need of each of the e-Learning services of these criteria. There are four main fields of criteria and each of them includes a set of sub-criteria as follows:

A. Service type or QoS. Performance

- Real Time/On-line: the service is conducted while the user is on-line.
- Synchronous / Asynchronous: specifies the service in terms of whether both the learner and instructor are either co-existing to enact the service (synchronous) or it is done with the presence of one of them only (asynchronous). All Synchronous services are real time while only some asynchronous services are real time.
- Administrative services: an off-line service that is done by an administrator (employee), hence low performance is acceptable.

B. Data Needs

- Required database: a parameter specifying the size of the database (if need).
- Sensitive data: privileged or proprietary information, such as student records, which, if compromised through alteration, corruption, loss, misuse, or unauthorized disclosure, could cause serious harm to the organization owning it.

C. Performance

- Speed/ Response time: the length of time taken for a service to react to a given stimulus or event.
- Accessibility/Availability: service accessibility from anywhere at any time.
- Reliability: a measure of the mean time between failures.

D. Others

- Dynamic Scalability: the nature of the service is subject to unplanned and sudden changes in the demand rate for the service.
- Spiky Demand (Short term need): seasonal planned and predictable changes in service access that occur at expected fixed time period.
- Processing Power: number crunching and processor consuming tasks.

All main fields except the Service type fields in this table are measured by four specific values as follows:

N/A This means the service is not affected by these criteria.

H: This means the service takes high value of criteria.

M This means the service takes medium value of criteria.

L This means the service takes low value of criteria.

Table 4.3. Default Criteria of e-Learning Services as Revealed by the Survey

Service Name	QoS Level	Service Type		Data Needs		Performance			Others		
		Real Time/On-line	Synchronous Or Asynchronous Or Administrative	Required DB Size	Sensitive Data	Speed/ Response time	Accessibility/ Availability	Reliability	Dynamic Scalability	Processing Power	Spiky Demand (Short term Need)
Closed Mailing List	High	No	Asy.	M	N/A	M	H	H	L	N/A	N/A
	Moderate					M	L	L	H	N/A	N/A
Office Hour Management	High	No	Adm.	N/A	N/A	M	M	M	L	N/A	N/A
	Moderate					L	L	L	M	N/A	N/A
Office Hour Session (On-line Chat Room)	High	Yes	Syn.	N/A	N/A	H	H	H	L	N/A	N/A
	Moderate					M	M	M	H	N/A	N/A
Discussion group (Forum)	High	No	Asy.	M	N/A	M	M	M	L	N/A	N/A
	Moderate					L	L	L	H	N/A	N/A
Collaborative Team work / E-Meeting	High	Yes	Syn.	N/A	N/A	H	H	H	L	N/A	N/A
	Moderate					M	M	M	H	N/A	N/A
Course Development /Course Authoring	High	No	Asy.	H	N/A	H	H	H	L	N/A	N/A
	Moderate					M	M	M	M	N/A	N/A
Lecture-on Demand(Deliver)	High	Yes	Asy.	H	N/A	H	H	H	L	H	N/A
	Moderate					M	M	M	H	M	N/A
Virtual Class Room	High	Yes	Syn.	N/A	N/A	H	H	H	L	N/A	N/A
	Moderate					M	M	M	M	N/A	L
Virtual Lecture Recording & Replaying	High	Yes	Syn. Recording Asy. Replayin	L	N/A	H	H	H	L	N/A	H
	Moderate					M	M	M	H	N/A	M
Assignments	High	No	Asy.	M	N/A	M	M	M	N/A	M	L
	Moderate					L	L	L	N/A	L	M
Exams/ Student Assessment	High	Yes	Asy.	M	H	H	H	H	L	N/A	H
	Moderate					M	M	M	L	N/A	M
Quiz	High	Yes	Asy.	M	M	H	M	M	L	N/A	L
	Moderate					M	M	M	L	N/A	L
Self testing	High	Yes	Asy.	L	N/A	M	M	M	H	N/A	M
	Moderate					L	L	L	H	N/A	M
Learning Process Analysis	High	No	Adm.	H	H	N/A	L	N/A	N/A	H	N/A
	Moderate					N/A	L	N/A	N/A	H	N/A
Virtual Library	High	No	Asy.	H	N/A	H	H	H	N/A	N/A	N/A
	Moderate					M	M	M	N/A	N/A	N/A
Personal Student Notebook with Annotation Facility	High	No	Asy.	L	N/A	M	M	M	L	N/A	H
	Moderate					L	M	M	M	N/A	H

4.3.6. Cloud Configuration Guidelines

Configuring a service on the cloud is governed by few guidelines that determine the most suitable cloud model for any application or service based on some criteria that have been previously identified for each e-Learning service. These guidelines are described below:

1. ***SaaS makes sense to use in one of the following cases*** **(Monfort et al. 2010; Kepes 2013):**
   - Applications where competitors use the same software because this fundamental technology is a requirement for doing business, but does not itself confer a competitive advantage. For example, email.
   - Applications where there is significant interplay between the organization and the outside world. For example, email newsletter campaign software.
   - Applications that have a significant need for web or mobile access. An example would be mobile sales management software.
   - Software that is to be used only for a short term need. An example would be collaboration software for a specific project.
   - Software where demand spikes significantly, for example tax or billing software used once a month.
   - Applications requiring low budget
2. ***PaaS makes sense to use in one of the folowing cases*** **(Kepes 2013; Xu, Hu, and Su 2013):**
   - In any situation where multiple developers will be working on a development project.
   - Where other external parties need to interact with the development process.
   - Where developers wish to automate testing and deployment services.
   - Methodologies based on iterative and incremental development, will also increase the uptake of PaaS as it eases the difficulties around rapid development and iteration of software.
   - Some examples of PaaS include Google App Engine, Microsoft Azure Services, and the Force.com platform.

3. ***IaaS makes sense to use in one of the folowing cases (Kepes 2013):***
    - Where demand is very volatile – any time there are significant spikes and troughs in terms of demand on the infrastructure.
    - For new organizations without the capital to invest in hardware
    - Where the organization is growing rapidly and scaling hardware would be problematic
    - Where there is pressure on the organization to limit capital expenditure and to move to operating expenditure
    - For specific line of business, trial or temporary infrastructural needs
4. ***FaaS makes sense to use in the following cases:***
    - Quick set up for a moderate to low performance services, especially when the time-to-market is short and the clients are not having high expectations.

However, this research suggested a new Cloud Model that we called it FaaS (Freeware as a Service). On the Internet, there are many services that are offered to public users completely free, e.g., emails, chatting, social networks, YouTube, calendar, etc. FaaS tries to make use of those free Internet services in favor of their clients. More details on FaaS are discussed in Chapter Five.

In some cases, it is recommended not to use the Cloud but rather use own on-premise facilities, which cancel the advantages of using the Cloud model.

5. ***On-premise makes sense in one of the following cases:***
    - There is a need for a large database
    - There are sensitive data.
    - High processing power is required.

SCCeLE's First Phase Rules

Figure 4.4 shows the rules comprising the first inference phase of SCCeLE. The first phase recommends one of the three models of on-premise, IaaS, and SaaS, while the other two models of PaaS and FaaS may appear in the Cloud Model Mix of the final recommendation. In the first phase, the need for large database, sensitive data, and large

processing power are the three major determinants for the on-premise model, while the speed and response time are the determinants for the IaaS model. The SaaS model depends on the criteria of dynamic scalability and spiky demands. The first inference phase has 13 rules. Table 4.4 depicts the main conditions of criteria for all hosting models, and it demonstrates the conditions of SCCeLE's first phase rules.

Table 4.4. The Main Condition of Criteria for All Hosting Models

Precaution/ No Problem

Hosting Model /Criteria	On-Premise	IaaS	PaaS	SaaS	FaaS
Spiky Demand (Short term need)	L	M-L	M-L	H-M	M //if partially dependant on the S.W
Dynamic Scalability	L	M-L	M-L	H-M	M // if partially dependant on the S.W
Required Data Base Size	H	M	M-L	L	L
Sensitive Data	H	M	M-L	L	L
Processing Power	H	M	M-L	L	L
Accessibility/Availability	M-L	H-M	H-M	H	H
Reliability	M-L	H-M	H-M	H	M
Speed/ Response time	H-M	H-M	M	M-L	L // if partially dependant on the S.W
QoS .performance	H	M	M	L	-L //if partially dependant on the S.W

Gain/Loss

Main Conditions for Initial Recommendations

R1 **if** Service -Need="Not needed"
Then Recommended-Model is "**Not needed**"
Exit

R2 **if** Step is "initial model selection"
There is H Data Base size.
There is H sensitive data
There is H Processing power
There is H-M Speed/ Response time
There is M-L Accessibility/Availability
There is M-L Reliability.
There is H QoS. Performance
There is L or No Dynamic Scalability.
There is L or No Spiky Demand
Then Recommended Model is "**On-Premise**"
Change Step to "Degradation"

R3 **if** Step is "initial model selection"
There is H Data Base size.
There is H sensitive data
There is H Processing power
There is H-M Speed/ Response time
There is M-L Accessibility/Availability
There is M-L Reliability.
There is H QoS. Performance
Then Recommended Model is "**On-Premise**"
Change Step to "Degradation"

R4 **if** Step is "initial model selection"
There is H Data Base size.
There is H sensitive data
There is H Processing power
There is L or No Dynamic Scalability.
There is L or No Spiky Demand
Then Recommended-Model is "**On-Premise**"
Change Step to "Degradation"

R5 **if** Step is "initial model selection"
There is H Data Base size.
There is H sensitive data
There is H Processing power
Then Recommended-Model is "**On-Premise**"
Change Step to "Degradation"

R6 **if** Step is "initial model selection"
There is H Data Base size.
Then Recommended-Model is "**On-Premise**"
Change Step to "Degradation"

R7 **if** Step is "initial model selection"
There is H sensitive data
Then Recommended-Model is "**On-Premise**"
Change Step to "Degradation"

R8 **if** Step is "initial model selection"
There is H Processing power
Then Recommended-Model is "**On-Premise**"
Change Step to "Degradation

R9 **if** Step is "initial model selection"
There is H-M Dynamic Scalability.
There is H-M Spiky Demand
There is L or No Data Base size.
There is L or No Sensitive data
There is L or No processing power
There is M-L Speed/ Response time
There is H Accessibility/Availability
There is H Reliability
There is L QoS. Performance
Then Recommended Model is "**SaaS**"
Change Step to "Degradation"

R10 **if** Step is "initial model selection"
There is H-M Dynamic Scalability.
There is H-M Spiky Demand
There is L or No Data base
There is L or No sensitive
There is L or No processing power
There is M-L Speed/ Response time
Then Recommended-Model is "**SaaS**"
Change Step to "Degradation"

R11 **if** Step is "initial model selection"
There is H-M Dynamic Scalability.
There is L or No Data base
There is L or No sensitive
There is L or No processing power
There is M-L Speed/ Response time
Then Recommended-Model is "**SaaS**"
Change Step to "Degradation"

R12 **if** Step is "initial model selection"
There is H-M Spiky Demand
There is L or No Data base
There is L or No sensitive
There is L or No processing power
There is M-L Speed/ Response time
Then Recommended-Model is "**SaaS**"
Change Step to "Degradation"

R13 **if** Step is "initial model selection"
Then Recommended-Model is "**IaaS**"
Change Step to "Degradation"

Figure 4.4. The Rules of SCCeLE's First Phase

4.4. The SCCeLE's Second Inference Phase

The second inference phase of SCCeLE is more pragmatic as it considers the organizational circumstances: Financial situation (Budget), Marketing Plan (Time-to-Market), and the Operational requirements (QoS.Performance). It also considers the technology environment status: software application availability as depicted by Figure 4.5. This phase of SCCeLE takes the initial cloud mix model and the four parameters as input. It reveals the final cloud mix model based on the rules of cloud configuration as output, as depicted by Figure 4.2.

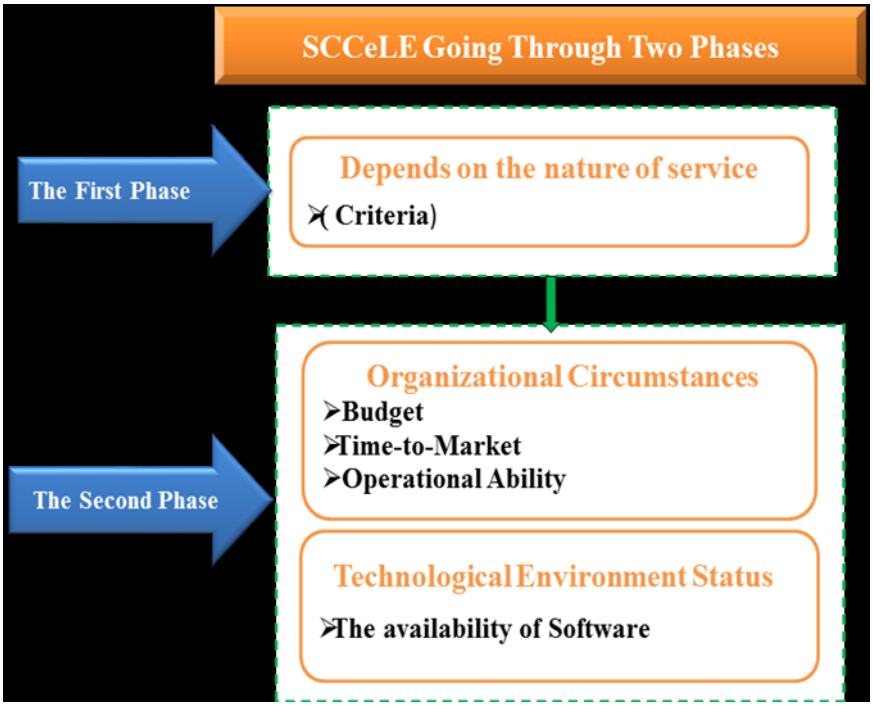


Figure 4.5. SCCeLE Input Parameters

The Rules and Upgrading/Downgrading Strategy of SCCeLE's Second Phase

The inference process of the second phase either upgrades or downgrades the initial recommendations of the first phase based on those parameters of pragmatic circumstances, according to this second phase degradation sequence: on-premise, IaaS, SaaS, and/or FaaS. PaaS is recommended if there is a need to develop software with special features as shown in Figure 4.6.

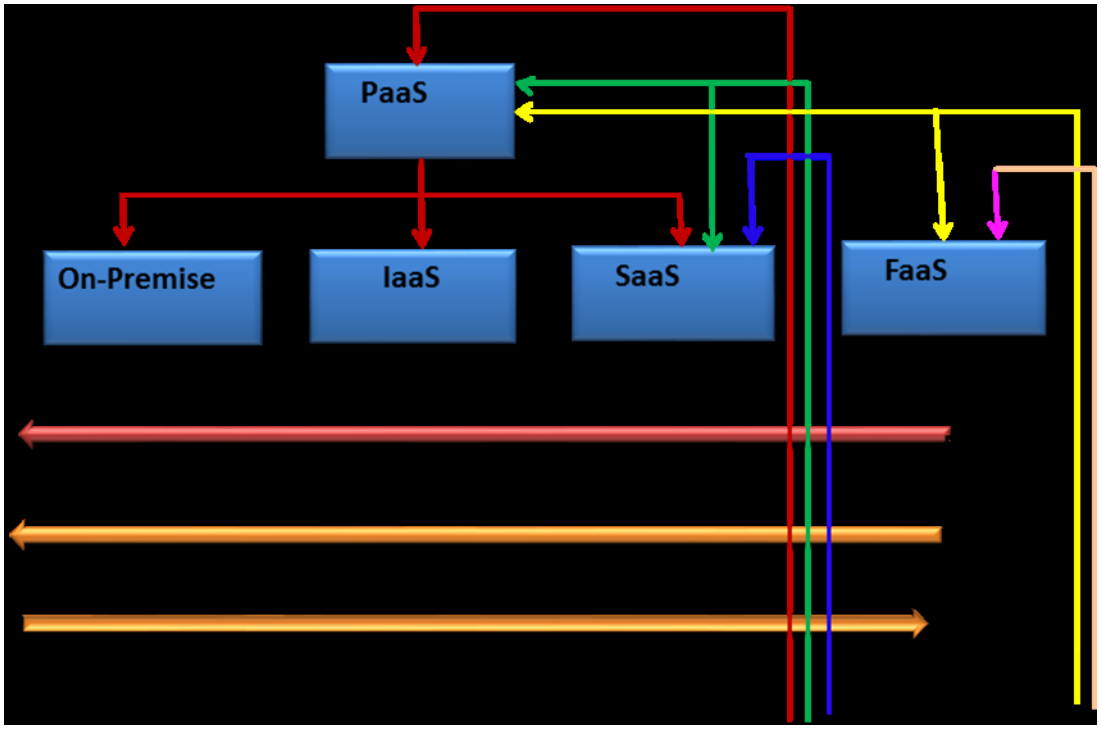


Figure 4.6. Upgrading/Downgrading Strategy of SCCeLE's Second Phase

Figure 4.7 shows a sample of the rules used by the second inference phase (for "IaaS" initial recommendation). Note that the reasons of upgrading and downgrading the initial recommendation are dictated by the pragmatic circumstances and the second phase drivers. Also note that it is possible to recommend a temporary step for developing customized software for satisfactory features and performance. In addition, the explanation modules of SCCeLE discrepancy report the gain/loss in performance as well as precautions to consider when contracting with the CSP. The second inference phase has 252 rules.

The Whole Set of SCCeLE Rules: The Second Phase is showing in the Appendix 1, Table 4.7 representing and describing all the cases considered of the second phase to make up the 252 rules.

R20 **If** Step is "Degradation"
Recommended-Model is "IaaS"
There is H QoS
There is H Budget
There is S.W-Commonly-Available =Y
There is Service -Need ≠ "optional"
There is Time-to –Market=H
Then Recommended-Model is "**On-premise**"
Exit
Loss: = + {Accessibility/Availability (if Accessibility-Availability=H) + Reliability (if Reliability =H)}
Gain =+ {QoS.Performance}

R21 **If** Step is "Degradation"
Recommended-Model is "IaaS"
There is H Budget
There is S.W- Available =NS or N
Time-to-Market=H-M
Then Recommended-Model is "**PaaS**"
Exit // to develop new customized S.W and then go back to IaaS.
Loss =+ {Delay in time-to-market}

R22 **If** Step is "Degradation"
Recommended-Model is "IaaS"
There is H-M Budget
There is S.W-Commonly-Available =Ns
There is L Time-to –Market
Then Recommended-Model is "**SaaS** and **PaaS**"
Exit
// to use SaaS for a temporary period while developing a customized S.W on PaaS ,and after finishing the S.W development go to IaaS and to run the developed S.W.
Loss =+ {Delay in time-to-market}

R23 **If** Step is "Degradation"
Recommended-Model is "IaaS"
There is H-M Budget
There is S.W-Commonly-Available =N
Time-Market=L
Then Recommended-Model is "**FaaS** and **PaaS**"
Exit
// to use FaaS for a quick start up for a temporary period while developing a customized S.W on PaaS ,and after finishing the S.W development go to IaaS and to run the developed S.W.
Loss =+ {Delay in time-to-market}

R24 **If** Step is "Degradation"
Recommended-Model is "IaaS"
There is L Budget
There is S.W-Commonly-Available =Ns
There is L Time-to –Market
Then Recommended-Model is "**SaaS**"
Exit
Loss =+ {QoS.Performance+ Speed/ Response time (if Speed-Response time=H)}
Precaution = + {DB size (if DB-Size=M) + Sensitive Data (if Sensitive-Data =M), Processing Power (if Processing-Power =M}
Gain =+ {Accessibility/Availability (if Accessibility-Availability=M or L) + Reliability (if Reliability =M or L)}

R25 **If** Step is "Degradation"
Recommended-Model is "IaaS"
Budget=L
There is S.W-Commonly-Available =N
Time-Market=L
Then Recommended-Model is "**FaaS**"
Exit
Loss =+ {QoS.Performance++, Reliability (if Reliability = H) + Speed/ Response time (if Speed-Response-time=H or M)}
Precaution = + { DB size (if DB-Size=M) + Sensitive Data (if Sensitive-Data =M), Processing Power (if Processing-Power =M} Spiky Configuration (if Spiky-on demand =H) Dynamic Scalability (if Dynamic Scalability =H)}
Gain =+ {Accessibility/Availability (if Accessibility-Availability=M or L) + Reliability (if Reliability = L)}

R 26 **If** Step is "Degradation"
Recommended-Model is" IaaS"
S.W-Commonly-Available = Y
Time-to –Market=L or budget=L
Then Recommended-Model is "**SaaS**
Exit
Loss =+ {QoS.Performance+ Speed/ Response time (if Speed-Response time=H)}
Precaution = + {DB size+ Sensitive Data + Processing Power}
Gain =+{ Accessibility/Availability (if Accessibility-Availability=M or L) + Reliability (if Reliability =M or L)}

Figure 4.7. Sample Rules of SCCeLE's Second Pragmatic Phase

Table 4.5 demonstrates the final Cloud Configuration Mix recommendation as a Recommended Cloud-Mix Model for certain circumstances of the e-Learning organization as generated by the SCCeLE expert system.

Table 4.5. The Output Recommendation of SCCeLE for a Medium Fully Virtual University (default service criteria are assumed)

Service Name	On-Premise	IaaS	PaaS	SaaS	FaaS
Closed Mailing List					✓
Office Hour Management				✓	
Office hour session (On-line Chat Room)				✓	
Discussion group (Forum)				✓	
Collaborative Team work / E-Meeting				✓	
Course Development /Course Authoring					✓
Lecture-on demand	✓			✓	
Virtual Class Room				✓	
Virtual Lecture Recording & Replaying				✓	
Assignment					
Exams/ Student assessment					✓
Quiz					✓
Self testing					✓
Learning process Analysis					✓
Virtual library	✓				
Personal Student Notebook with Annotation Facility					✓

4.5. SCCeLE Recommendations for the CSPs

Figure 4.8 demonstrates important point in the SCCeLE rule-based expert system; SCCeLE aids the CSPs as it does with the educational organizations. With the SCCeLE system, the cloud provider will have a good business idea about the e-learning environment so that they can follow a specific business model. The value proposition of this business is to provide the suitable e-learning environment through the provision of

different cloud model platforms for e-learning organization to perform all the services. SCCeLE highlights a new area for cloud provider which is the e-learning arena, and it provides CSPs with a market map of the best Cloud mix for each type of e-Learning services for all types of organizations. The recommended entries of the map are generated by the SCCeLE based on the default values for all parameters as identified by the survey. Table 4.6 shows a sample market map. The market map will help the CSPs to understand the market needs for each category of the educational organizations so that they can identify their target market and tailor their service offerings according to their targets and objectives.

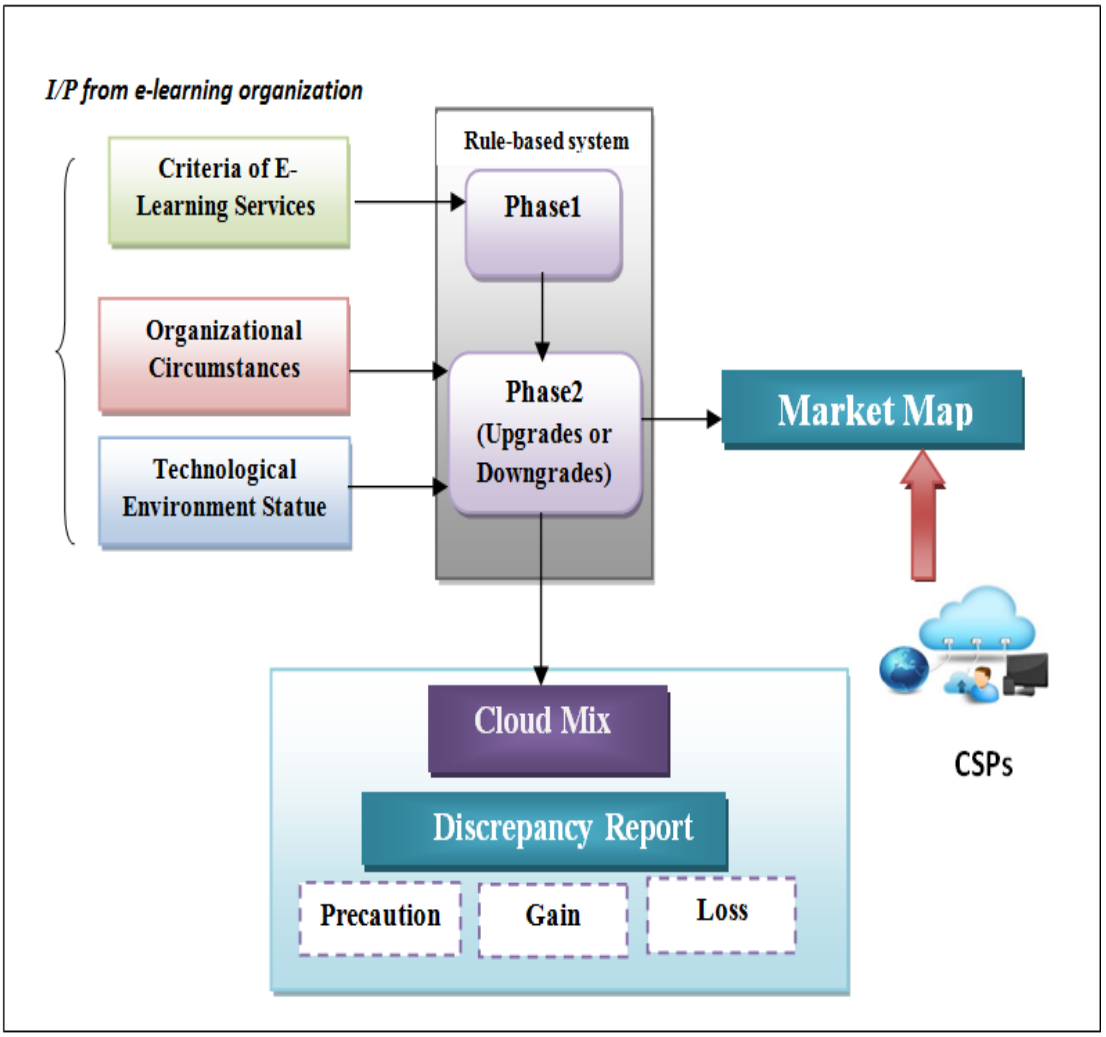


Figure 4.8. SCCeLE Recommendations for the CSPs

Table 4.6. Recommended e-Learning Services Market Map as Generated by the SCCeLE

Services Types /Organization Types	QoS. Features														
	Fully Virtual University			Partial Virtual University			Fully Virtual Training Institute			Partial virtual Training Institute			Self Training Company		
	L	M	S	L	M	S	L	M	S	L	M	S	L	M	S
Closed Mailing List	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	Not Needed	IaaS	Not Needed	Not Needed
Office Hour Management	IaaS	IaaS	SaaS	SaaS	Not Needed	Not Needed	IaaS	SaaS	SaaS	Not Needed	Not Needed	Not Needed	SaaS	Not Needed	Not Needed
Office Hour Session (On-line Chat Room)	IaaS	IaaS	IaaS	IaaS	IaaS	Not Needed	IaaS	IaaS	IaaS	IaaS	Not Needed	Not Needed	IaaS	Not Needed	Not Needed
Discussion group (Forum)	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	Not Needed	IaaS	Not Needed	Not Needed
Collaborative Team work / E-Meeting	IaaS	IaaS	IaaS	IaaS	IaaS	Not Needed	IaaS	IaaS	IaaS	IaaS	Not Needed	Not Needed	IaaS	Not Needed	Not Needed
Course Development /Course Authoring	On-Premise	On-Premise	On-Premise	On-Premise	On-Premise	Not Needed	On-Premise	On-Premise	Not Needed	On-Premise	Not Needed	Not Needed	Not Needed	Not Needed	Not Needed
Lecture-on demand	On-Premise	On-Premise	On-Premise	On-Premise	On-Premise	Not Needed	On-Premise	On-Premise	On-Premise	On-Premise	Not Needed	Not Needed	On-Premise	On-Premise	On-Premise
Virtual Class Room	IaaS	IaaS	IaaS	IaaS	IaaS	Not Needed	IaaS	IaaS	IaaS	IaaS	Not Needed	Not Needed	IaaS	IaaS	IaaS
Virtual Lecture Recording & Replaying	IaaS	IaaS	IaaS	IaaS	IaaS	Not Needed	IaaS	IaaS	IaaS	IaaS	Not Needed	Not Needed	IaaS	IaaS	IaaS
Assignment	IaaS	IaaS	IaaS	IaaS	IaaS	Not Needed	IaaS	IaaS	IaaS	IaaS	Not Needed	Not Needed	IaaS	Not Needed	Not Needed
Exams/ Student assessment	On-Premise	On-Premise	On-Premise	On-Premise	Not Needed	Not Needed	On-Premise	On-Premise	Not Needed	Not Needed	Not Needed	Not Needed	On-Premise	Not Needed	Not Needed
Quiz	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	Not Needed	Not Needed	IaaS	IaaS	Not Needed
Self testing	IaaS	IaaS	SaaS	IaaS	SaaS	SaaS	IaaS	SaaS	SaaS	SaaS	SaaS	Not Needed	SaaS	Not Needed	Not Needed
Learning process Analysis	On-Premise	On-Premise	On-Premise	On-Premise	On-Premise	Not Needed	On-Premise	On-Premise	On-Premise	On-Premise	Not Needed	Not Needed	Not Needed	Not Needed	Not Needed
Virtual library	On-Premise	On-Premise	On-Premise	On-Premise	On-Premise	On-Premise	On-Premise	On-Premise	On-Premise	On-Premise	On-Premise	Not Needed	On-Premise	Not Needed	Not Needed
Personal Student Notebook with Annotation Facility	IaaS	IaaS	SaaS	SaaS	SaaS	Not Needed	IaaS	SaaS	SaaS	SaaS	Not Needed	Not Needed	SaaS	Not Needed	Not Needed

Chapter Five

FaaS: The Conceptual and Operational Models

Chapter Five

FaaS: The Conceptual and Operational Models

This chapter proposes a new cloud model of Freeware as a Service (FaaS), and gives the idea of software development methodology (Software Development by Wrapping, SDW). Examples and case studies of some e-Learning services were implemented with specially customized scenarios on top of the appropriate free Internet services will be presented.

5.1. Introduction

e-Learning organizations need large budgets to establish an e-Learning environment on their premises. There is a need for three major components in such a budget; two of them go for the establishment of the environment—namely, hardware infrastructure and e-Learning software—while the third one goes for deployment and operation—namely, staffing and running costs. The IaaS Cloud model avails the platform and hardware less expensively, leaving the operation as the responsibility of the client. Meanwhile, SaaS offers the expensive software for rent, taking full responsibility of all the activities of the operation including maintenance, and upgrade (Verma and Rizvi 2013). However, SaaS CSPs are not generally enthusiastic to offer but the generic software that is commonly used by everybody and that most organizations require (Ghazizadeh 2012). Specialized software requires specialized target customers and that makes the model less economical and less profitable. This research raised the following question: "Are those commonly

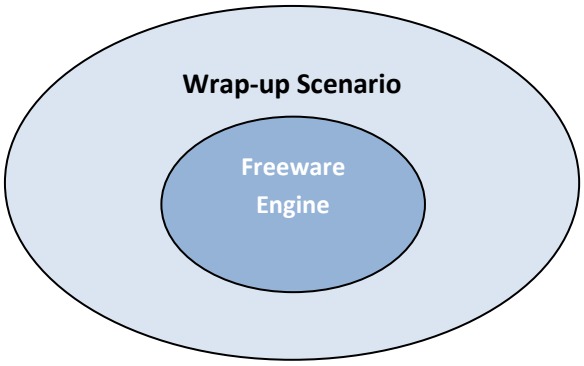
known three CSP service models—namely, IaaS, PaaS, and SaaS—the only possible options; or is it possible that technology opens new opportunities for another fourth model that is economically more suitable?" This research proposes a fourth model that CSPs can use to overcome this dilemma. FaaS is designed to overcome this dilema; the dilema of offering expensive specialized software yet making good profit.

Noteworthy, many Internet services are offered to public users completely for free, e.g., emails, chatting services, social networks, YouTube, calendar …etc. The service providers of these free services offer everything for free: software, platform, storage, and even operation, maintenance, and upgrade. It is a free Cloud-like service. The freely offered services are offered in a generic fashion that fits everyone, e.g., emailing service. In specialized software, such as in e-Learning, the services might require customized set of features and scenarios of interaction with the user, although still categorized under the same service type as the generic freely offered one. To explain, the emailing in e-Learning is usually a closed circle email in which the students are limited to communicate only with the stakeholders of their section (e.g., with the instructors, assistants, and/or administrators). They even do not have to use the account ID's of the recipients (when sending an email) but rather check their names from closed circle list of names. Moreover, the sender does not have to login to the mailing engine but rather he/she is always logged in once logged into the LMS system. This is a mailing service scenario still does the core tasks of any emailing system, such as sending, receiving, inbox …etc, yet differing completely from what is commonly offered by a generic emailing system.

This research raised the other following question: "Is it possible to build software with a specialized scenario and yet utilizing an existing software engine that implements the core features of the required software?" The idea was to investigate a methodology of software development through implementing a customized interface that interacts with the user at one side and communicates the requests in a customized fashion to the utility engine to get the actual service and then tailor the response and feed it back to the user in a proper way. This is what we called "Software Development by Wrapping" (SDW),

which refers to building an interface that wraps an existing software engine to obtain the core service, as shown in Figure 5.1

Figure 5.1. A Sketch Depicting How the SDW Methodology Wraps Up the Freeware Service Engine with a Customized Specialized Scenario



5.2. Proposed Approach

This research proposes an economically less expensive Cloud Model offering services to specialized application domains through utilizing freely available Internet services, although those free services are not designed to serve the e-Learning system. This proposed model is called FaaS, (Freeware as a Service) Cloud Model. We consider this approach and the services offered as a fourth cloud model. Figure 5.2 depicts the relationship between the freeware service and the newly developed specialized software for the e-Learning. FaaS offers two complementing components: a software development methodology (Software Development by Wrapping, SDW) and a Cloud Operational Model. Both methodology and operation are not limited to the e-Learning domain of services but rather they are generic and can be applied to any other domain of applications. However, this research focuses its experiments and prototype implementations only on e-Learning.

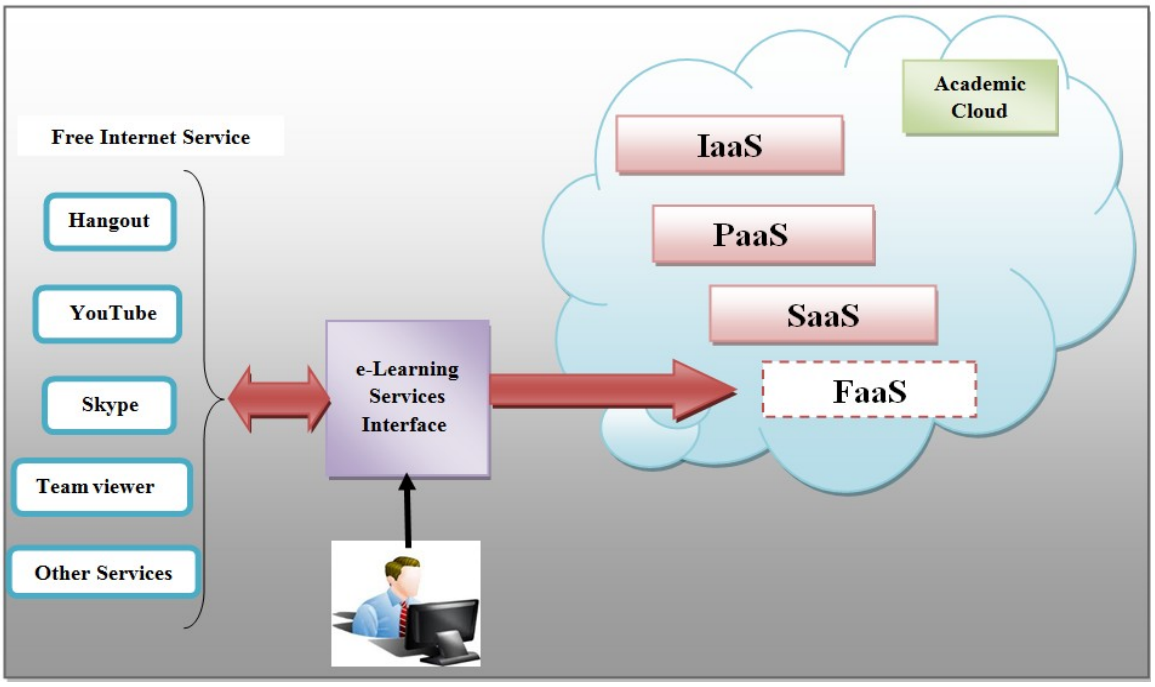


Figure 5.2. Proposed Approach for Developing e-Learning Services on Top of Freely Available Internet Service

A. SDW Methodology

Although the free services are usually generic, the SDW suggests that CSPs still can develop specialized and customized applications on top of such free services by wrapping the free service up by a specially designed interface that communicates with the service engine to get the basic service according to a specific scenario that suites a certain application domain , e.g., e-Learning. In the FaaS approach, we wrap up those free services in such a way that offers a more suitable look and feel for the e-learning environment with a minimum cost for development. The assumption here is that the free service provider avails an open source or API for the programmers to use; e.g., Google has Google+ and Google Apps. Figure 5.3 depicts the idea of software development technique under the FaaS.

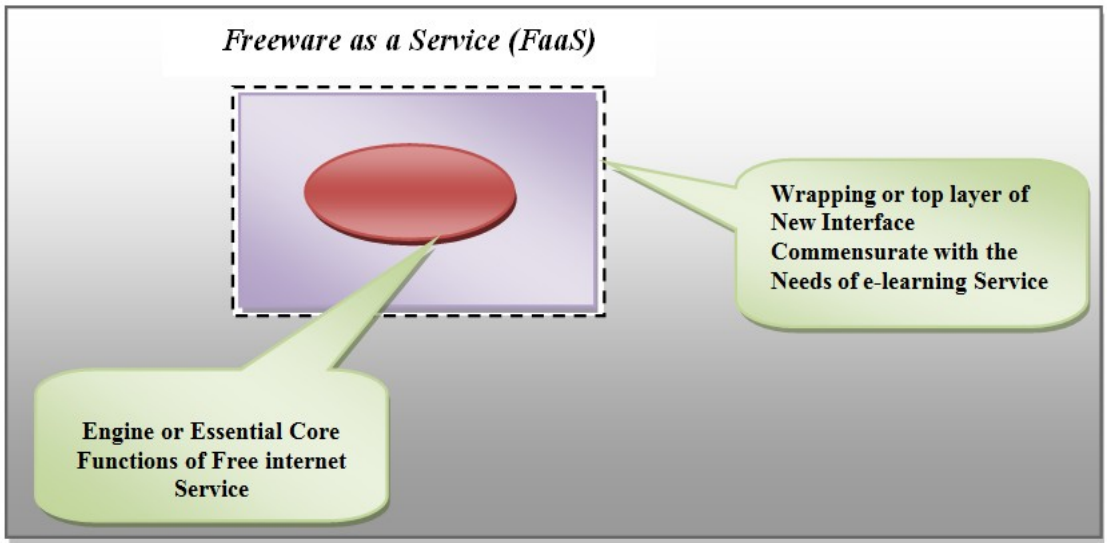


Figure 5.3. The Idea of Software Development SDW Technique Under FaaS

B. Cloud Operational Model

The operational model of FaaS uses a composite 2-server platform configurations: one at the free service provider, which offers the service in a generic fashion to the public freely, while the other server is at the CSP who offers the specialized service with the newly customized interface and scenario. Figure 5.4 depicts how this operational model works. In this operational model, the user interacts with the software according to an interface that is specially designed according to a scenario suitable to the specialized domain. However, the actual service runs on the servers at the premises of, and under full operation and support of the free service provider.

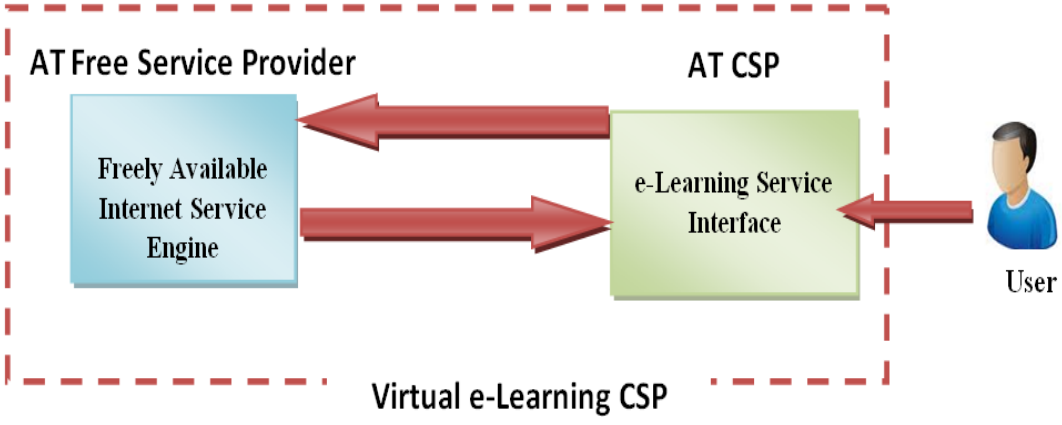


Figure 5.4. The Operational Model of FaaS

In fact, the actual service is offered as usual on the servers of the free service provider who takes a full responsibility of deployment, operation, maintenance, and even update. The specialized CSP carries only the interface that the user interacts with. This interface implements the specialized scenario as requested by the corresponding specialized service and then requests the actual service from the engine of the free service in a proper way; it then provides the responses and feedback to the user using a proper format. Noteworthy, the user feels like getting the whole service by the specialized CSP; he/she does not realize the composite model of servers.

Of course, this composite operational model of 2-servers platform affects the overall performance of the service. The performance criteria of the FaaS-based services are the poorest among those of all other cloud models, simply because the performance is dependent on a third party—the freeware service provider—the actual operator of the service.

The usefulness of the FaaS model consists in the following: The FaaS approach can be used by CSPs to develop less expensive e-Learning environments because this approach saves both the implementation and operation costs of e-Learning systems. The less quality and limited features will quickly and cheaply overcome many of challenges facing small e-Learning organizations. On the other hand, small organizations that do not have the capital to meet their needs by this approach can obtain the required e-learning services at affordable prices to them.

5.3. Examples and Case Studies

In this research, we studied some very famous e-Learning systems especially the e-Learning systems that is proprietary of the Deanship of Distance learning at King Abdulaziz University (KAU) including; the e-Learning Management Electronic System (EMES) and the Virtual Class Room System (CENTRA). Based on studying these systems, we can recognize the design and features of their services and how these services of e-Learning systems work. We got insight into the scenario of Closed Circle Mailing System that is used in Blackboard and EMES. Likewise, we also got insight into the scenario of Office Hour's One-On-One Chatting System, Collaborative Teamwork e-Meeting, and a Virtual Classroom that is used in CENTRA. On the other hand, we identified many of the popular and enjoyed internet services offered to public users

completely free. Thus, in this research, we integrate free services with the features e-Learning services through using SDW methodology.

To experiment with the proposed methodology (SDW), several e-Learning services were implemented with specially customized scenarios on top of the appropriate free Internet services. For instance, Google Apps were used to develop many applications, e.g., a Closed Circle Mailing System on top of the free Gmail service. Many other prototypes were also developed on top of Google's Hangout, such as Office Hours' One-On-One Chatting System, Collaborative Teamwork e-Meeting, and a Virtual Classroom. The last three cases show how this approach can be used in developing several different services with different properties using only one free internet service engine. Figure 5.5 shows the implemented prototypes and the corresponding free services they utilized. A more detailed discussion on these prototypes is presented in the following sections.

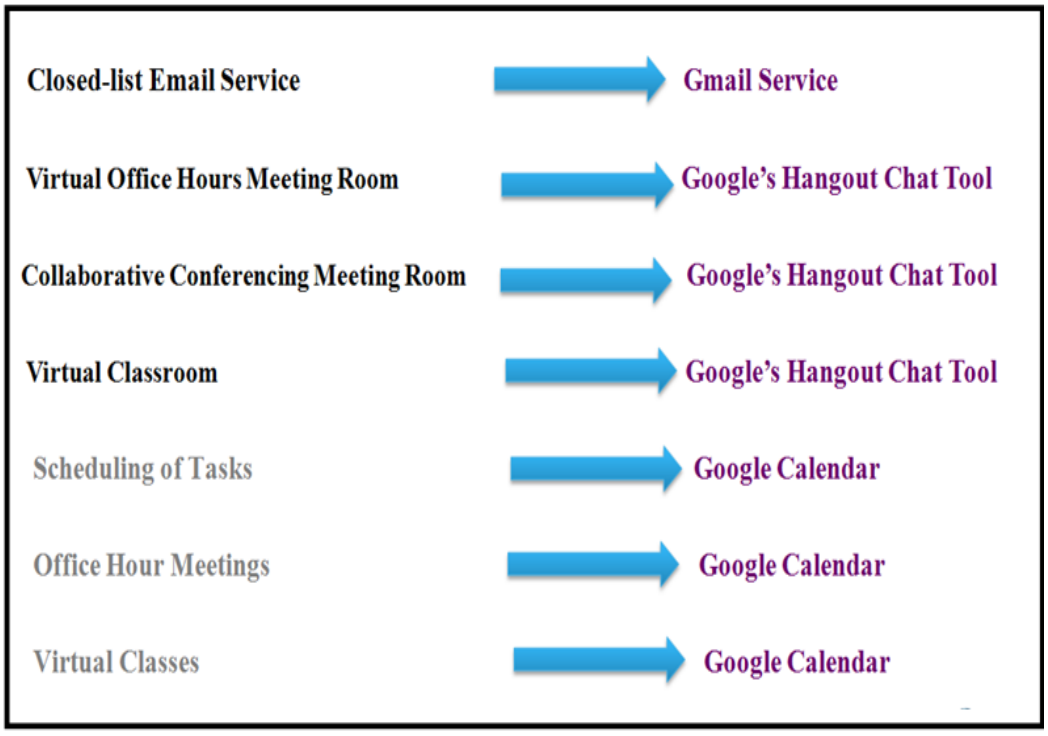


Figure 5.5. Some of the Prototyped e-Learning Services as Developed Under the FaaS Development Methodology

5.3.1. Closed Circle Mailing System with Specially Customized Scenario

Closed Circle Mailing System was implemented with specially customized scenario and developed on top of the free Gmail service as follows:

- **Closed Circle Mailing System**

  Emailing in e-Learning is usually a closed circle email in which the students are limited to communicate only with and the stakeholders of their section (e.g., the instructors, assistants, and/or administrators). They even do not have to use the account ID's of the recipients (when sending an email) but rather check their names from the closed circle list of names. Moreover, the sender does not have to login to the mailing engine but rather he/she is always logged in once logged into the LMS system. This is a mailing service scenario that still does the core tasks of any emailing system, such as sending, receiving, inbox …etc, yet differing completely from what is commonly offered by a generic emailing system.

- **Google Gmail Service**

  The Google Gmail service offers email clients access to retrieving and sending emails through Gmail account. Instead of having to manage your own outgoing mail server on our DigitalOcean VPS, we can simply configure Google's SMTP server settings into whatever script or program we wish to send email from. All we need is either a (i) free Gmail account or (ii) paid Google Apps account. We need incoming mail (POP3 or IMAP) server and outgoing e-mail server (STMP) name for Gmail for sending and receiving mail through Gmail from and to any email. We have the option to have Google store and index the emails you send via its SMTP server, so all our sent emails will be searchable and backed-up on Google's servers. If we elect to use Gmail or Google Apps account for our email as well, we will have all our emails in one convenient place (Miscellaneous, 2013).

Google's Gmail service has the great features and possibilities that enable us to customize according to a specific scenario that suites a certain email service. In this research, we used Google Gmail service as free internet service to perform the Closed Circle Email scenario tasks for e-Learning. We apply the SDW methodology in this scenario by wrapping the Gmail service up using a specially designed interface that communicates with the Gmail engine to get the core tasks but according to a Closed

Circle Email scenario. Consequently, the CSPs can offer this service as a FaaS cloud model.

Closed Circle Mailing System consists of the same main components of the general mailing list as shown in Figure 5.6

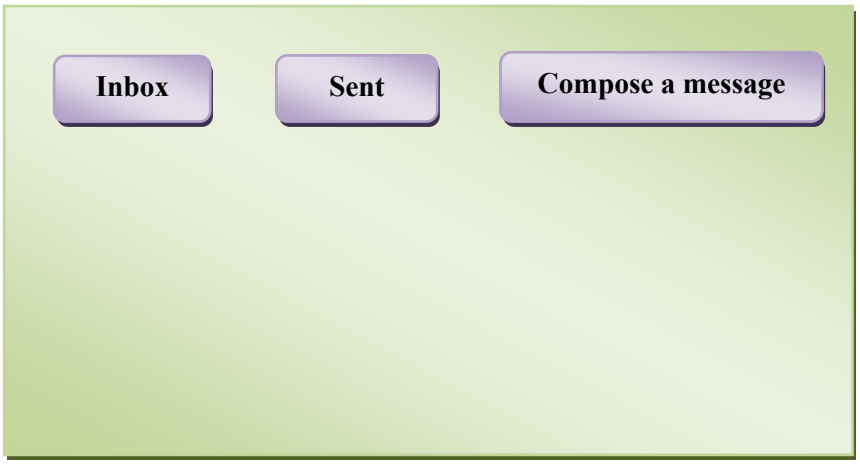


Figure 5.6. Closed Circle Mailing System Scenario

- **Inbox.** Students can see all messages received from the stakeholders of their section (e.g., students, instructors, assistants, and/or administrators). As well, for the instructor.

- **Sent Mail.** Students can see all messages that they sent from their accounts to all members' accounts (i.e.) the stakeholders of their section (e.g., students, instructors, assistants, and/or administrators). As well, for the instructor.

- **Compose a Message.** Students and instructors will follow steps when using the email service to send an email in a specific section.

1. It will appear as the normal message consisting of the following main components: to, cc, title, the text of the message, and send button.
2. When a student or an instructor clicks on ***to,*** the groups of closed mailing list for student or instructor of their section will appear. The type of groups can be:
   - Instructor
   - Instructor's assistant
   - Administrator

- Students

3. Then the student and/or instructor can select the type of users, and the list of names of selected type will be appear (retrieve the list of names for this section from the DB), and then they can select specific names from each list.
4. Then, all the selected names will be posted into the message of the email.
5. Then, the student and/or instructor can write the title and the text of message then, they can click on send button.
6. Finally, the message will be successfully sent. Otherwize a fail send error message will be displayed.

- ## The Operational Model of FaaS—The Closed Circle Mailing Service in e-Learning

Figure 5.7 depicts how the FaaS operational model works with the Closed Circle Mailing service and Gmail service. The operational model of FaaS here uses a composite 2-server platform configurations: one at the Google provider, which offers the Gmail service in a generic fashion to the public freely, while the other server is at the CSP who is offering the Closed Circle Mailing service with the newly customized interface and scenario. In this operational model, the user interacts with interface that is created by CSP. This interface implements the specialized scenario of the Closed Circle Mailing service and then requests the actual service from the engine of the Gmail service in a proper way; it then provides the responses and feedback to the user in a proper format. Accordingly, the user will deal with Closed Circle Mailing service interface formally and externally, and with Gmail service functionally and internally.

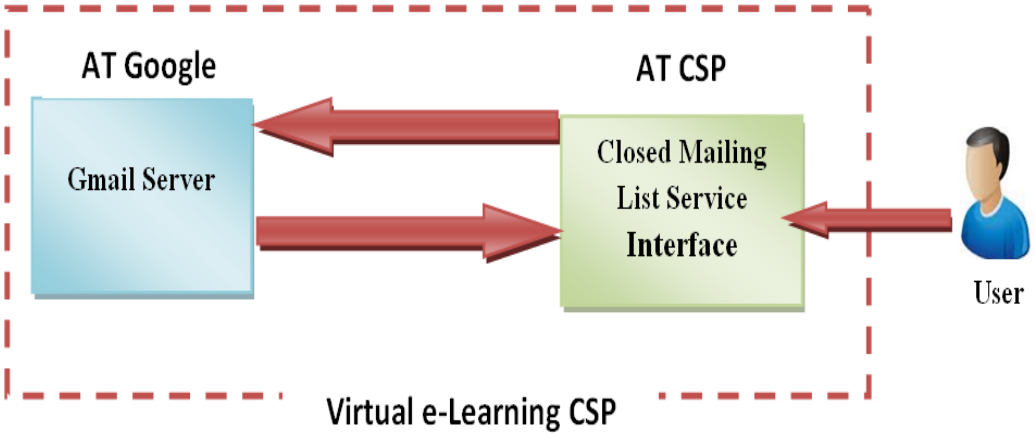


Figure 5.7. The Operational Model of FaaS—The Closed Circle Mailing Service in e-Learning

5.3.2 Office Hours' One-On-One Chatting System with Specially Customized Scenario

Office Hours' One-On-One chatting system was implemented with specially customized scenario. It was developed on top of the free Google's Hangout service as follows:

- **Office Hours' One-On-One Chatting System**

  We will use office hours' one-on-one chatting service to execute the appointment of office hours between the instructor and the student during the learning process. It is an online synchronous communication service through which the student can have a one-on-one session with the instructor through an online chat room.

- **Google's Hangout**

  Google's new Hangouts system provides a consistent chat and video collaboration experience across multiple platforms. Google+ Hangouts is a free video chat service from Google that enables both one-on-one chats and group chats with up to ten people at a time. It is somewhat similar to Skype, FaceTime and Facebook Video Chat. The new Hangouts app works even better with Google+. When we use Hangouts and when we have a Google+ account, we may start chats with the Google+ Circles using Hangouts. Chat discussions are limited to 100 people. The possibilities of this technology include: Video Chatting, location sharing, sharing documents, scratchpads, images and YouTube videos

with other users, "Hangouts on Air" feature is used for broadcasting live video conversations that are accessible to anyone with a web browser , Google Drive, A digital whiteboard, Slideshare and friendly online drawing tool (Oberer and Erkollar 2012; Cochrane et al. 2011).

Google's chatting system, Hangout™ service has great features and utilities that enable us to customizable according to a specific scenario that suits certain interactive session services. In this research, we use Google Hangout service as free internet service to perform the One-On-One Office Hours scenario tasks for the e-Learning service. We apply the SDW methodology in this scenario by wrapping the Hangout service up by a specially designed interface that communicates with the Hangout engine to get the core tasks but according to One-On-One Office Hours scenario. Consequently, the CSPs can offer this service as a FaaS cloud model.

We called the LMS system that offers all the e-Learning services as a FaaS "Smart Cloud LMS". When the provider of the e-learning organizations enters to the smart cloud LMS to select the Service, the screens of customization and personalization will appear to allow the provider to adapt the service formally as shown in Figures 5.8 and 5.9.

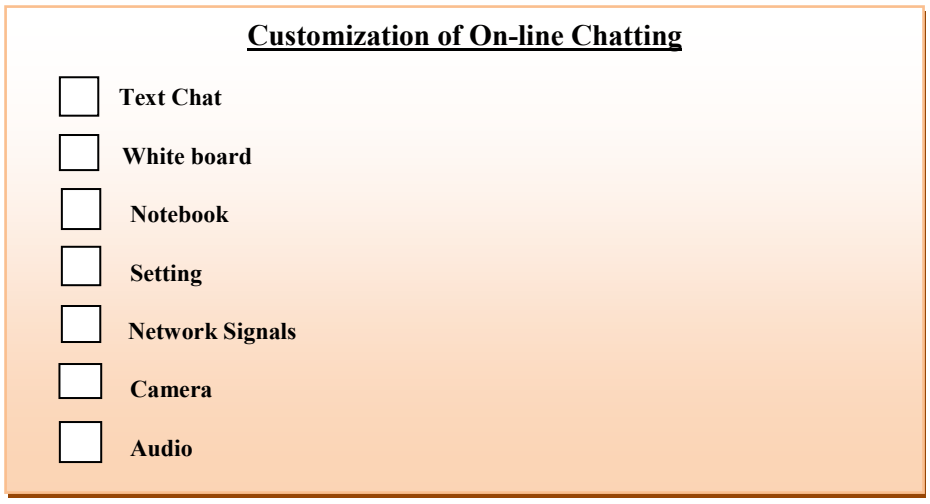


Figure 5.8. Customization Options

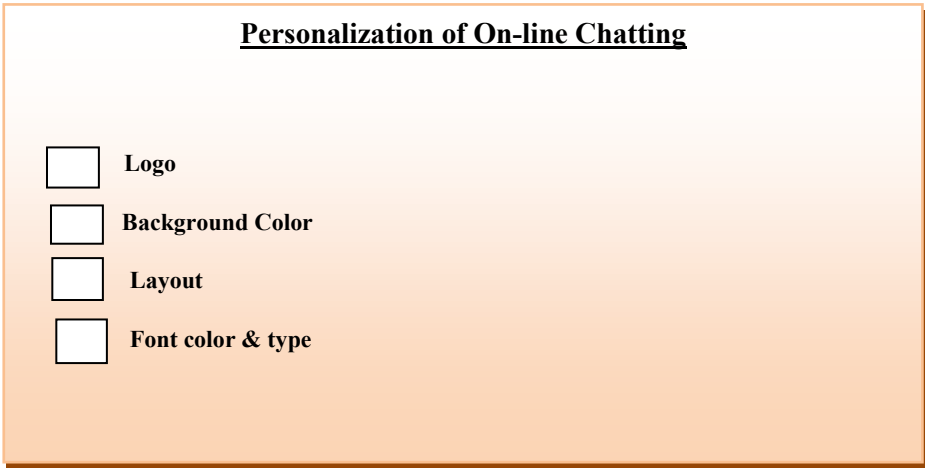


Figure 5.9. Personalization Options

When users (Instructors and/or Students) want to use any service from the smart cloud LMS, they should enter their IDs and passwords as shown in Figures 5.10, and then select the specific section from the list of sections for specific course in which they are enrolled.

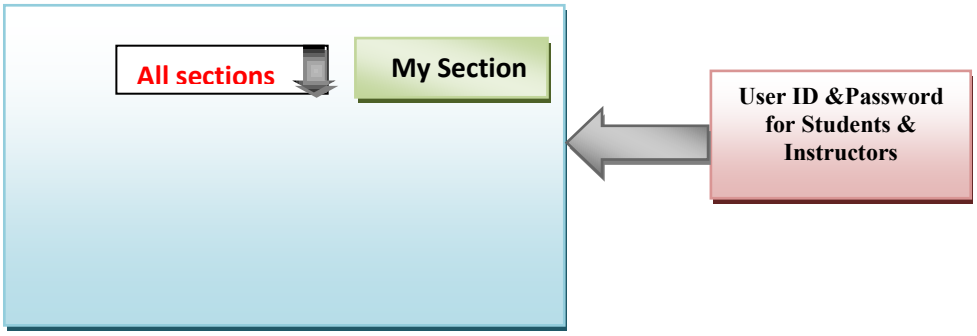


Figure 5.10. The List of All Sections for Specific Courses

- After the user selects the certain section, all services that are offered as FaaS will appear and become available to the instructors and students.
- After the user (Instructor and /or Student) selects the Office Hour's Session service, the schedule that containing of all Office Hour Sessions for this specific section and for this user will appear.
- When the user (Instructor and /or Student) clicks on ***Upcoming Schedule tab***, the schedule times of all Office Hour Sessions that will take place between the instructor and student for specific section will appear as shown in Figures 5.11.

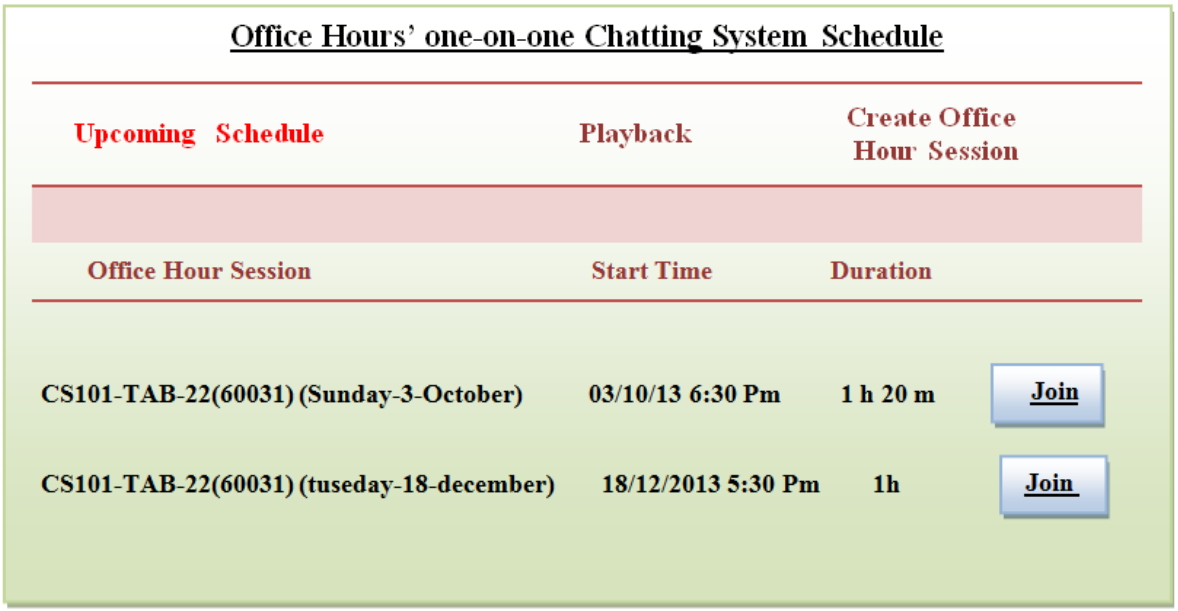


Figure 5.11. Upcoming Schedule of Office Hours' One-On-One Chatting System

- When the user (Instructor and/or Student) clicks on the ***Playback tab,*** a table that containing any sessions that have been previously recorded between the instructor and student for specific section will appear. They can be also played back any session in this table as shown in Figures 5.12.

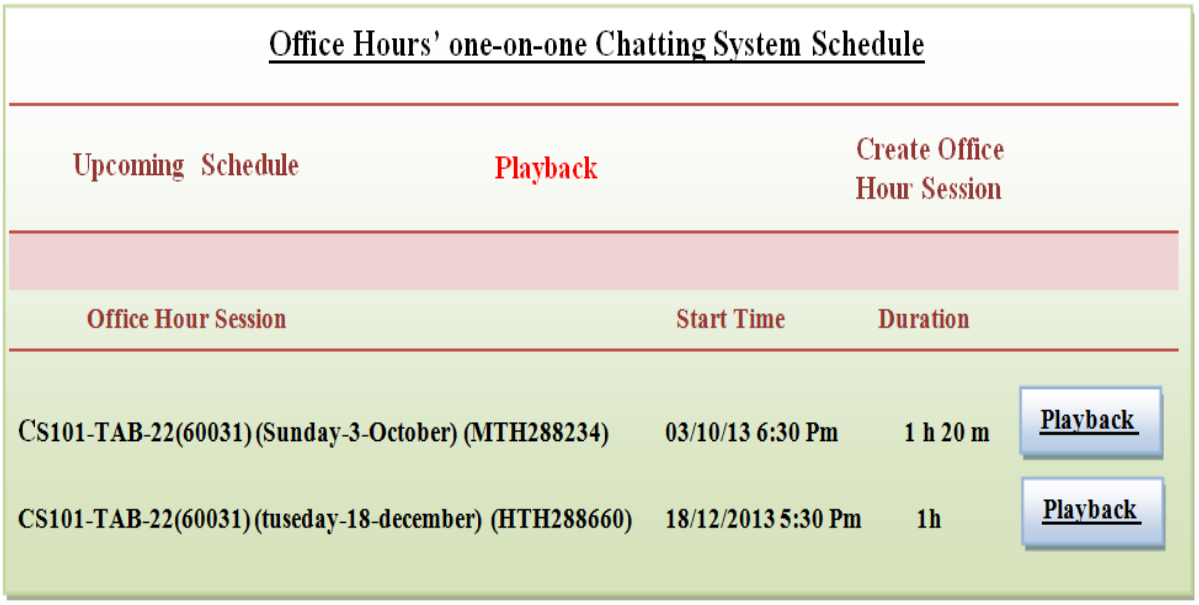


Figure 5.12. Playback Schedule of Office Hours' One-On-One Chatting System

- When the students need to create a new Office Hour Sessions with any instructors, they click on the **Create Office Hour Session tab** and fill in the required data as shown in Figures 5.13.

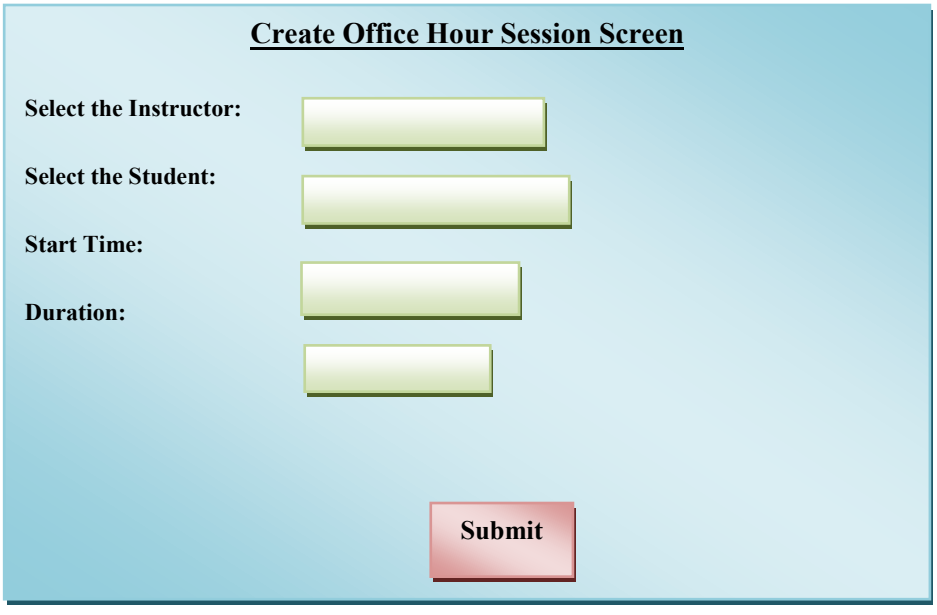


Figure 5.13. Create New Office Hours' One-On-One Sessions

The Office Hours' One-On-One Chatting System is an interactive session that is carried out using Hangout and YouTube free services. Hangout offers many of the required utilities, such as whiteboard, Chatting, Video calls, while YouTube is used for recording the sessions and playing them back. Other software utilities are also used, e.g., Notepad to simulate the Notebook utility. When the instructor and/or student clicks on the "join button" on the Upcoming Schedule, the screen of the Hangout service will appear with a new interface and the Office Hours' One-On-One Chatting Session between instructor and student will start as shown in Figures 5.14.

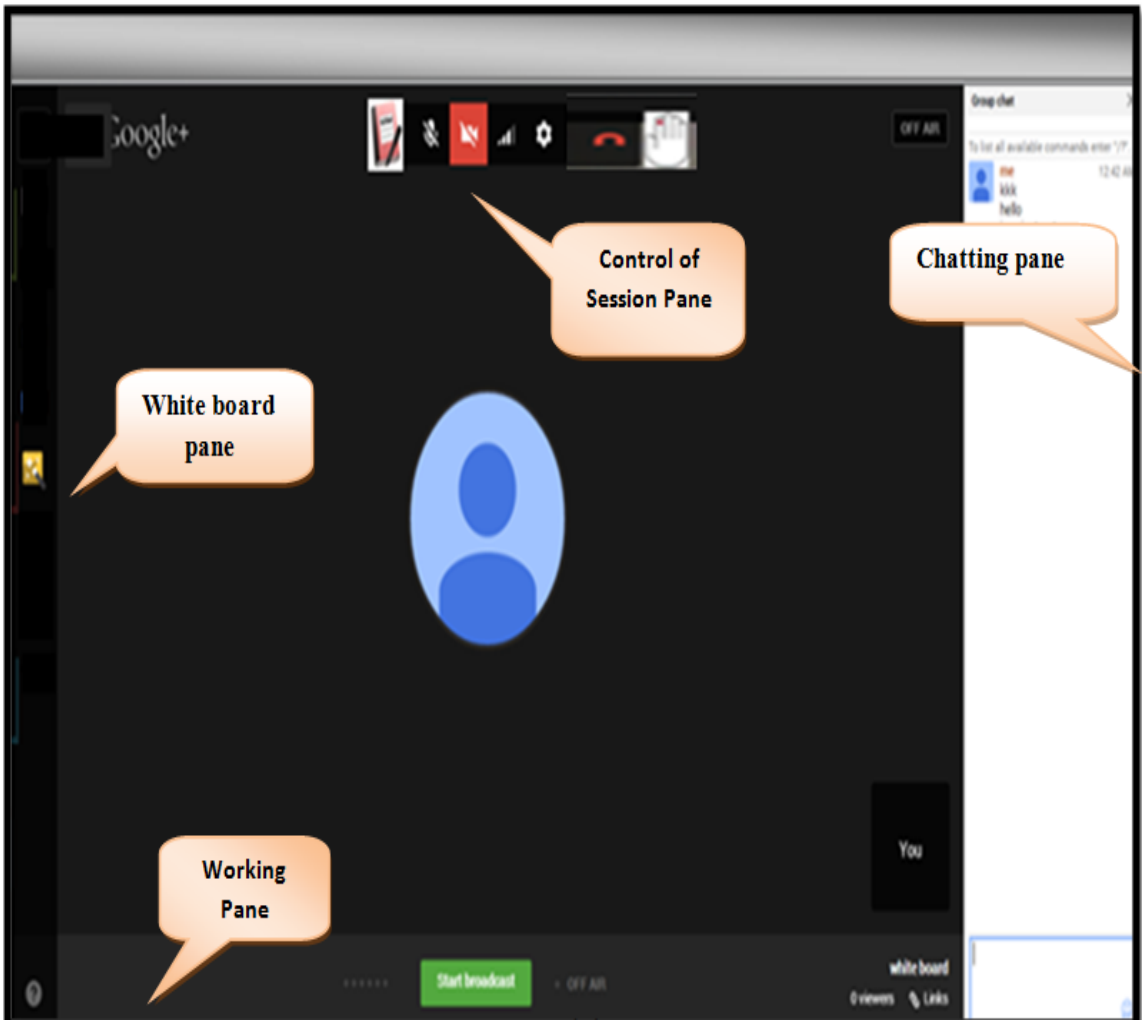


Figure 5.14. Office Hours' One-On-One Chatting Interface Developed on Top of Google's Hangout

- **The Operational Model of FaaS—The Office Hours' One-On-One Chatting Service in e-Learning**

  Figure 5.15 depicts how the FaaS operational model works with the Office Hours' One-On-One Chatting service and Hangout. The operational model of FaaS here uses a composite 2-server platform configuration: one at Google as the service provider, which offers the Hangout service freely to the public in a generic fashion, while the other server is at the CSP who is offering the Office Hours' One-On-One Chatting service with the newly customized interface and scenario. In this operational model, the user interacts with the interface that is created by the CSP. This interface implements the specialized scenario of Office Hours Chatting service. It requests the actual service from the engine of the Hangout service in a proper way; it then provides the responses and feedback to the user in a proper format. Accordingly, the user will deal with Office Hours' One-On-One Chatting service interface formally and externally, and with Hangout session service functionally and internally.

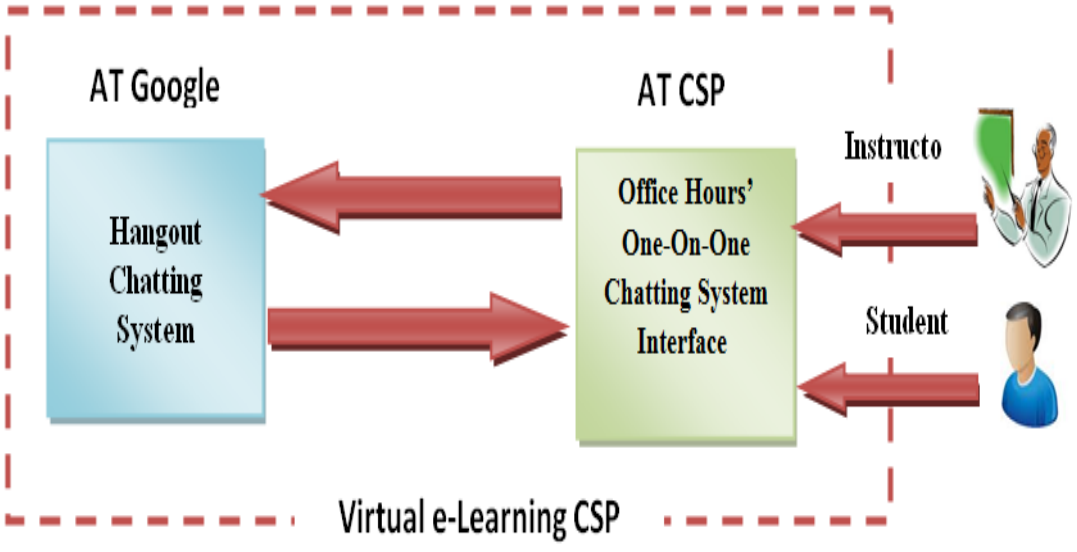


Figure 5.15 The Operational Model of FaaS—The Office Hours' One-On-One Chatting Service in e-Learning

5.3.3 Collaborative Teamwork e-Meeting with Specially Customized Scenario

Collaborative Teamwork e-Meeting was implemented with specially customized scenario. It was developed on top of the free Google's Hangout service as follows:

- **Collaborative Teamwork e-Meeting**

  An online synchronous service that allows a team of students or a team of students and their instructor to collaborate in doing things together without the need to meet physically.

In this research, we also use Google Hangout service as free internet service to perform the Collaborative Teamwork e-Meeting scenario tasks as an e-Learning service. We apply the SDW methodology in this scenario by wrapping the Hangout service up using a specially designed interface that communicates with the Hangout engine to get the core tasks but according to Collaborative Teamwork e-Meeting scenario. Consequently, the CSPs can offer this service as a FaaS cloud model.

The Collaborative Teamwork e-Meeting is an interactive session which is carried out by using the Hangout and YouTube free services. Hangout offers many of the required utilities, such as whiteboard, Chatting, Video calls, Application Sharing, Video Play …etc as shown in Table 5.1, while YouTube is used for recording the sessions and playing them back. Other software utilities used here as outsourcing include Notepad, Word Application and Google Drive to simulate the Notebook , Agenda , Minutes of the Meeting utility. These utilities are not provided in the Hangout software, and we used these applications to complement the requested interface to commensurate with the Collaborative Teamwork service.

When the user enters to the Collaborative Teamwork e-Meeting, the screen of the Hangout with a new interface appears and the session of Collaborative Teamwork e-Meeting starts. It consists of the following panes as shown in Figure 5.16.

Figure 5.16. Collaborative Teamwork e-Meeting Interface Developed on Top of Google's Hangout

Table 5.1. Description of The Hangout Tools

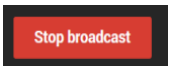
Tools	Description
	***Desktop Screen Share:*** to share the instructor's desktop screen and show running applications.
	***Capture:*** to capture the working pane on the screen.
	***Whiteboard:*** to write and draw on by the instructor.
	***Video Play:*** to play and show the video on YouTube.
	***Control of attendance:*** to control of appearing the collaborators of the e- meeting in the recording.
	***Remote Access:*** to access the remote desktop of any collaborator in the e- meeting.
	***Start broadcast:*** to start the session and/or the recording. When clicking on this button, it will change to "Stop broadcast".
	***Stop broadcast:*** to end the session and/or the recording, and after that the recording session will be saved in the database.
	***Audio:*** to activate the audio of the instructor or to set it on the mute.
	***Camera:*** to activate the photo of instructor in video call or to inactivate.
	***Close Video Call:*** to exit from the on-line session.
	***Notebook:*** to write the notes and drafts by the instructor.
	***Step Out:*** to temporarily step away from the lecture temporarily and then come back.

Figure 5.17 depicts the Whiteboard tool that allows users to write and draw anything during the Collaborative Teamwork e-Meeting session.

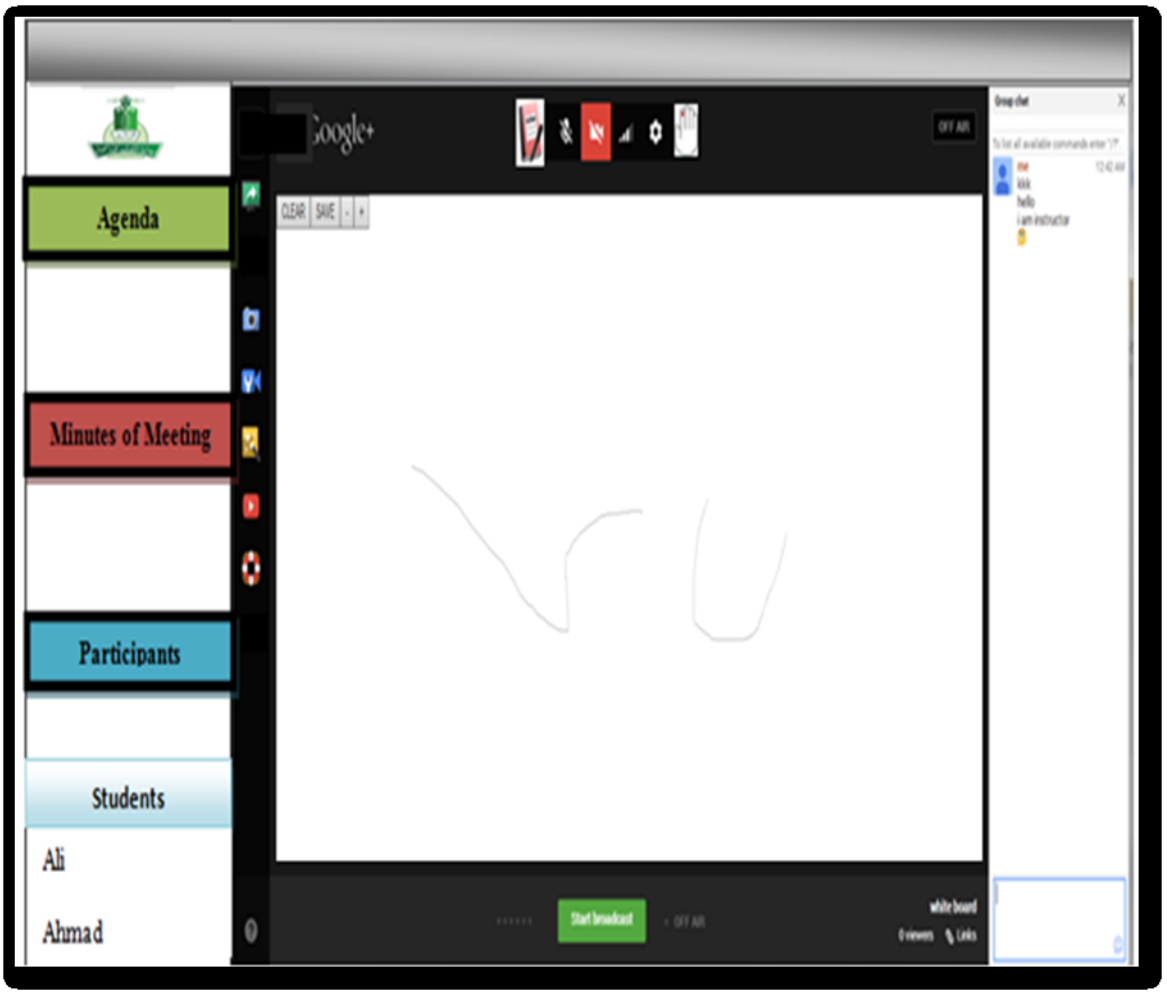


Figure 5.17. Using the Whiteboard Tool of Google's Hangout with a New Interface during the Collaborative Teamwork e-Meeting Service

Figure 5.18 depicts the desktop and application share tool that allows users to share the applications and to get access to a specific desktop during the Collaborative Teamwork e-Meeting session.

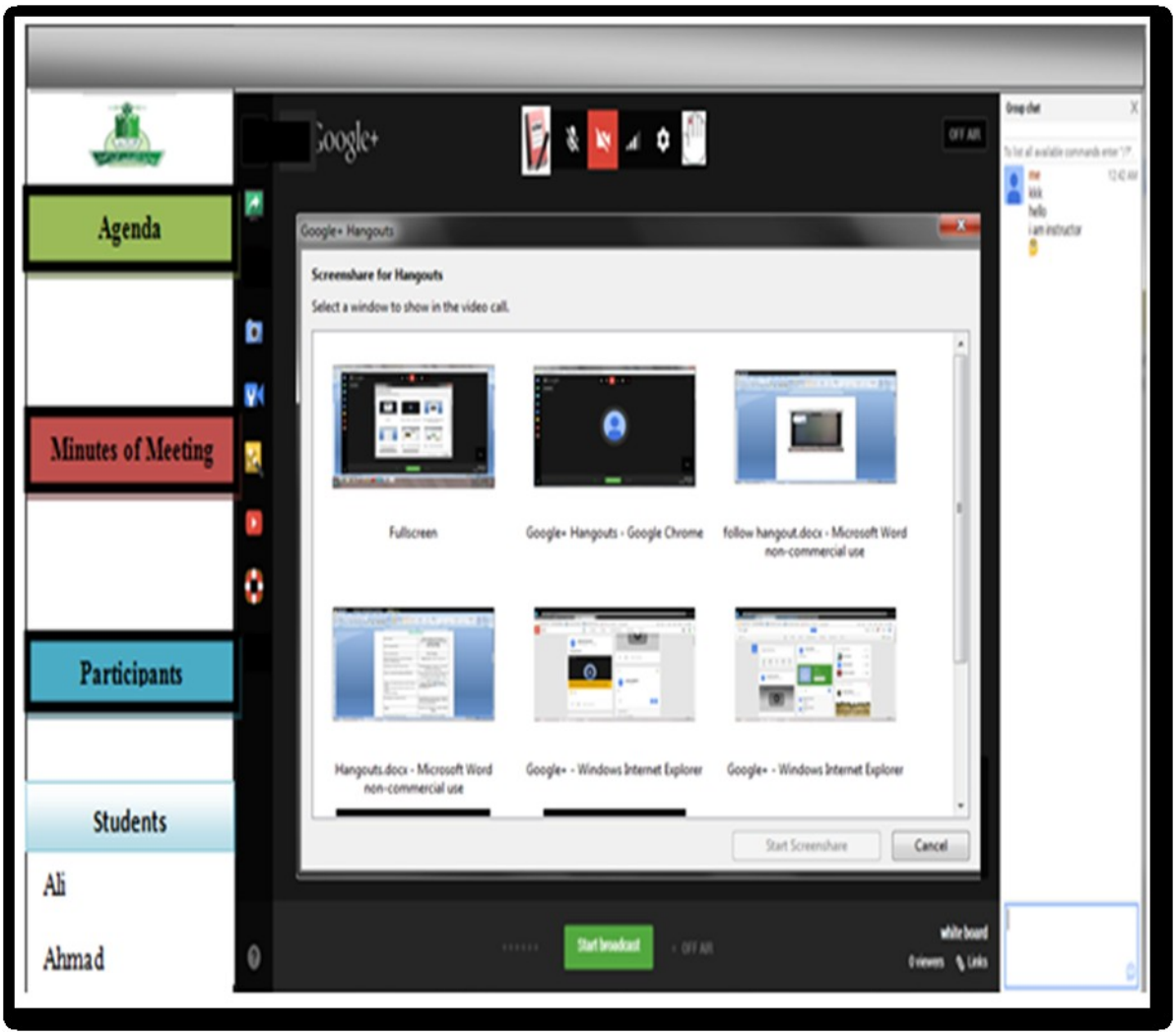


Figure 5.18. Using Desktop Sharing Tool of Google's Hangout with a New Interface during the Collaborative Teamwork e-Meeting Service

- **The Operational Model of FaaS—The Collaborative Teamwork e-Meeting Service in e-Learning**

  Figure 5.19 depicts how the FaaS operational model works with the Collaborative Teamwork e-Meeting service and Hangout. The operational model of FaaS here uses composite 2-server platform configurations: one at the Google provider, which offers the Hangout service freely to the public in a generic fashion, while the other server is at the CSP who is offering the Collaborative Teamwork e-Meeting service with the newly customized interface and scenario. In this operational model, the user interacts with interface that is created by CSP. This interface implements the specialized scenario of Collaborative Teamwork e-Meeting service and then requests the actual service from the engine of the

Hangout service in a proper way; it then provides the responses and feedback to the user in a proper format. Accordingly, the user will deal with Collaborative Teamwork service interface formally and externally, and with general Hangout session service functionally and internally.

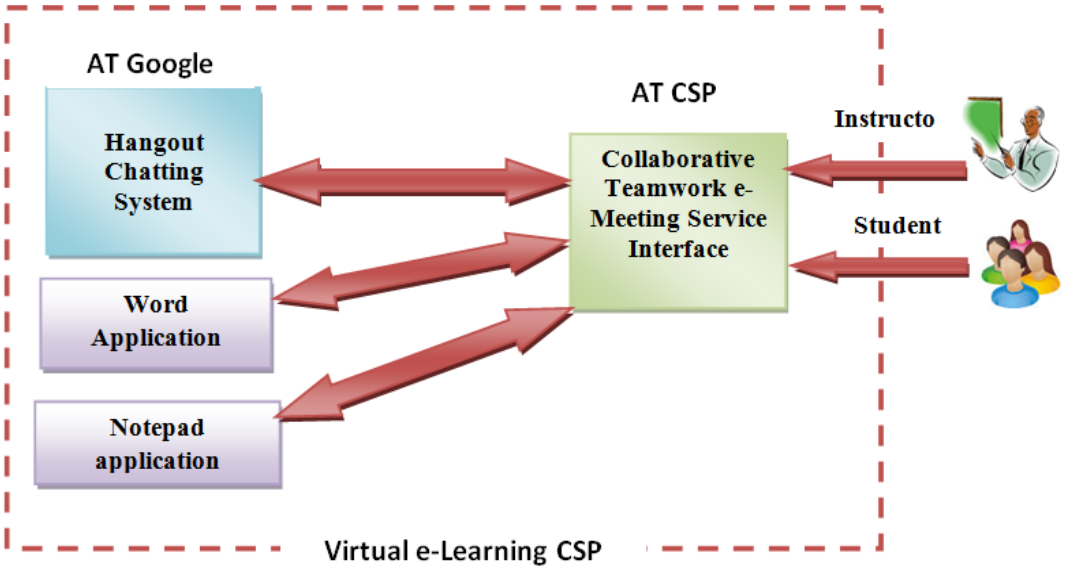


Figure 5.19. The Operational Model of FaaS—The Collaborative Teamwork e-Meeting Service in e-Learning

5.3.4. Virtual Classroom with Specially Customized Scenario

Virtual classroom was implemented with specially customized scenario. It was developed on top of the free Google's Hangout service as follows:

- **Virtual Classroom**

  An online simulation of a traditional classroom in which lectures are virtually and synchronously conducted where each individual (instructor and students) is distantly located.

In this research, we also used Google Hangout service as a free internet service to perform the Virtual Classroom scenario tasks for e-Learning. We apply the SDW methodology in this scenario by wrapping the Hangout service up by a specially designed interface that communicates with the Hangout engine to get the core tasks but

according to Virtual Classroom scenario. Consequently, the CSPs can offer this service as a FaaS cloud model.

The Virtual Classroom is an interactive session which is carried out using Hangout and YouTube. The virtual classroom is carried out using other software utilities such as that used in the collaborative teamwork e-meeting service. The virtual classroom screen looks different for the students, instructors and assistants or administrators. Each of them has certain options and specific permissions as will be shown in the next figure.

A. Virtual Classroom for Instructor

When the instructor enters to the virtual classroom, the name of this instructor will appear on the participant's pane and he/she can follow up the sequence of students' questions through the property of Q&A in the Hangout session. The screen of the Virtual Classroom for the instructor consists of some panes and options as shown in Figure 5.20.

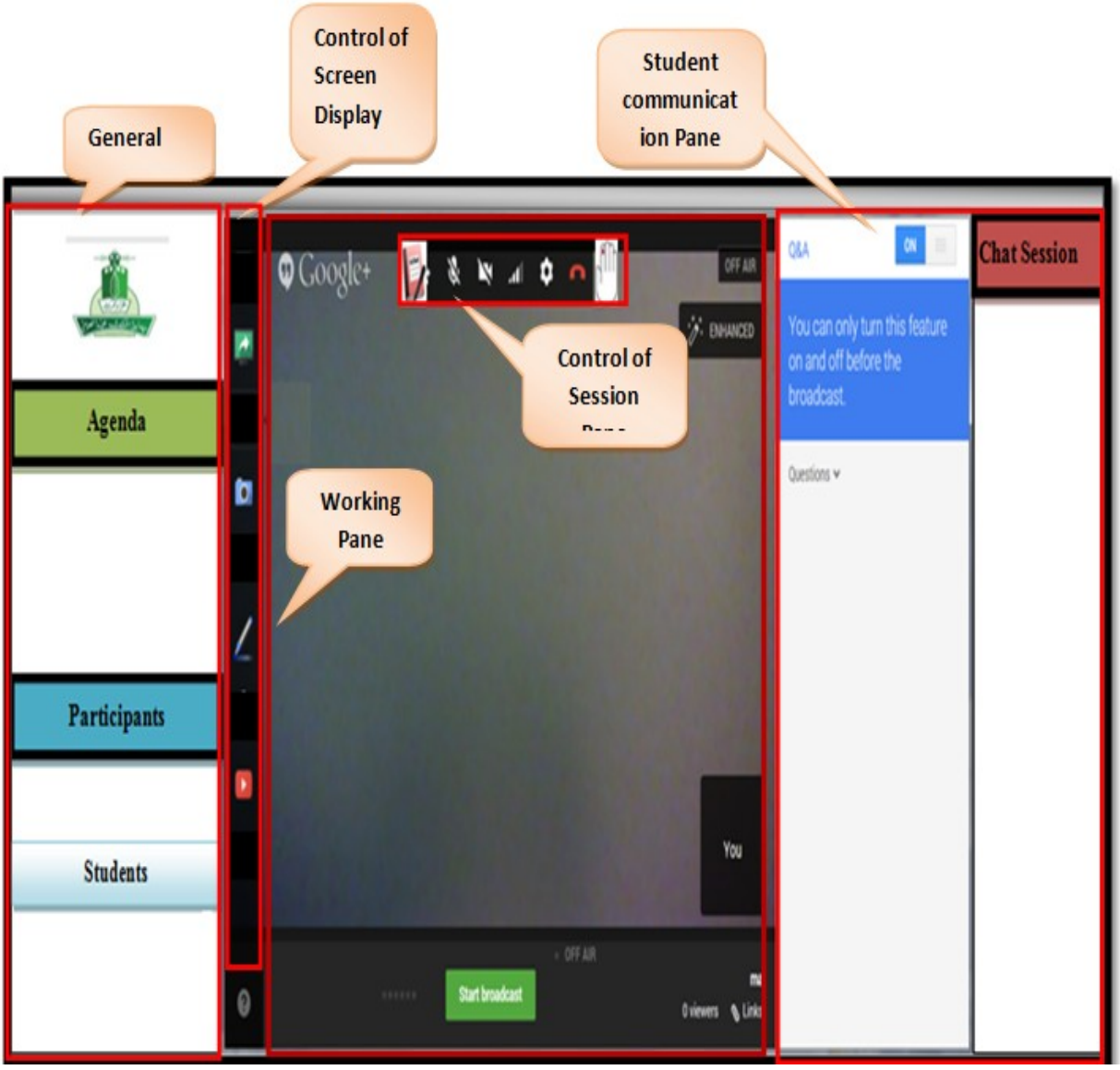


Figure 5.20. Virtual Classroom Interface for Instructor Developed on Top of Google's Hangout

B. Virtual Classroom for Student

When student enters to the virtual classroom, the name of this student will be appear on the student's pane. Students in virtual classroom can ask the instructor in sequence and through the property of Q&A in the Hangout session as shown in Figure 5.21.

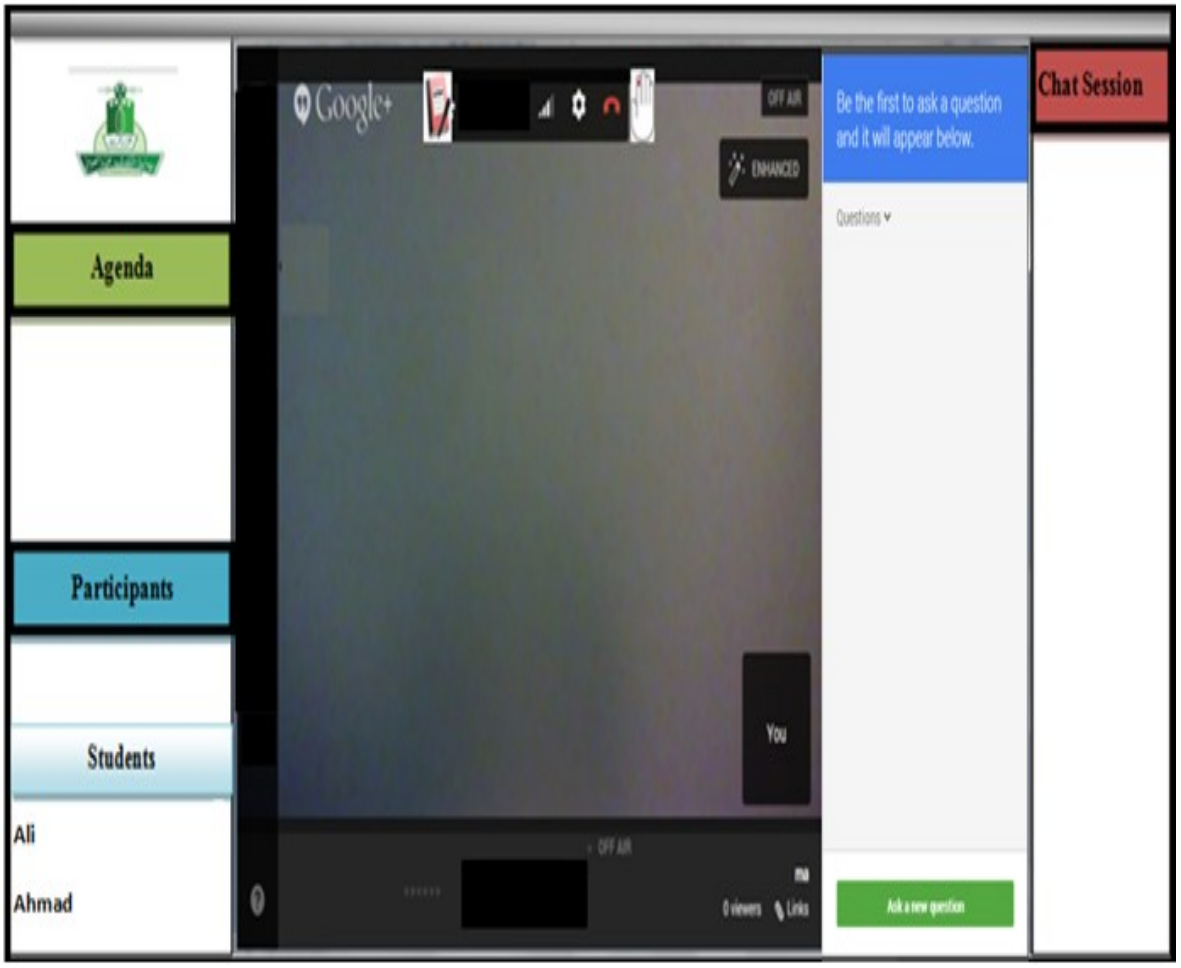


Figure 5.21. Virtual Classroom Interface for Students Developed on Top of Google's Hangout

C. Virtual Classroom for Assistants and Administrators

Assistants and administrator can enter to the virtual classroom as collaborators, and their names will not appear the participant's pane.They will be hiden during the session of the Virtual Classroom by using the property of "control of attendance" so they are can't be seen in the session recording as shown in Figure 5.22.

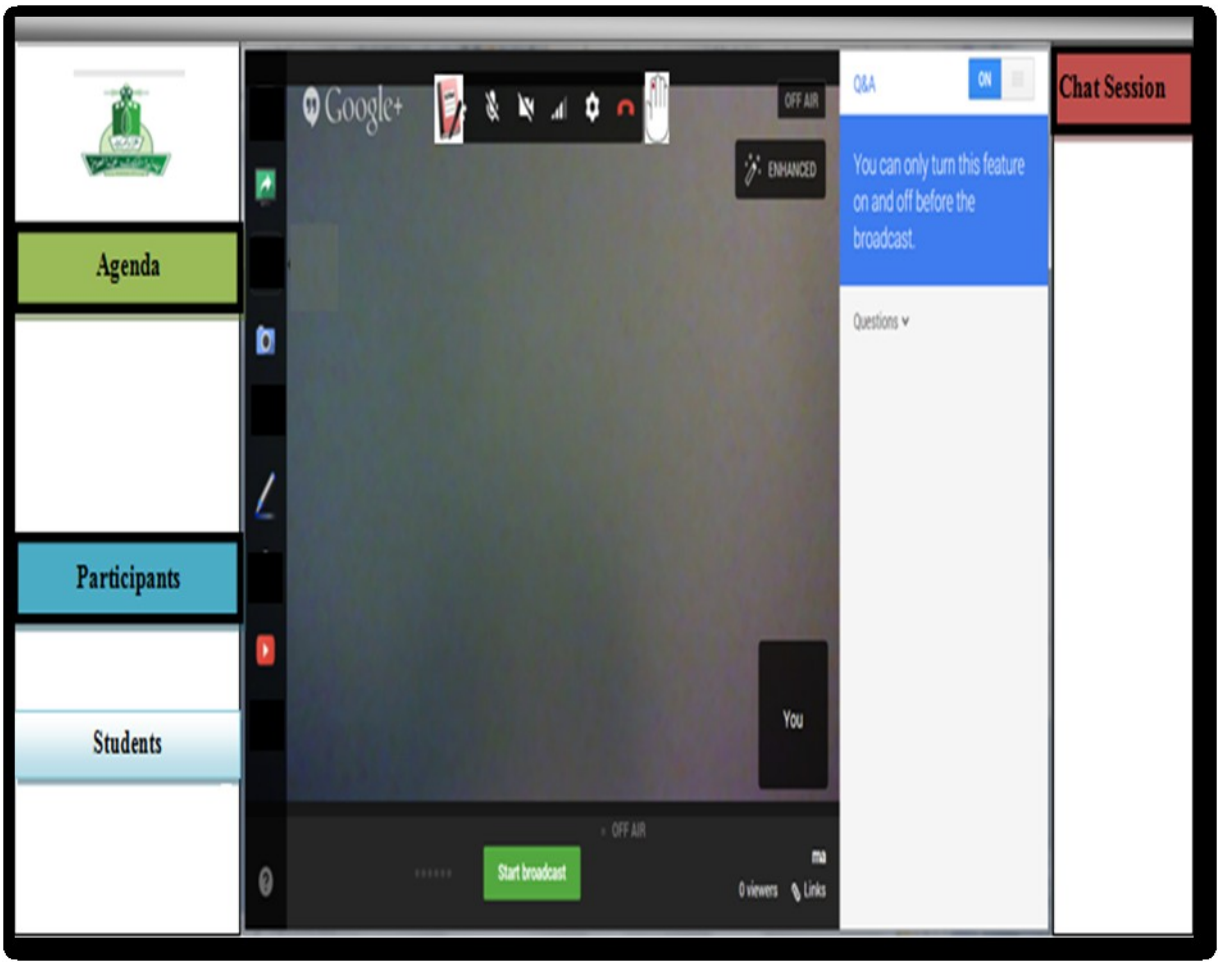


Figure 5.22. Virtual Classroom Interface for Assistants and Administrators Developed on top of Google's Hangout

- **The Operational Model of FaaS—The Virtual Classroom Service in e-Learning**

Figure 5.23 depicts how this operational model works with the Virtual Classroom service and Hangout. In this operational model, the user interacts with the interface that is created by the CSP. This interface implements the specialized scenario of Virtual Classroom service and then requests the actual service from the engine of the Hangout service in a proper way; it then provides the responses and feedback to the user in a proper format. Accordingly, the user will deal with the Virtual Classroom service interface formally and externally, and with general Hangout session service functionally and internally.

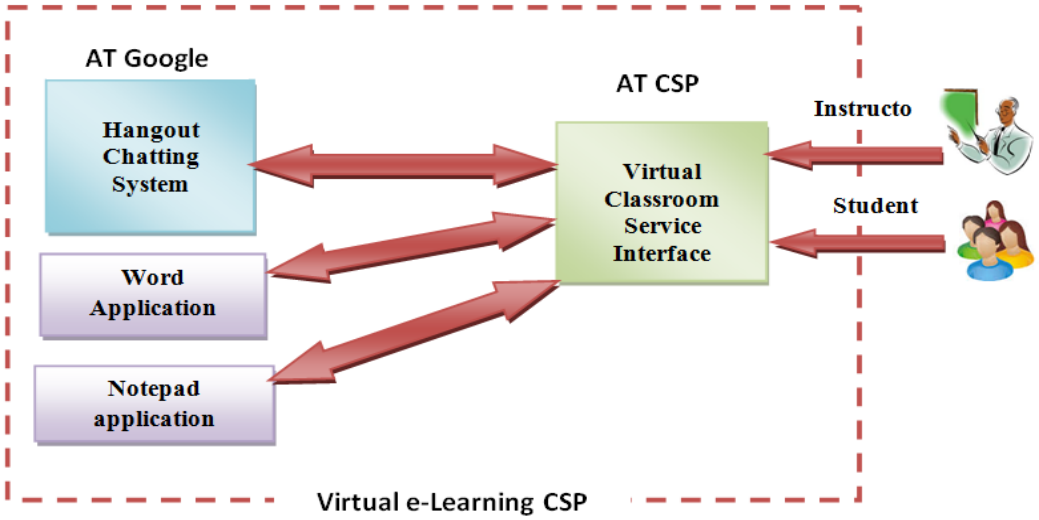


Figure 5.23. The Operational Model of FaaS—The Virtual Classroom Service in e-Learning

Table 5.2 The e-Learning Services Features and the Corresponding Features on Free Internet Services as Used in the Experimental Implementation of the Prototypes

Features of e-Learning Services	Features of Free Internet Services
Office Hours' One-On-One Meeting	
Office Hour Session (On-line Chat). *Video Chat*	Hangout. *Video Chat*
Office Hour Session (On-line Chat).*Txt Chat*	Hangout. *Inside Text Chat*
Office Hour Session (On-line Chat). *Whiteboard*	Hangout. *Whiteboard*
Office Hour Session (On-line Chat). *Notebook*	Notepad. *Popup window* Word. *Popup window*
Office Hour Session (On-line Chat). *Step Out*	Programming
Office Hour Session (On-line Chat). *Start Recording*	Hangout. *Start Broadcast*
Office Hour Session (On-line Chat). *Stop Recording*	Hangout. *End Broadcast*
Office Hour Session (On-line Chat). *Playback*	You tube. *Playback* Google+ Page. *Hangout-onair Post*
Office Hour Session (On-line Chat). *Exit*	Hangout. *Exit*
Collaborative e-Teamwork	

Features of e-Learning Services	Features of Free Internet Services
Collaborative e-Meeting. *Vide Chat*	Hangout. *Video Chat*
Collaborative e-Meeting. *Txt Chat*	Hangout. *Outside Txt Chat*
Collaborative e-Meeting. *Whiteboard*	Hangout. *Whiteboard*
Collaborative e-Meeting. *Notebook*	Notepad. *Popup window* Word. *Popup window*
Collaborative e-Meeting. *Agenda*	Notepad. *Editor* Word. *Editor* Google Drive. *Create Document*
Collaborative e-Meeting. *Minutes of Meeting*	Notepad. *Editor* Word. *Editor*
Collaborative e-Meeting. *Participants*	Programming
Collaborative e-Meeting. *Desktop Screen Share*	Hangout. *Desktop Screen Share*
Collaborative e-Meeting. *Capture*	Hangout. *Capture*
Collaborative e-Meeting. *Video Play*	Hangout .*YouTube*
Collaborative e-Meeting. *Control of attendance*	Hangout.*Control of attendance*
Collaborative e-Meeting. *Remote Access*	Hangout.*Remote Access*
Collaborative e-Meeting. *Step Out*	Programming
Collaborative e-Meeting. *Start Recording*	Hangout. *Start Broadcast*
Collaborative e-Meeting. *Stop Recording*	Hangout. *End Broadcast*
Collaborative e-Meeting. *Playback*	You tube. *Playback* Google+ Page. *Hangoutonair Post*
Collaborative e-Meeting. *Exit*	Hangout. *Exit*
Virtual Classroom	
Virtual Class Room. *Vide Chat*	Hangout .*Vide Chat*
Virtual Class Room.*Txt Chat*	Hangout. *Outside Txt Chat*
Virtual Class Room. *Whiteboard*	Hangout .*Whiteboard*
Virtual Class Room. *Notebook*	Notepad. *Popup window* Word. *Popup window*
Virtual Class Room. *Agenda*	Notepad. *Editor* Word. *Editor* Google Drive. *Create Document*
Virtual Classroom. *Participants*	Programming

Features of e-Learning Services	Features of Free Internet Services
Virtual Class Room. *Desktop Screen Share*	Hangout. *Desktop Screen Share*
Virtual Class Room. *Capture*	Hangout .*Capture*
Virtual Class Room. *Video Play*	Hangout .*YouTube*
Virtual Class Room. *Control of attendance*	Hangout. *Control of attendance*
Virtual Class Room. *Remote Access*	Hangout. *Remote Access*
Virtual Class Room. *Step Out*	Programming
Virtual Class Room. *Q&A*	Hangout. .*Q&A*
Virtual Class Room. *Start Recording*	Hangout. *Start Broadcast*
Virtual Class Room. *Stop Recording*	Hangout. *End Broadcast*
Virtual Class Room. *Playback*	You tube. *Playback* Google+ Page. *Hangoutonair Post*
Virtual Class Room. *Exit*	Hangout. *Exit*

Chapter Six

SCCeLE and FaaS Prototype Implementation

Chapter Six

SCCeLE and FaaS Prototype Implementation

This chapter discus in details the implementation of two prototypes; SCCeLE rule-based expert system and FaaS approach. It also shows how these prototypes are implemented.

6.1. Implementation of SCCeLE Prototype

Implantation of the SCCeLE prototype consists of two stages. The first stage is to build SCCeLE prototype, and the second stage is to apply SCCeLE prototype on the default values to provide cloud mix model recommendations to e-Learning organizations and CSPs.

6.1.1. Building the SCCeLE Prototype (Excel model)

SCCeLE expert system prototype is built by designing and programming the two phases of SCCeLE using Microsoft Excel© and the visual .NET© development environment. It passes through the following steps and it is a simple prototype to apply the ideas we suggest.

6.1.1.1. Survey and Data Collection

Data that assisted in the construction and using of the SCCeLE system is collected from the Survey that was conducted to understand the nature of the e-Learning environment in the market. This survey identified many aspects of the model and it has underwent three stages as follows:

- ***Interviews***

  Many educational organizations of different types were visited and interviews were arranged and held with them. That helped us to identify and understand the types and sizes of the available e-Learning organizations in the market today, and also to identify the important and required e-Learning services for those organizations.

- ***Literature Review***

  This research reviews different publications in some of the leading digital libraries. Some that have been visited include: IEEE Xplore, SpringerLink and Science Direct. Most of the reviewed publications are published between 2009 and 2013. This is because it help us in achieving the aim of this Survey. Based on all these studies, we can revise the impotnat and popular e-learning services that are used in the e-Learning enviroment including the ones that have been identified previously from interviews. We were able to identify the basic effective criteria of e-Learning services that are important in determining each type of cloud model . Then we got the most important guidelines that determine the suitable type of hosting platforn accoding to the criteria type. Also, we explored all the environmental circumstances that influence the selection of the appropriate hosting platform.

- ***The Questionnaire***

  The data sample that we have adopted in this study was obtained from the questionnaires which were conducted on several groups; a number of departments, colleges and the experienced e-Learning faculty members at King Abdul-Aziz University (KAU), and also on many international institutes, international school, electronic universities and companies. This questionnaire aims to study the relationship between e-Learning organizations and e-Learning services through identifying the e-Learning organizations' needs and expected QoS for different e-Learning services, also it aims to recognize the opinions of majority people in determining the value of the criteria for each e-learning service .

6.1.1.2. Designing the Rules

Based on study of the criteria of e-learning services, the guidelines and environmental circumstances, the rules of the two inferencing phases of SCCeLE rule-based expert system are designed and built using the Macro programming facility of Microsoft Excel© and visual .NET© . The first inferencing phase has 13 rules and the second inferencing phase is implemented using 252 rules.

6.1.2. Applying SCCeLE Prototype on the Default Values

After building the SCCeLE system, we applied it on the values that were obtained from the questionnaire and they became as the default values of the parameters for this system, as shown in Figure 6.1. This prototype also allows users to change these values and enter the appropriate values to them.

Services /Organization Types	QoS. Performance	Commonly Available S.W	Fully virtual university		
Orgnization Size			Large	Medium	Small
Default Budget			High	High	Medium
Closed Mailing list	Medium	No	Essential/High quality	Essential/High quality	Essential/High quality
Office Hour Management	Low	Yes	Essential/High quality	Essential/High quality	Optional/Moderate quality
Office hour session (On-line Chat Room)	High	Yes	Essential/High quality	Essential/High quality	Optional/Moderate quality
Discussion group (Forum)	Medium	Yes	Essential/High quality	Essential/High quality	Optional/Moderate quality
Collaborative Team work / E-Meeting	High	Yes	Essential/High quality	Essential/High quality	Optional/Moderate quality
Course Development /Course Authoring	Medium	No	Essential/High quality	Essential/High quality	Optional/Moderate quality
Lecture-on-Demand(delivery)	Medium	Yes	Essential/High quality	Essential/High quality	Optional/Moderate quality
Virtual Class Room	High	Yes	Essential/High quality	Essential/High quality	Essential/High quality
Virtual lecture Playback & Recording	High	Yes	Essential/High quality	Essential/High quality	Essential/High quality
Assignments	Medium	Yes	Essential/High quality	Essential/High quality	Essential/High quality
Student Assessment and Exams	Medium	No	Essential/High quality	Essential/High quality	Essential/High quality
Quiz	Medium	No	Essential/High quality	Essential/High quality	Optional/Moderate quality
Self Testing	Medium	No	Essential/High quality	Essential/High quality	Optional/Moderate quality
Learning Process Analysis	Medium	No	Essential/High quality	Optional/Moderate quality	Optional/Moderate quality
Virtual library	Medium	Yes	Essential/High quality	Essential/High quality	Optional/Moderate quality
Personal Student Notebook Tool with Annotation Facility	Medium	No	Essential/High quality	Essential/High quality	Optional/Moderate quality

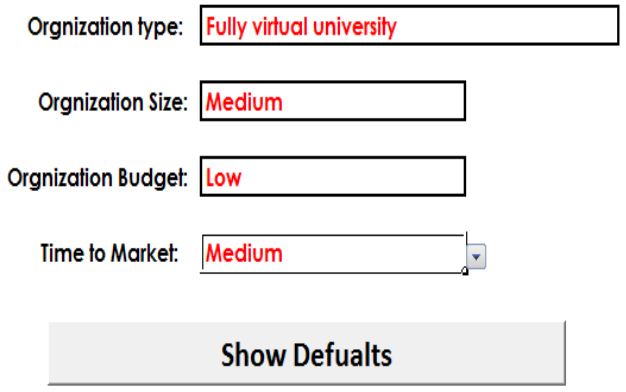
QoS. Features					
Partial virtual university			Fully virtual training institute		
Large	Medium	Small	Large	Medium	Small
Medium	Medium	Low	High	Medium	Medium
Essential/High quality	Essential/Moderate quality	Optional/Moderate quality	Essential/High quality	Essential/Moderate quality	Essential/Moderate quality
Optional/Moderate quality	Not Needed	Not Needed	Essential/High quality	Optional/Moderate quality	Optional/Moderate quality
Optional/Moderate quality	Optional/Moderate quality	Not Needed	Essential/High quality	Optional/Moderate quality	Optional/Moderate quality
Optional/Moderate quality	Optional/Moderate quality	Optional/Moderate quality	Essential/High quality	Optional/Moderate quality	Optional/Moderate quality
Optional/Moderate quality	Optional/Moderate quality	Not Needed	Essential/High quality	Essential/Moderate quality	Optional/Moderate quality
Optional/Moderate quality	Optional/Moderate quality	Not Needed	Optional/Moderate quality	Optional/Moderate quality	Not Needed
Optional/Moderate quality	Optional/Moderate quality	Not Needed	Essential/High quality	Essential/Moderate quality	Optional/Moderate quality
Optional/Moderate quality	Optional/Moderate quality	Not Needed	Essential/High quality	Essential/High quality	Essential/High quality
Optional/Moderate quality	Optional/Moderate quality	Not Needed	Essential/High quality	Essential/High quality	Essential/High quality
Optional/Moderate quality	Optional/Moderate quality	Not Needed	Essential/High quality	Optional/Moderate quality	Optional/Moderate quality
Optional/Moderate quality	Not Needed	Not Needed	Essential/High quality	Optional/Moderate quality	Not Needed
Essential/Moderate quality	Optional/Moderate quality	Optional/Moderate quality	Essential/High quality	Optional/Moderate quality	Optional/Moderate quality
Essential/High quality	Optional/Moderate quality	Optional/Moderate quality	Essential/High quality	Essential/Moderate quality	Optional/Moderate quality
Optional/Moderate quality	Optional/Moderate quality	Not Needed	Essential/High quality	Optional/Moderate quality	Optional/Moderate quality
Essential/High quality	Optional/Moderate quality	Optional/Moderate quality	Essential/High quality	Optional/Moderate quality	Optional/Moderate quality
Optional/Moderate quality	Optional/Moderate quality	Not Needed	Essential/High quality	Essential/Moderate quality	Optional/Moderate quality

Partial virtual training institute			Self Training Company		
Large	Medium	Small	Large	Medium	Small
Medium	Low	Low	Medium	Low	Low
Optional/Moderate quality	Optional/Moderate quality	Not Needed	Optional/Moderate quality	Not Needed	Not Needed
Not Needed	Not Needed	Not Needed	Optional/Moderate quality	Not Needed	Not Needed
Optional/Moderate quality	Not Needed	Not Needed	Optional/Moderate quality	Not Needed	Not Needed
Optional/Moderate quality	Optional/Moderate quality	Not Needed	Optional/Moderate quality	Not Needed	Not Needed
Optional/Moderate quality	Not Needed	Not Needed	Optional/Moderate quality	Not Needed	Not Needed
Optional/Moderate quality	Not Needed	Not Needed	Not Needed	Not Needed	Not Needed
Optional/Moderate quality	Not Needed	Not Needed	Essential/High quality	Essential/High quality	Optional/Moderate quality
Optional/Moderate quality	Not Needed	Not Needed	Essential/High quality	Optional/Moderate quality	Optional/Moderate quality
Optional/Moderate quality	Not Needed	Not Needed	Essential/High quality	Optional/Moderate quality	Optional/Moderate quality
Optional/Moderate quality	Not Needed	Not Needed	Optional/Moderate quality	Not Needed	Not Needed
Not Needed	Not Needed	Not Needed	Optional/Moderate quality	Not Needed	Not Needed
Optional/Moderate quality	Not Needed	Not Needed	Optional/Moderate quality	Optional/Moderate quality	Not Needed
Optional/Moderate quality	Optional/Moderate quality	Not Needed	Optional/Moderate quality	Not Needed	Not Needed
Optional/Moderate quality	Not Needed	Not Needed	Not Needed	Not Needed	Not Needed
Optional/Moderate quality	Optional/Moderate quality	Not Needed	Optional/Moderate quality	Not Needed	Not Needed
Optional/Moderate quality	Not Needed	Not Needed	Optional/Moderate quality	Not Needed	Not Needed

Figure 6.1. Inserting All Values (That are Obtained from the Questionnaire) into the SCCeLE Prototype and Setting them as Default Values

Snapshots of the program used to reveal the cloud mix model:

First screen (Figure 6.2) in the program is used to set the pragmatic parameters of the second phase of system that considers the busniess aspects of the organization. The user is asked to select the (type, size, Budget and time to market) of the organization from the dropdown lists. Consequently, the expert system will show the defulat values of (level of needs, QoS, and whether the commnly available Sofware that supports this service exists or not) for each service. Also, users can change these values from several options specified in this system.



Services /Organization Types	Commonly Available S.W	Fully virtual university
		Medium
Closed Mailing list	No	Essential/High quality
Office Hour Management	Yes	Essential/High quality
Office hour session (On-line Chat Room)	Yes	Essential/High quality
Discussion group (Forum)	Yes	Essential/High quality
Collaborative Team work / E-Meeting	Yes	Essential/High quality
Course Development /Course Authoring	No	Essential/High quality
Lecture-on-Demand(delivery)	Yes	Essential/High quality
Virtual Class Room	Yes	Essential/High quality
Virtual lecture Playback & Recording	Yes	Essential/High quality
Assignments	Yes	Essential/High quality
Student Assessment and Exams	No	Essential/High quality
Quiz	No	Essential/High quality
Self Testing	No	Essential/High quality
Learning Process Analysis	No	Optional/Moderate quality
Virtual library	Yes	Essential/High quality
Personal Student Notebook Tool with Annotation Facility	No	Essential/High quality

Save and Go Next

Figure 6.2. Setting the Parameters of SCCeLE's Second Phase

The second screen (Figure 6.3) is used to set the technical parameters and crateria for each e-learning service during the first phase of system that considers the technical aspects of the e-Learning services. These values are H (high), M (meduim) and L (low). Accordinally, the system will show the inatial recommendation and the final recommendation for each service based on the technical and busniess aspects.

Criteria/Services Type	QoS	Service type	Data needs		Performance			Others			Recommended Model	Final Recommendation
Service Name		Real time/On-line	Required database	Sensitive data	Speed/ Response time	Accessibility/ Availability	Reliability	Dynamic Scalability	Processing power	Spiky Demand (Short term need)		
Closed Mailing List	High	No	Medium	N/A	Medium	High	High	Low	N/A	N/A	IaaS	FaaS
Office Hour Management	High	No	N/A	N/A	Medium	Medium	Medium	Low	N/A	N/A	IaaS	SaaS
Office hour session (On-line Chat Room)	High	Yes	N/A	N/A	High	High	High	Low	N/A	N/A	IaaS	SaaS
Discussion group (Forum)	High	No	Medium	N/A	Medium	Medium	Medium	Low	N/A	N/A	IaaS	SaaS
Collaborative Team work / E-Meeting	High	Yes	N/A	N/A	High	High	High	Low	N/A	N/A	IaaS	SaaS
Course Development /Course Authoring	High	No	High	N/A	High	High	High	Low	N/A	N/A	On-Premise	FaaS
Lecture-on demand	High	Yes	High	N/A	High	High	High	Low	High	N/A	On-Premise	SaaS
Virtual Class Room	High	Yes	N/A	N/A	High	High	High	Low	N/A	N/A	IaaS	SaaS
Virtual Lecture Recording & Replaying	High	Yes	Low	N/A	High	High	High	Low	N/A	High	IaaS	SaaS
Assignment	High	No	Medium	N/A	Medium	Medium	Medium	N/A	Medium	Low	IaaS	SaaS
Exams/ Student assessment	High	Yes	Medium	High	High	High	High	Low	N/A	High	On-Premise	FaaS
Quiz	High	Yes	Medium	Medium	High	Medium	Medium	Low	N/A	Low	IaaS	FaaS
Self testing	High	Yes	Low	N/A	Medium	Medium	Medium	High	N/A	Medium	IaaS	FaaS
Learning process Analysis	Moderate	No	High	High	N/A	Low	N/A	N/A	High	N/A	On-Premise	FaaS
Virtual library	High	No	High	N/A	High	High	High	N/A	N/A	N/A	On-Premise	SaaS
Personal Student Notebook with Annotation Facility	High	No	Low	N/A	Medium	Medium	Medium	Low	N/A	High	IaaS	FaaS

Recommend

Figure 6.3. Setting the Technical Parameters of the SCCeLE's during the First Phase and Revealing the Initial Recommendation and the Final Recommendation for Each e-Learning Service

The third screen (Figure 6.4) displays the explanation module of SCCeLE reports (Discrepancy Report) the gain/loss in performance as well as precautions to consider when contracting with the CSP.

Criteria/Services Type		Data needs		Performance			Others		
Service Name	Recommendation	Required database	Sensitive data	Speed/ Response time	Accessibility/ Availability	Reliability	Dynamic Scalability	Processing power	Spiky Demand (Short term need)
Closed Mailing List	IaaS	Medium	N/A	Medium	High	High	Low	N/A	N/A
	FaaS	Low	Low	Low	Low	Low	Low	Low	Low
Office Hour Management	IaaS	N/A	N/A	Medium	Medium	Medium	Low	N/A	N/A
	SaaS	Low	Low	Low	Low	Low	Low	Low	Low
Office hour session (On-line Chat Room)	IaaS	N/A	N/A	High	High	High	Low	N/A	N/A
	SaaS	Low	Low	Low	Low	Low	Low	Low	Low
Discussion group (Forum)	IaaS	Medium	N/A	Medium	Medium	Medium	Low	N/A	N/A
	SaaS	Low	Low	Low	Low	Low	Low	Low	Low
Collaborative Team work / E-Meeting	IaaS	N/A	N/A	High	High	High	Low	N/A	N/A
	SaaS	Low	Low	Low	Low	Low	Low	Low	Low
Course Development /Course Authoring	On-Premise	High	N/A	High	High	High	Low	N/A	N/A
	FaaS	Low	Low	Low	Low	Low	Low	Low	Low
Lecture-on demand	On-Premise	High	N/A	High	High	High	Low	High	N/A
	SaaS	Low	Low	Low	Low	Low	Low	Low	Low
Virtual Class Room	IaaS	N/A	N/A	High	High	High	Low	N/A	N/A
	SaaS	Low	Low	Low	Low	Low	Low	Low	Low
Virtual Lecture Recording & Replaying	IaaS	Low	N/A	High	High	High	Low	N/A	High
	SaaS	Low	Low	Low	Low	Low	Low	Low	Low
Assignment	IaaS	Medium	N/A	Medium	Medium	Medium	N/A	Medium	Low
	SaaS	Low	Low	Low	Low	Low	Low	Low	Low
Exams/ Student assessment	On-Premise	Medium	High	High	High	High	Low	N/A	High
	FaaS	Low	Low	Low	Low	Low	Low	Low	Low
Quiz	IaaS	Medium	Medium	High	Medium	Medium	Low	N/A	Low
	FaaS	Low	Low	Low	Low	Low	Low	Low	Low
Self testing	IaaS	Low	N/A	Medium	Medium	Medium	High	N/A	Medium
	FaaS	Low	Low	Low	Low	Low	Low	Low	Low
Learning process Analysis	On-Premise	High	High	N/A	Low	N/A	N/A	High	N/A
	FaaS	Low	Low	Low	Low	Low	Low	Low	Low
Virtual library	On-Premise	High	N/A	High	High	High	N/A	N/A	N/A
	SaaS	Low	Low	Low	Low	Low	Low	Low	Low
Personal Student Notebook with Annotation Facility	IaaS	Low	N/A	Medium	Medium	Medium	Low	N/A	High
	FaaS	Low	Low	Low	Low	Low	Low	Low	Low

Final Recommendation

Figure 6.4. The Discrepancy Report of SCCeLE

The fourth screen (Figure 6.5) is used to demonstrate the Cloud Configuration Mix recommendation for certain circumstances as generated by the SCCeLE expert system.

Service Name	On-Premise	IaaS	PaaS	SaaS	FaaS
Closed Mailing List					X
Office Hour Management				X	
Office hour session (On-line Chat Room)				X	
Discussion group (Forum)				X	
Collaborative Team work / E-Meeting				X	
Course Development /Course Authoring					X
Lecture-on demand	X				
Virtual Class Room				X	
Virtual Lecture Recording & Replaying				X	
Assignment				X	
Exams/ Student assessment					X
Quiz					X
Self testing					X
Learning process Analysis					X
Virtual library	X				
Personal Student Notebook with Annotation Facility					X

Fig.6.5. The Output Recommendation of SCCeLE (Cloud Mix Model) for a Medium Fully Virtual University (default service criteria is assumed)

The fifth screen (Figure 6.6) is to show a market map with the best cloud mix model for each type of e-Learning services, for all types of organizations. The recommended entries of the map are generated by the SCCeLE based on the default values for all parameters as identified by the survey.

Services /Organization Types	QoS. Features														
	Fully virtual university			Partial virtual university			Fully virtual training institute			Partial virtual training institute			Self Training Company		
Orgnization Size	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small
Closed Mailing list	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	Not Needed	IaaS	Not Needed	Not Needed
Office Hour Management	IaaS	IaaS	SaaS	SaaS	Not Needed	Not Needed	IaaS	SaaS	SaaS	Not Needed	Not Needed	Not Needed	SaaS	Not Needed	Not Needed
Office hour session (On-line Chat Room)	IaaS	IaaS	IaaS	IaaS	IaaS	Not Needed	IaaS	IaaS	IaaS	IaaS	Not Needed	Not Needed	IaaS	Not Needed	Not Needed
Discussion group (Forum)	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	Not Needed	IaaS	Not Needed	Not Needed
Collaborative Team work / E-Meeting	IaaS	IaaS	IaaS	IaaS	IaaS	Not Needed	IaaS	IaaS	IaaS	IaaS	Not Needed	Not Needed	IaaS	Not Needed	Not Needed
Course Development /Course Authoring	On-Premise	On-Premise	On-Premise	On-Premise	On-Premise	Not Needed	On-Premise	On-Premise	Not Needed	On-Premise	Not Needed	Not Needed	Not Needed	Not Needed	Not Needed
Lecture-on-Demand(delivery)	On-Premise	On-Premise	On-Premise	On-Premise	On-Premise	Not Needed	On-Premise	On-Premise	On-Premise	On-Premise	Not Needed	Not Needed	On-Premise	On-Premise	On-Premise
Virtual Class Room	IaaS	IaaS	IaaS	IaaS	IaaS	Not Needed	IaaS	IaaS	IaaS	IaaS	Not Needed	Not Needed	IaaS	IaaS	IaaS
Virtual lecture Playback & Recording	IaaS	IaaS	IaaS	IaaS	IaaS	Not Needed	IaaS	IaaS	IaaS	IaaS	Not Needed	Not Needed	IaaS	IaaS	IaaS
Assignments	IaaS	IaaS	IaaS	IaaS	IaaS	Not Needed	IaaS	IaaS	IaaS	IaaS	Not Needed	Not Needed	IaaS	Not Needed	Not Needed
Student Assessment and Exams	On-Premise	On-Premise	On-Premise	On-Premise	Not Needed	Not Needed	On-Premise	On-Premise	Not Needed	Not Needed	Not Needed	Not Needed	On-Premise	Not Needed	Not Needed
Quiz	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	IaaS	Not Needed	Not Needed	IaaS	IaaS	Not Needed
Self Testing	IaaS	IaaS	SaaS	IaaS	SaaS	SaaS	IaaS	SaaS	SaaS	SaaS	SaaS	Not Needed	SaaS	Not Needed	Not Needed
Learning Process Analysis	On-Premise	On-Premise	On-Premise	On-Premise	On-Premise	Not Needed	On-Premise	On-Premise	On-Premise	On-Premise	Not Needed	Not Needed	Not Needed	Not Needed	Not Needed
Virtual library	On-Premise	On-Premise	On-Premise	On-Premise	On-Premise	On-Premise	On-Premise	On-Premise	On-Premise	On-Premise	On-Premise	Not Needed	On-Premise	Not Needed	Not Needed
Personal Student Notebook Tool with Annotation Facility	IaaS	IaaS	SaaS	SaaS	SaaS	Not Needed	IaaS	SaaS	SaaS	SaaS	Not Needed	Not Needed	SaaS	Not Needed	Not Needed

Calculate

Figure 6.6. A Recommended e-Learning Services Market Map as Generated by the SCCeLE

6.2. Implementation of the FaaS Prototype

A simple prototype has been designed and implemented using Java EE, JSTL, Html, Javascript and Sql database development environment to build the FaaS model and to prove the idea behind the SDW methodology.

The following snapshots of the program demonstrate some e-Learning services that are implemented by the FaaS model.

6.2.1. Smart Cloud LMS Prototype

First screen (Figure 6.7) in the program displays the Homepage of the Smart Cloud LMS that consists of four prototypes which have been designed and implemented to prove the idea behind the SDW methodology.

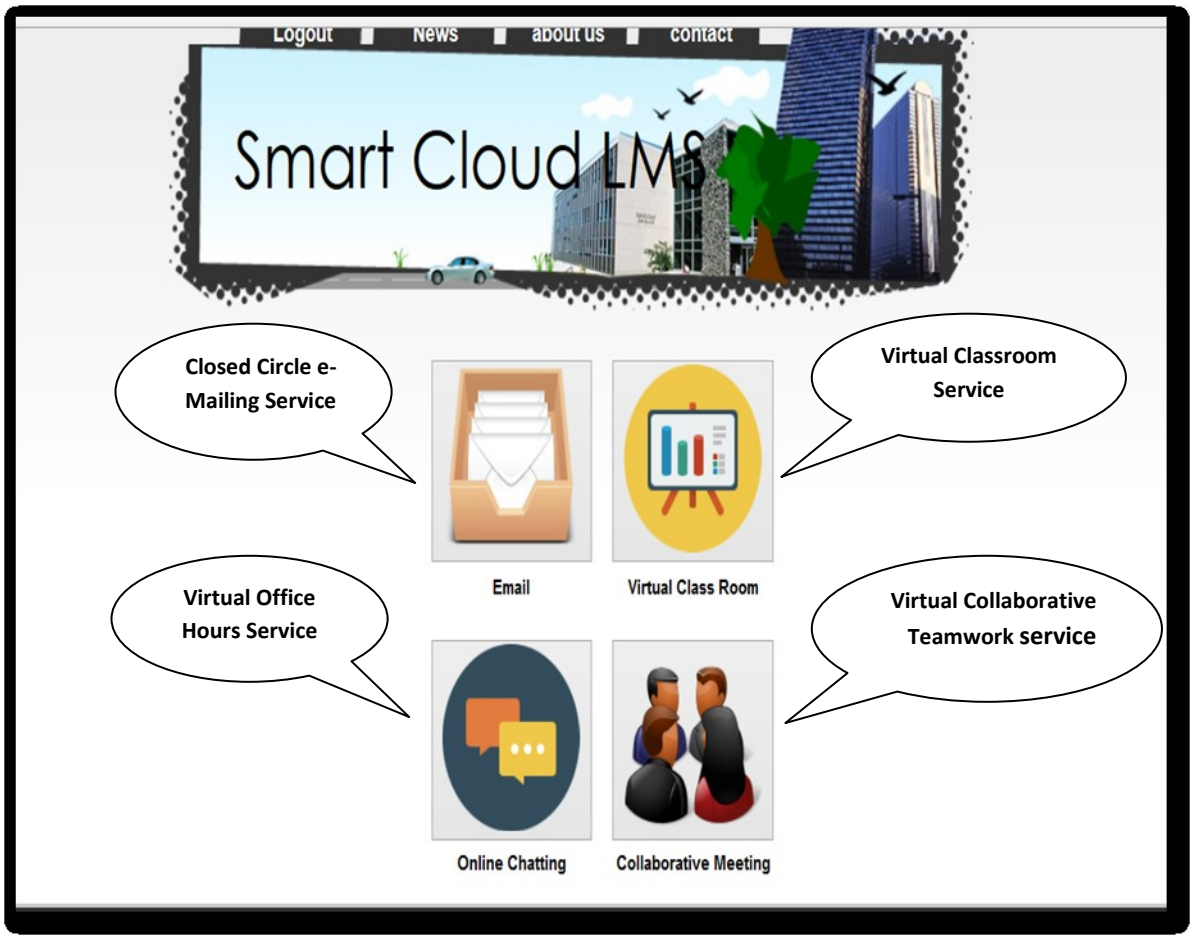


Figure 6.7. Smart Cloud LMS Prototypes Homepage

Second screen (Figure 6.8) displays the homepage of the registeration administrative tasks in the Smart Cloud LMS, where the administrator of the Smart Cloud LMS is responsible for all administrative tasks of the registeration process including; adding courses; adding sections for each course and assigening (instructors, assistants and/or administrators) for each section as shown in Figure 6.9. Finally, the administrator can register students for certain sections of the course.

Figure 6.8. Registration Administrative Tasks Homepage

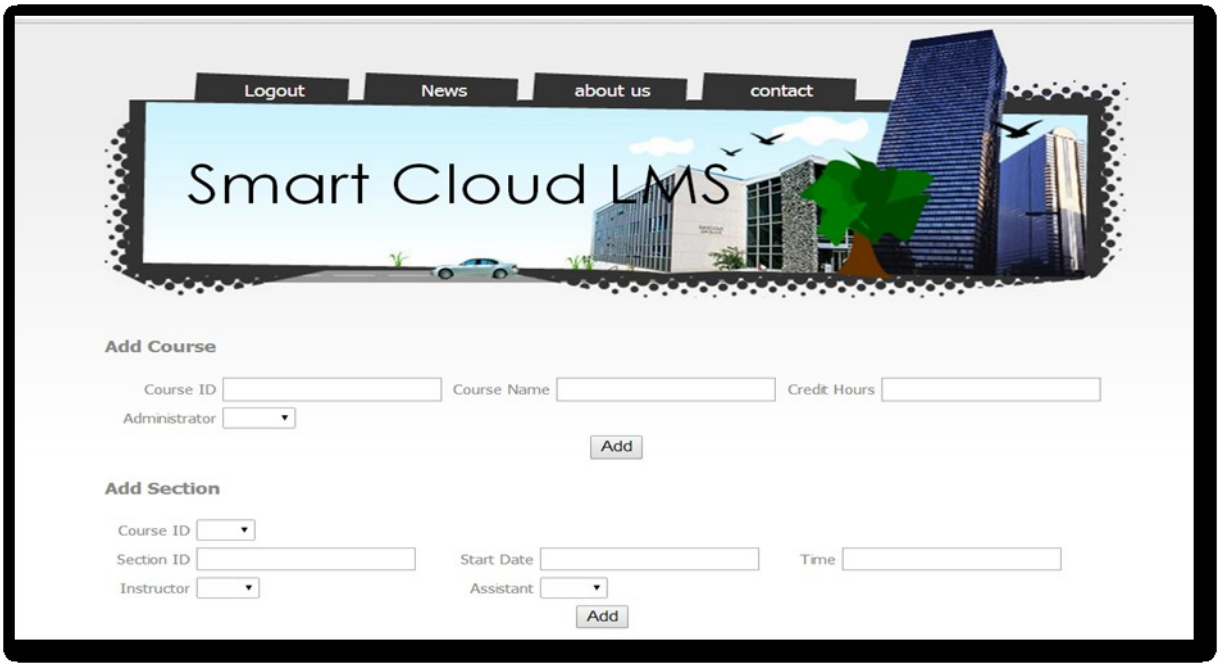


Figure 6.9. Assigning Sections, Instructors and/or Asistants for a Specific Course

6.2.1.1 The Closed Circle e-Mailing Service

The implemented prototype uses a specially designed scenario (Closed Circle eMailing System) on top of the free emailing service of Gmail. Figure 6.10 and Figure 6.11 show those important differences in the scenario between the generic emailing system and the Closed Circle e-Mailing service. The sender has to select the recipients from a closed list of stakeholders (usually colleagues and/or instructor of the same section) without even knowing their email addresses. In fact, none of the involved members knows or needs to know their email addresses. After selecting the recipients from the closed list, the system fetches the email addresses from the proprietary database and prepares to compose the email message as requested by the generic emailing engine that will do the rest of the work. It is worth noting that the student can have as many closed-circle emailing lists as the number of sections he/she has registered in. Accordingly, the different emailing boxes for each of these Closed Circles will contain only those messages from/to the specific closed list of stakeholders.

Figure 6.10. A Closed Circle e-Mailing List to Choose the Recipients From

Figure 6.11. The Selected Recipients are then Passed to the "To" Field of the Gmail Message

6.2.1.2 Virtual Office Hours, Virtual Collaborative Teamwork, and Virtual Classroom

A number of e-Learning services have been prototyped using Google's chatting system "Hangout™", specifically, one-on-one office hours sessions, collaborative teamwork e-Meetings, and the virtual classrooms. Those three e-Learning services have many things in common. The first utility is a One-On-One session; the second has a limited small group size; while the third is a Virtual Classroom that uses many specific utilities. They all require an interactive session, which is simulated through using Hangout and YouTube. The tailored scenarios as prototyped for the e-Learning service of scheduling and managing the interactive sessions of the three types of e-Learning services will be discussed in the folowing sections.

A. Office Hours' One-On-One Chatting Service

- ***Booking a Meeting***

  Figure 6.12: On this screen, a student can request a One-On-One Office Hours Session by booking a meeting .

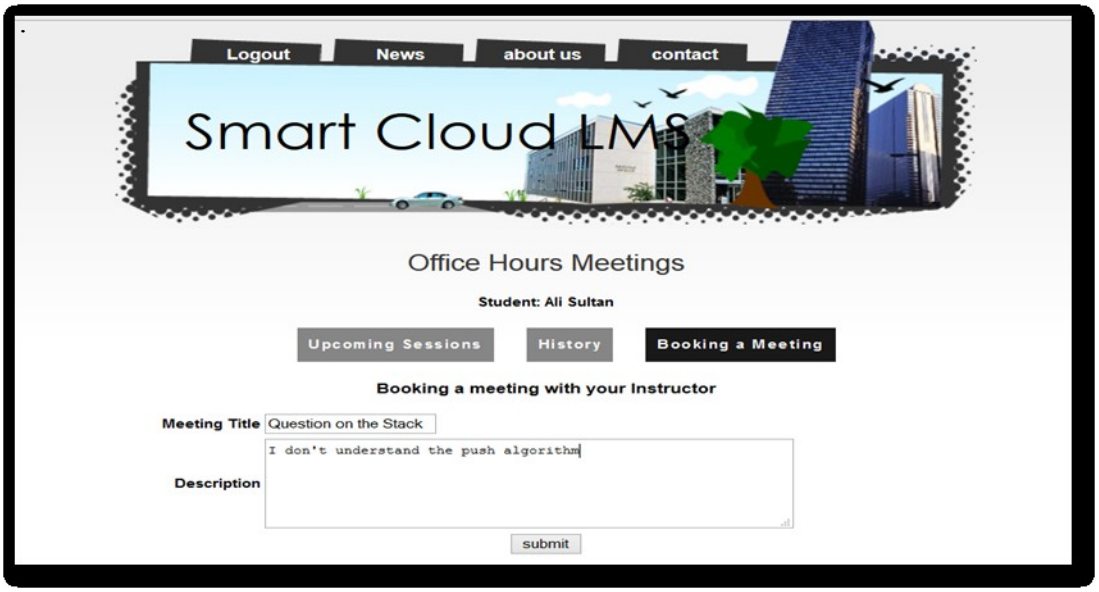


Figure 6.12. Booking a Meeting for Office Hours' One-On-One Chatting by Students

The administrator is responsible for arranging and assigning the new upcoming meetings between the students and the instructor based on the students' requests**.** Figure 6.13 shows the administrator interface for assigning new upcomming meetings.

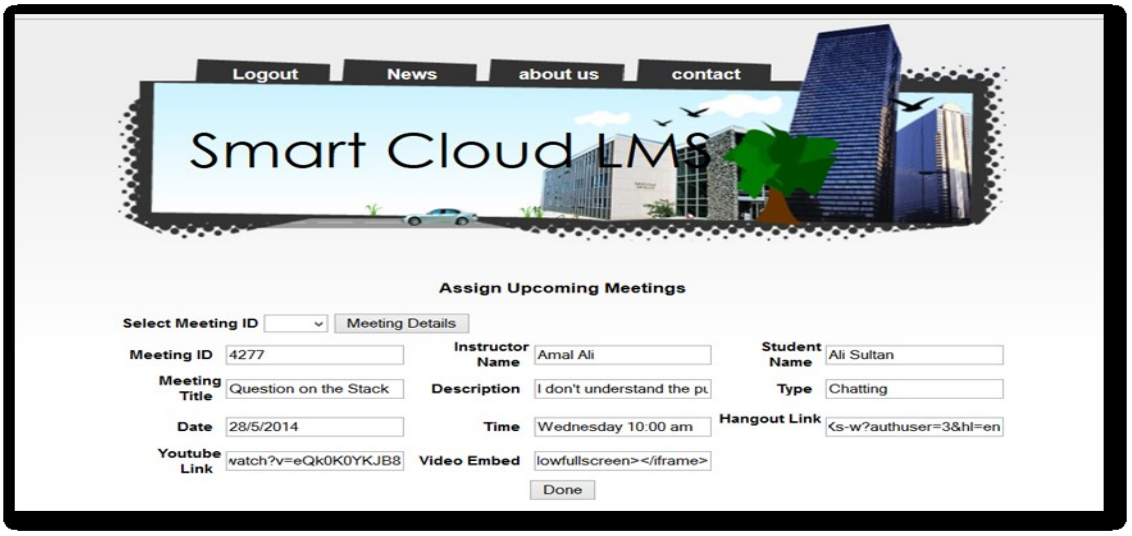
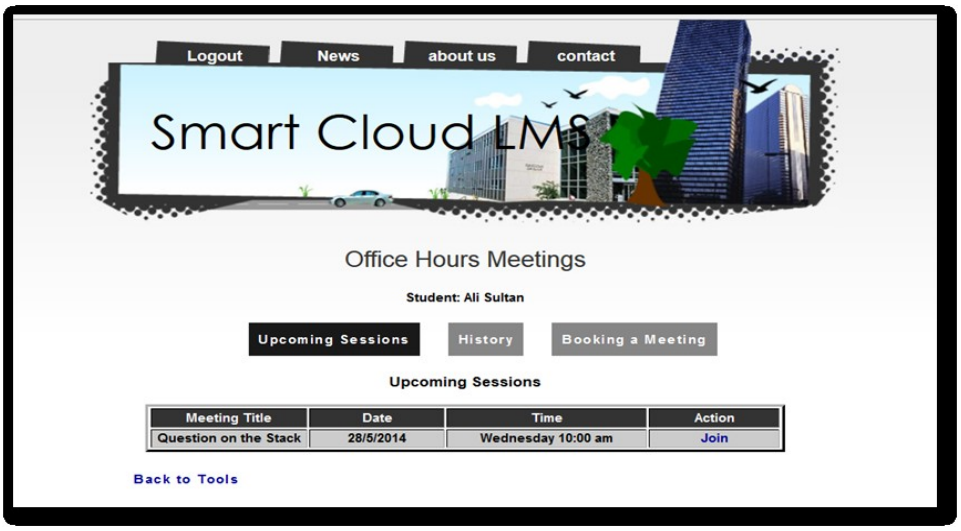


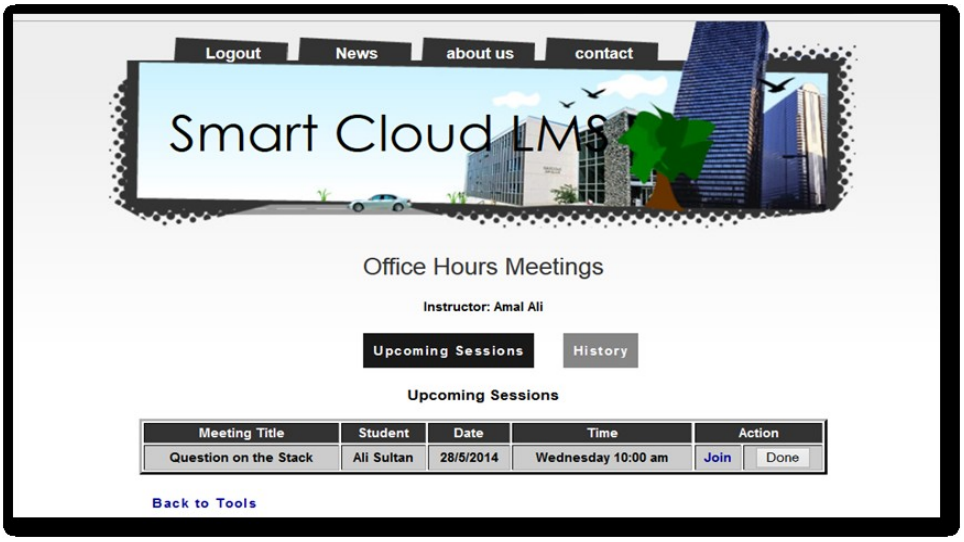
Figure 6.13. Assigning New Upcoming Meetings for Office Hours' One-On-One Chatting by the Administrator

- ***Upcoming Sessions***

The instructor can see all the important information of the new One-On-One Office Hour Sessions under the upcoming sessions list that are requested by the student and specified by the administrator. Both students and instructors can join upcoming Office Hour Sessions. Figure 6.14 shows the user interface for scheduled upcoming sessions.



a) Student Interface



b) Instructor Interface

Figure 6.14. The User Interface for Scheduled Upcoming Office Hour Sessions

Figure 6.15 shows the user interface for new Office Hours' One-On-One Chatting Session developed on top of Google's Hangout after joining the upcoming session.

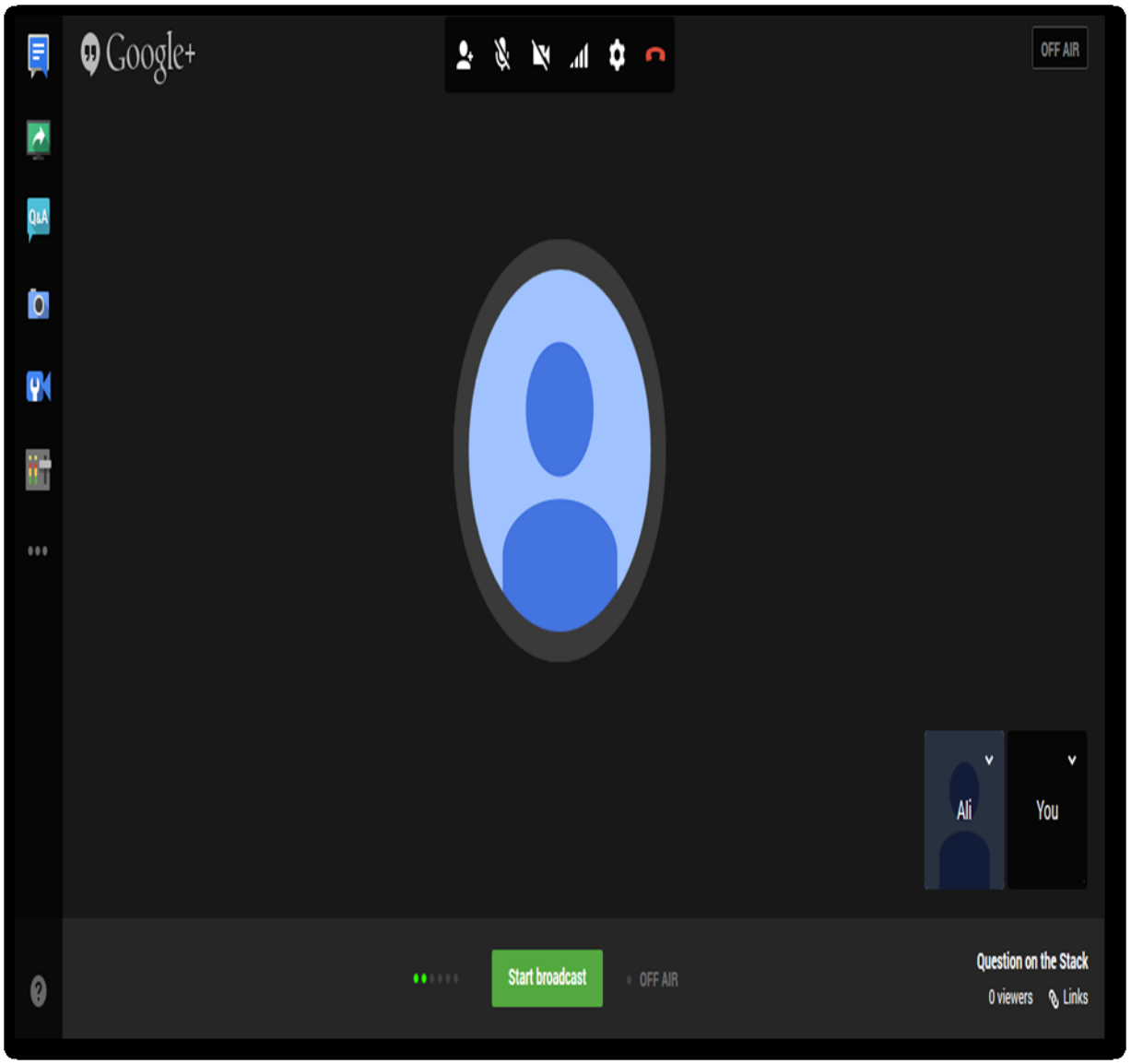
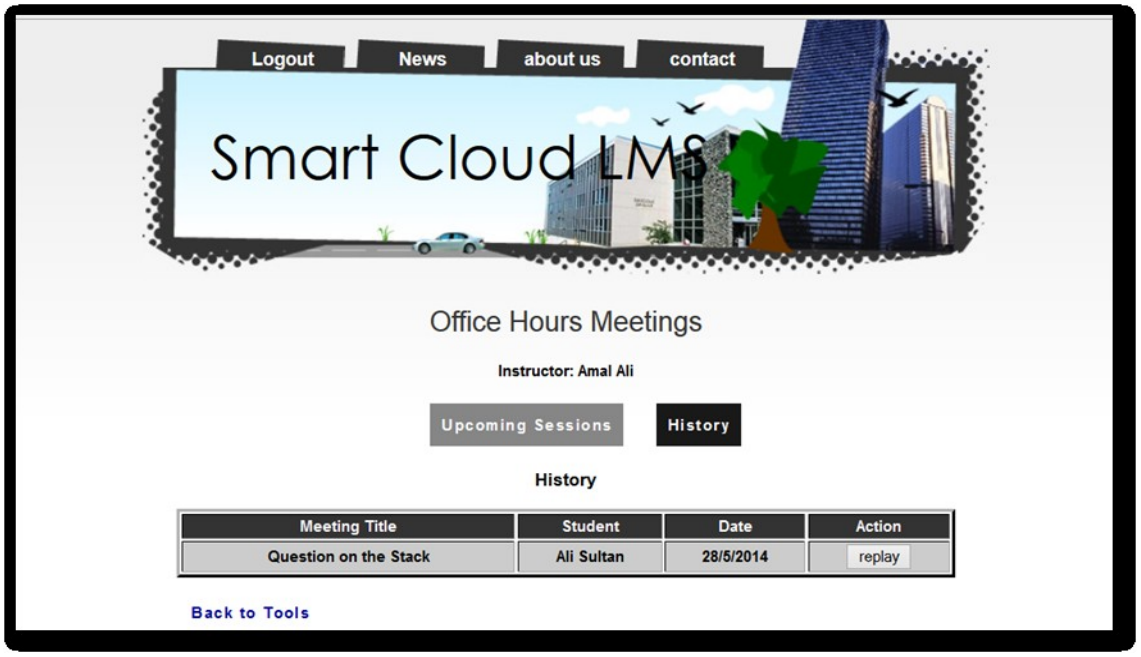


Figure 6.15. The User Interface for New Office Hours' One-On-One Chatting Session Developed on Top of Google's Hangout

- ***The History of Done Sessions***

  Students and instructors can re-play any previous meeting sessions which can be found on the history tab. Figure 6.16 shows the user interface for the history of done sessions with a replay capability.

a) Student Interface



b) Instructor Interface

Figure 6.16. The User Interface for History of Done Office Hour Sessions with a Replay Capability

B. The Collaborative Teamwork e-Meetings

- ***Assign a Collaborative Meeting***

Figure 6.17: On this screen, the instructor can initiate the request and assign new Collaborative Meetings with students.

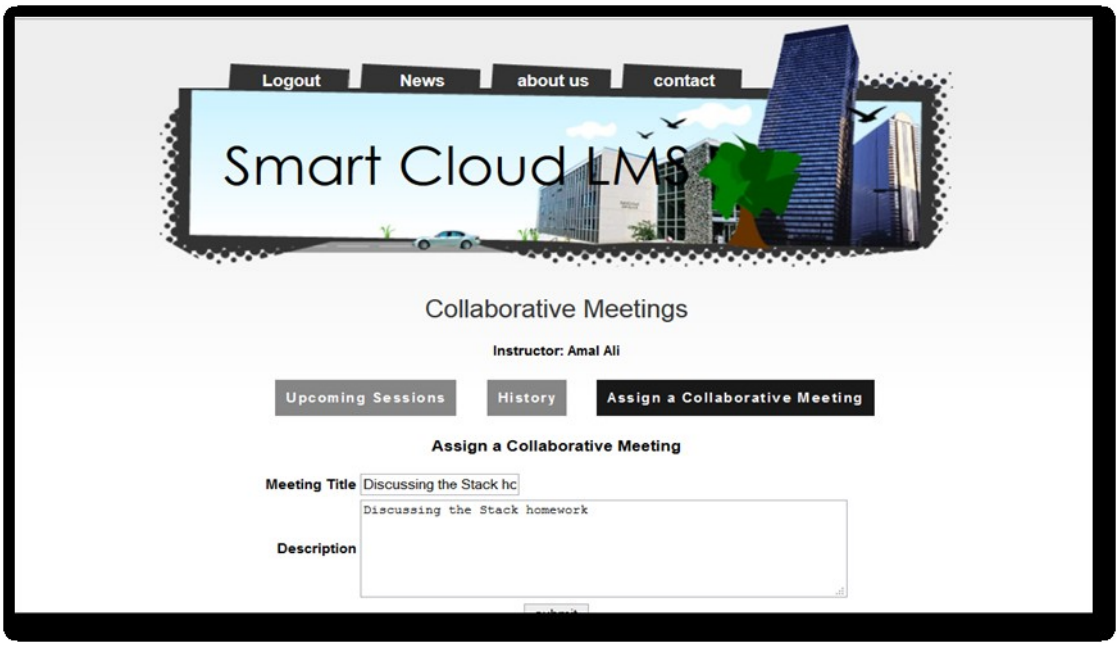


Figure 6.17. Initiating New Collaborative Teamwork e-Meetings by Instructors

Figure 6.18 shows the administrator interface for assigning new upcomming meetings.

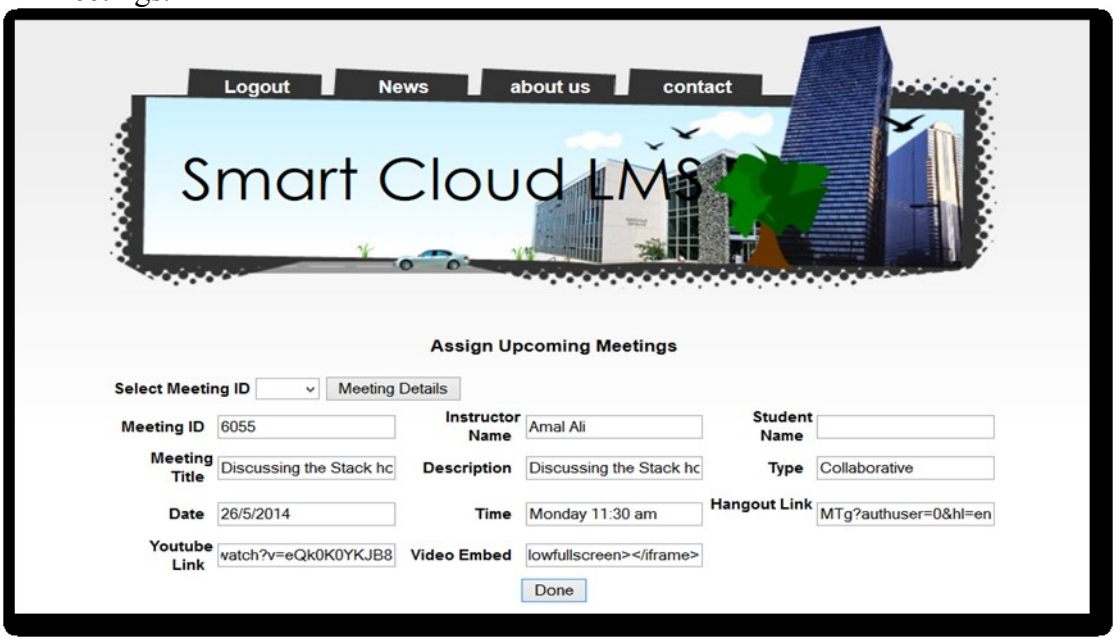


Figure 6.18. Assigning New Upcoming Meetings for Collaborative Teamwork e-Meetings by the Administrator

- ***Upcoming Sessions***

Student and instructors can join all upcoming Collaborative Teamwork e Meetings. Figure 6.19 shows the user interface for scheduled upcoming sessions.

a) Student Interface

b) Instructor Interface

Figure 6.19. The User Interface for Scheduled Upcoming Sessions of Collaborative Teamwork e-Meetings

Figure 6.20 shows the user interface for new Collaborative Teamwork e-Meetings developed on top of Google's Hangout after joining the upcoming session

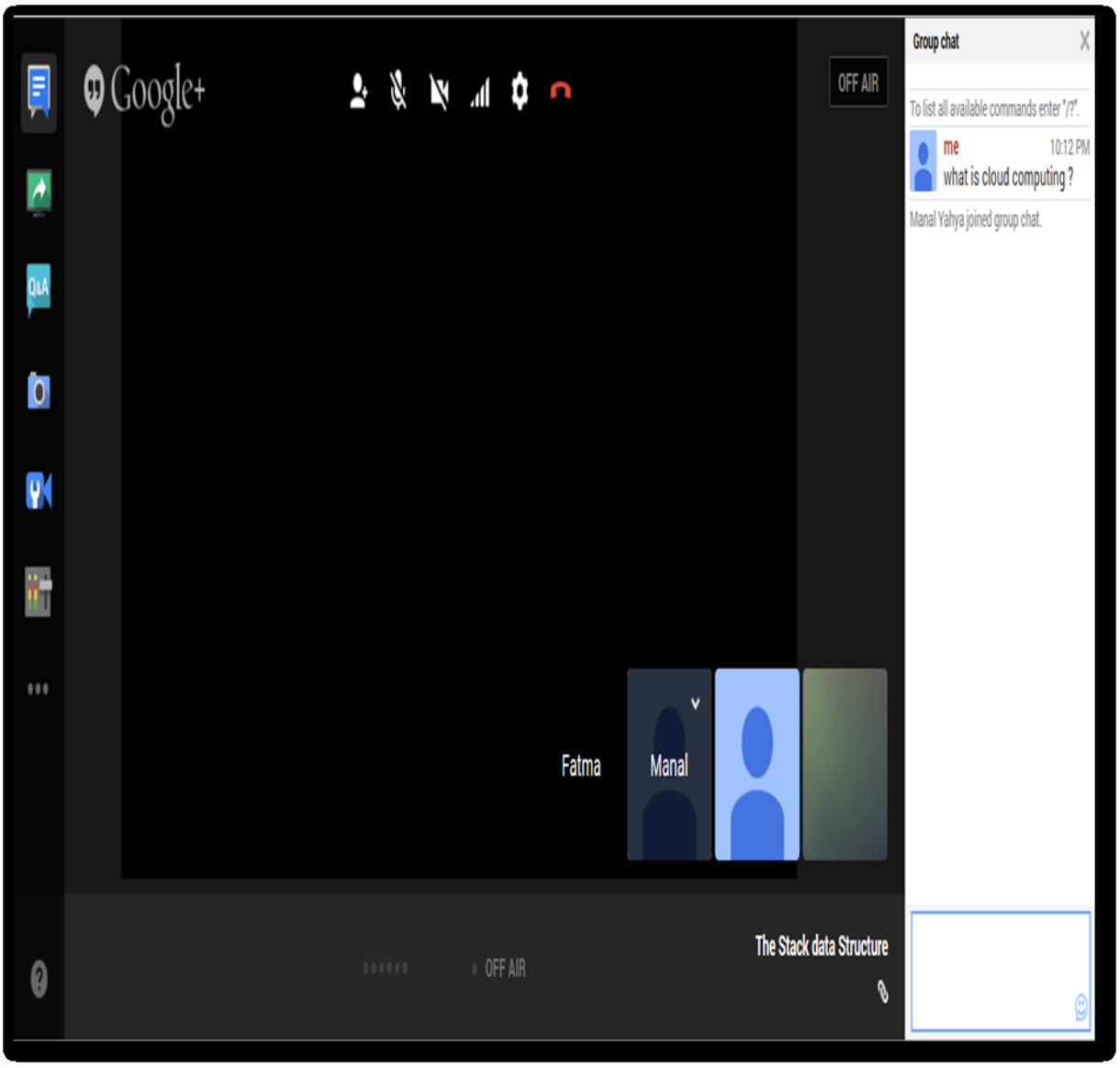
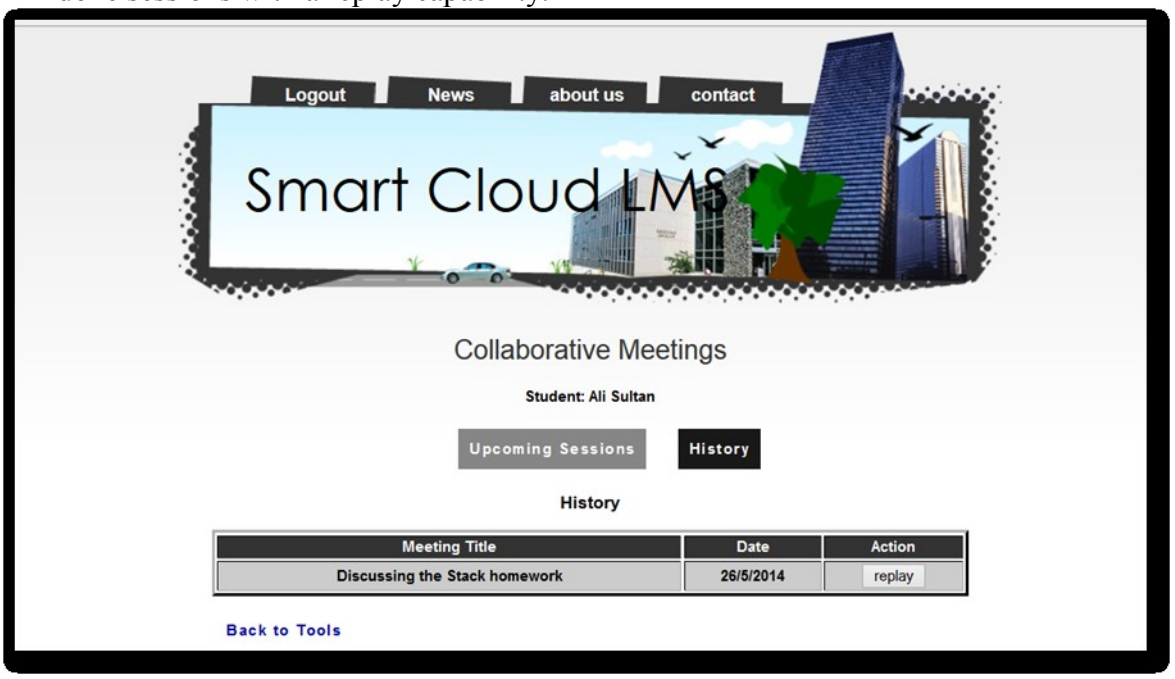


Figure 6.20. The User Interface for New Collaborative Teamwork e-Meetings Developed on Top of Google's Hangout

- ***The History of Done Sessions***

  Students and instructors can also re-play any previous meeting sessions which can be found on the history tab. Figure 6.21 shows the user interface for the history of done sessions with a replay capability.



a) Student Interface

b) Instructor Interface

Figure 6.21. The User Interface for History of Done Collaborative Teamwork Sessions with a Replay Capability

C. The Virtual Classroom

- ***Assigning a Virtual Meeting***

Figure 6.22: On this screen, the instructor can initiate a request and assign new Virtual Classroom meetings with students.

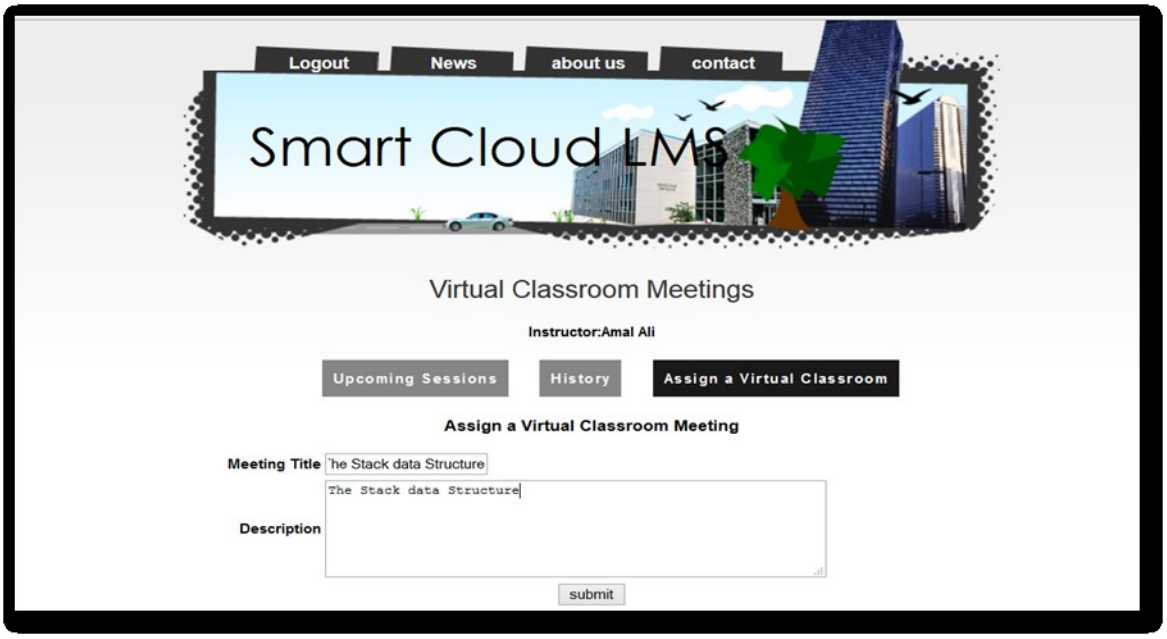


Figure 6.22. Initiating New Virtual Classroom Meeting by the Instructor

Figure 6.23 shows the administrator interface for assigning new upcomming meetings of virtual classroom.

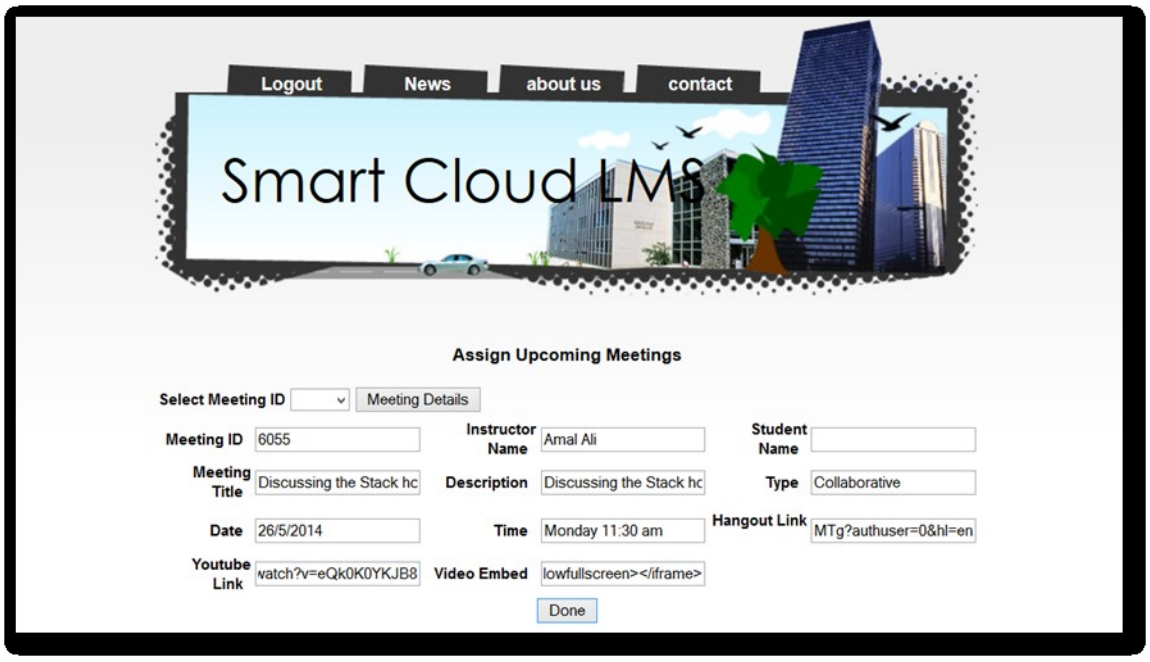
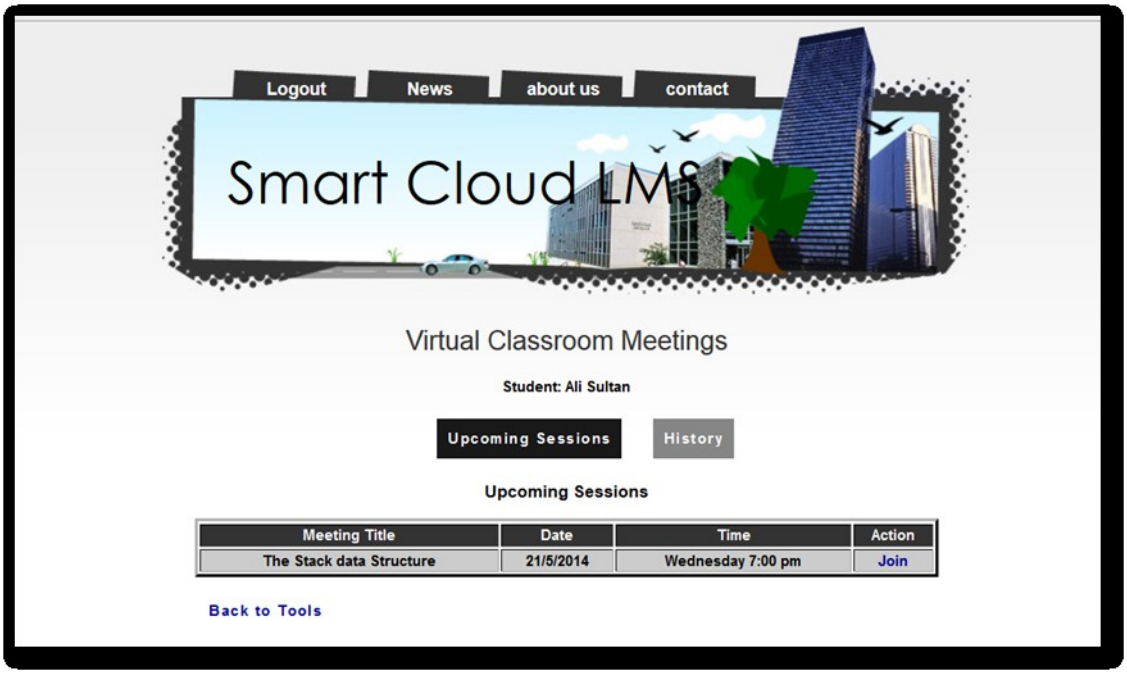


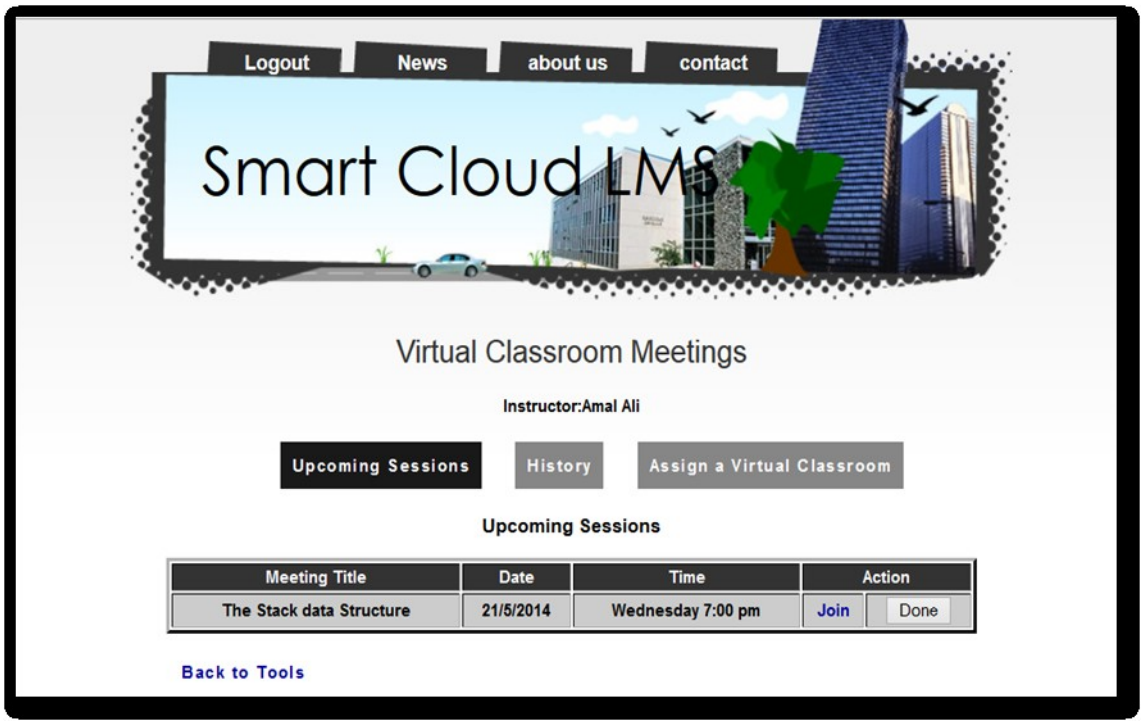
Figure 6.23. Assigning New Upcomming Meetings for Virtual Classroom by the Administrator

- ***Upcoming Sessions***

Student and instructors can join all upcoming Virtual Classroom meetings. Figure 6.24 shows the user interface for scheduled upcoming sessions.



a) Student Interface



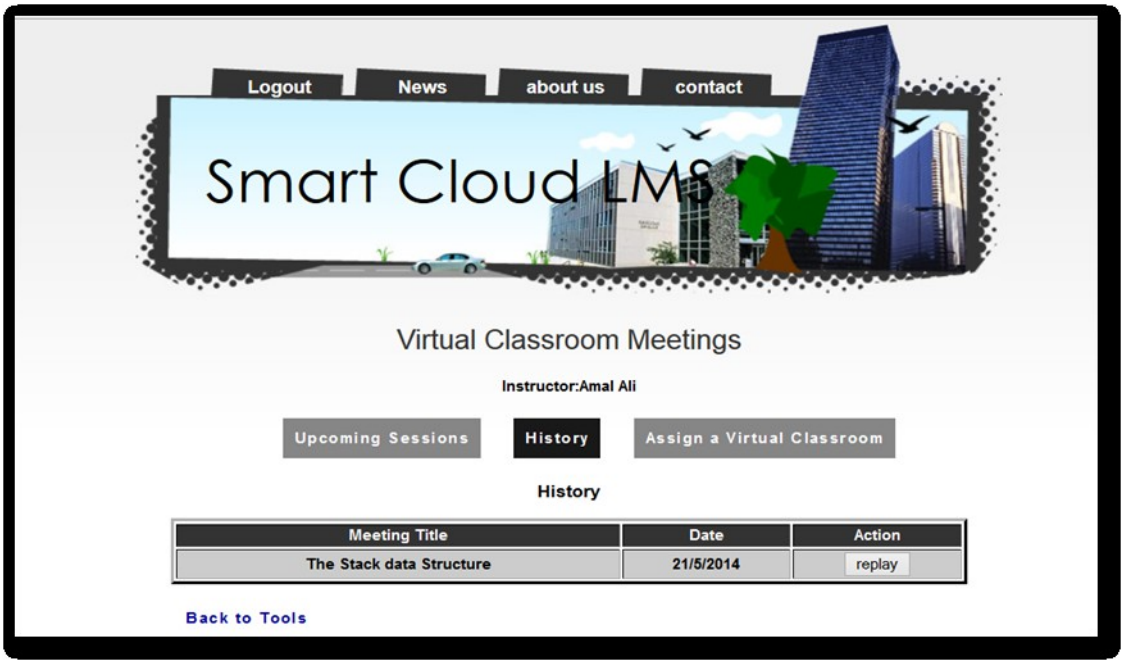
b) Instructor Interface

Figure 6.24. The User Interface for Scheduled Upcoming Sessions of Virtual Classroom

- ***The History of Done Sessions***

  Students and instructors can also re-play any previous meetings which can be found on the History tab. Figure 6.25 shows the user interface for the history of done sessions with a replay capability.

a) Student Interface



b) Instructor Interface

Figure 6.25. The User Interface for History of Done Virtual Classroom Sessions with a Replay Capability

Chapter Seven

Conclusion and Future Work

Chapter Seven

Conclusion and Future Work

This chapter concludes the work conducted throughout this thesis. Section 7.1, reviews the results and highlights the main contributions. Section 7.2 points out few future research directions.

7.1. Conclusion

The main contribution of this research is of two folds. First an e-Learning-Cloud model is developed. In this model, taxonomy of e-Learning organizations is outlined; e-Learning services are laid down; a map of the needed services of each category of e-Learning organizations together with their requested QoS are drawn out of a market survey; the performance criteria of each of the services were studied and suggested; and rule-based expert consultant system is designed and implemented (SCCeLE).

The expert recommender suggests the best Cloud Computing model for each of the identified e-Learning services based on both the service criteria requirements and the circumstances for each individual e-Learning organization according to its specific devoted budget, time-to-market plan, and QoS operational requirements as well as the technology environmental status and availability of software supporting the service.

This expert system supports both the e-Learning organizations and the CSPs in promoting the business of e-Learning. It guides the e-Learning organizations in optimally implementing their e-Learning environments through recommending a suitable cloud-mix implementation model that suits their budgets and other considerations and goals. On the other hand, it encourages CSPs to enter the e-Learning business domain through implementing an e-Learning market map that aids them in identifying their target market's needs and helps them in designing their offerings through availing appropriate information.

The second contribution of this research is recommending an approach for developing e-Learning services through wrapping around freely available or shareware Internet services that were designed without e-Learning in mind. This approach saves both implementation and operation costs of e-Learning systems, which will encourage both current small CSPs and new comers to enter the e-Learning specialized market. It will also avail the e-Learning services to the small e-Learning organizations in a quick and less expensive manner, which will again encourage and boost this business.

The answers of the two hypotheses are raised in this thesis, which can be summarized as follows:

The answer of the first hypothesis is: Yes, it is possible to use the software technology to boost e-learning business through encouraging both educational organization and CSPs to adopt e-Learning, and that has been achieved by implementing the rule-based expert system (SCCeLE):

- SCCeLE tests the idea and offers a useful tool for *e-Learning organizations to* use in defining the most suitable e-Learning environment implementation strategy using a mix of cloud models.
- SCCeLE also gives consultant to *CSPs* where it encourages the CSPs to conquer the business of e-Learning as it aids them in drawing a full picture on the e-Learning market, and supports them in identifying their target market.

The answer of the second hypothesis is: the commonly known three CSP service models—namely, IaaS, PaaS, and SaaS are not the only possible options; and it is possible that technology opens a new opportunity for another fourth model that is more economically suitable. That has been achieved by implementing SWD methodology and the proposed FaaS as a fourth cloud model for developing e-Learning services software on top of freely available internet services.

7.2. Future Work

However, there are still some research issues that are already recognized and require further future investigation. Tasks along both dimensions of this research are planned for future work. For instance, more investigations are yet to be worked out for designing all the remaining e-Learning services using the FaaS technology, such as scheduling of tasks for example 'office hours meetings' and 'virtual classes' using Google Calendar. Other issues yet to be investigated include playback and streaming; assignments and exams; forums and discussion groups, etc.

Along the other research dimension requiring further investigation is the expert recommender for the CSPs. It is a similar expert system like that of the e-Learning organizations but for the CSPs Extra abilities in addition to the market map which are yet to be designed. In addition to extending the rule-base to for example ask the CSP many questions about their business plans; financial abilities; preferred cloud models, .etc, upon which a tailored recommendation that more closely fits the specific CSP's circumstances and plans would be recommended. We believe that both the expert recommenders, for the e-Learning organizations and for the CSPs, will together contribute to build a new business model for the emerging and promising market of e-Learning. Finally, one of the important future issues that we look forward to implementing is the experimental evaluation of the SCCeLE recommendation system.

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Appendices

Appendix 1: The Whole Set of SCCeLE Rules: The Second Phase.

Table 4.7 Representing and Describing The Whole Set of SCCeLE Rules (The 252 Rules of the Second Phase)

Initial Recommendation	Budget	Time-to Market	Commonly Available SW	Needs & QoS	Final Recommendation
On-premise	H	H	Y	Essential :H	On-premise
	H	H	Y	Essential: M	On-premise
	H	H	Y	Optional: M	On-premise
	H	H	N	Essential :H	PaaS
	H	H	N	Essential: M	PaaS
	H	H	N	Optional: M	PaaS
	H	H	Ns	Essential :H	PaaS
	H	H	Ns	Essential: M	PaaS
	H	H	Ns	Optional: M	PaaS
	H	H	Ns	Not needed	
On-premise	H	M	Y	Essential :H	IaaS
	H	M	Y	Essential: M	IaaS
	H	M	Y	Optional: M	IaaS
	H	M	N	Essential :H	PaaS
	H	M	N	Essential: M	PaaS
	H	M	N	Optional: M	PaaS
	H	M	Ns	Essential :H	PaaS

Initial Recommendation	Budget	Time-to Market	Commonly Available SW	Needs & QoS	Final Recommendation
	H	M	Ns	Essential: M	PaaS
	H	M	Ns	Optional: M	PaaS
On-premise	H	L	Y	Essential :H	SaaS then IaaS
	H	L	Y	Essential: M	SaaS
	H	L	Y	Optional: M	SaaS
	H	L	N	Essential :H	FaaS and PaaS
	H	L	N	Essential: M	FaaS and PaaS
	H	L	N	Optional: M	FaaS and PaaS
	H	L	N	Not needed	
	H	L	Ns	Essential :H	SaaS and PaaS
	H	L	Ns	Essential: M	SaaS and PaaS
	H	L	Ns	Optional: M	SaaS and PaaS
On-premise	M	H	Y	Essential :H	IaaS
	M	H	Y	Essential: M	IaaS
	M	H	Y	Optional: M	IaaS
	M	H	N	Essential :H	PaaS
	M	H	N	Essential: M	PaaS
	M	H	N	Optional: M	PaaS
	M	H	Ns	Essential :H	PaaS
	M	H	Ns	Essential: M	PaaS
	M	H	Ns	Optional: M	PaaS
On-premise	M	M	Y	Essential :H	IaaS
	M	M	Y	Essential: M	IaaS
	M	M	Y	Optional: M	IaaS

Initial Recommendation	Budget	Time-to Market	Commonly Available SW	Needs & QoS	Final Recommendation
	M	M	N	Essential :H	PaaS
	M	M	N	Essential: M	PaaS
	M	M	N	Optional: M	PaaS
	M	M	Ns	Essential :H	PaaS
	M	M	Ns	Essential: M	PaaS
	M	M	Ns	Optional: M	PaaS
On-premise	M	L	Y	Essential :H	SaaS then IaaS
	M	L	Y	Essential: M	SaaS
	M	L	Y	Optional: M	SaaS
	M	L	N	Essential :H	FaaS and PaaS
	M	L	N	Essential: M	FaaS and PaaS
	M	L	N	Optional: M	FaaS and PaaS
	M	L	N	Not needed	
	M	L	Ns	Essential :H	SaaS and PaaS
	M	L	Ns	Essential: M	SaaS and PaaS
	M	L	Ns	Optional: M	SaaS and PaaS
On-premise	L	H	Y	Essential :H	SaaS
	L	H	Y	Essential: M	SaaS
	L	H	Y	Optional: M	SaaS
	L	H	N	Essential :H	FaaS
	L	H	N	Essential: M	FaaS
	L	H	N	Optional: M	FaaS
	L	H	Ns	Essential :H	SaaS
	L	H	Ns	Essential: M	FaaS
	L	H	Ns	Optional: M	FaaS

Initial Recommendation	Budget	Time-to Market	Commonly Available SW	Needs & QoS	Final Recommendation
On-premise	L	M	Y	Essential :H	SaaS
	L	M	Y	Essential: M	SaaS
	L	M	Y	Optional: M	SaaS
	L	M	N	Essential :H	FaaS
	L	M	N	Essential: M	FaaS
	L	M	N	Optional: M	FaaS
	L	M	Ns	Essential :H	SaaS
	L	M	Ns	Essential: M	FaaS
	L	M	Ns	Optional: M	FaaS
	L	L	Y	Essential :H	SaaS
	L	L	Y	Essential: M	SaaS
	L	L	Y	Optional: M	SaaS
	L	L	N	Essential :H	FaaS
	L	L	N	Essential: M	FaaS
	L	L	N	Optional: M	FaaS
	L	L	Ns	Essential :H	SaaS
	L	L	Ns	Essential: M	FaaS
	L	L	Ns	Optional: M	FaaS
IaaS	H	H	Y	Essential :H	On-Premise
	H	H	Y	Essential: M	IaaS
	H	H	Y	Optional: M	IaaS
	H	H	N	Essential :H	PaaS
	H	H	N	Essential: M	PaaS
	H	H	N	Optional: M	PaaS

Initial Recommendation	Budget	Time-to Market	Commonly Available SW	Needs & QoS	Final Recommendation
	H	H	N	Not needed	
	H	H	Ns	Essential :H	PaaS
	H	H	Ns	Essential: M	PaaS
	H	H	Ns	Optional: M	PaaS
	H	M	Y	Essential :H	IaaS
	H	M	Y	Essential: M	IaaS
	H	M	Y	Optional: M	IaaS
	H	M	N	Essential :H	PaaS
	H	M	N	Essential: M	PaaS
	H	M	N	Optional: M	PaaS
	H	M	Ns	Essential :H	PaaS
	H	M	Ns	Essential: M	PaaS
	H	M	Ns	Optional: M	PaaS
	H	L	Y	Essential :H	SaaS then IaaS
	H	L	Y	Essential: M	SaaS
	H	L	Y	Optional: M	SaaS
	H	L	N	Essential :H	FaaS and PaaS
	H	L	N	Essential: M	FaaS and PaaS
	H	L	N	Optional: M	FaaS and PaaS
	H	L	Ns	Essential :H	SaaS and PaaS
	H	L	Ns	Essential: M	SaaS and PaaS
	H	L	Ns	Optional: M	SaaS and PaaS
IaaS	M	H	Y	Essential :H	IaaS
	M	H	Y	Essential: M	IaaS
	M	H	Y	Optional: M	IaaS

Initial Recommendation	Budget	Time-to Market	Commonly Available SW	Needs & QoS	Final Recommendation
	M	H	N	Essential :H	PaaS
	M	H	N	Essential: M	PaaS
	M	H	N	Optional: M	PaaS
	M	H	Ns	Essential :H	PaaS
	M	H	Ns	Essential: M	PaaS
	M	H	Ns	Optional: M	PaaS
	M	M	Y	Essential :H	IaaS
	M	M	Y	Essential: M	IaaS
	M	M	Y	Optional: M	IaaS
	M	M	N	Essential :H	PaaS
	M	M	N	Essential: M	PaaS
	M	M	N	Optional: M	PaaS
	M	M	Ns	Essential :H	PaaS
	M	M	Ns	Essential: M	PaaS
	M	M	Ns	Optional: M	PaaS
	M	L	Y	Essential :H	SaaS then IaaS
	M	L	Y	Essential: M	SaaS
	M	L	Y	Optional: M	SaaS
	M	L	N	Essential :H	FaaS and PaaS
	M	L	N	Essential: M	FaaS and PaaS
	M	L	N	Optional: M	FaaS and PaaS
	M	L	Ns	Essential :H	SaaS and PaaS
	M	L	Ns	Essential: M	SaaS and PaaS
	M	L	Ns	Optional: M	SaaS and PaaS
IaaS	L	H	Y	Essential :H	SaaS

Initial Recommendation	Budget	Time-to Market	Commonly Available SW	Needs & QoS	Final Recommendation
	L	H	Y	Essential: M	SaaS
	L	H	Y	Optional: M	SaaS
	L	H	N	Essential :H	FaaS
	L	H	N	Essential: M	FaaS
	L	H	N	Optional: M	FaaS
	L	H	Ns	Essential :H	SaaS
	L	H	Ns	Essential: M	FaaS
	L	H	Ns	Optional: M	FaaS
	L	M	Y	Essential :H	SaaS
	L	M	Y	Essential: M	SaaS
	L	M	Y	Optional: M	SaaS
	L	M	N	Essential :H	FaaS
	L	M	N	Essential: M	FaaS
	L	M	N	Optional: M	FaaS
	L	M	Ns	Essential :H	SaaS
	L	M	Ns	Essential: M	FaaS
	L	M	Ns	Optional: M	FaaS
	L	L	Y	Essential :H	SaaS
	L	L	Y	Essential: M	SaaS
	L	L	Y	Optional: M	SaaS
	L	L	N	Essential :H	FaaS
	L	L	N	Essential: M	FaaS
	L	L	N	Optional: M	FaaS
	L	L	Ns	Essential :H	SaaS
	L	L	Ns	Essential: M	FaaS

Initial Recommendation	Budget	Time-to Market	Commonly Available SW	Needs & QoS	Final Recommendation
	L	L	Ns	Optional: M	FaaS
SaaS	H	H	Y	Essential :H	IaaS
	H	H	Y	Essential: M	SaaS
	H	H	Y	Optional: M	SaaS
	H	H	N	Essential :H	PaaS
	H	H	N	Essential: M	PaaS
	H	H	N	Optional: M	FaaS
	H	H	Ns	Essential :H	PaaS
	H	H	Ns	Essential: M	PaaS
	H	H	Ns	Optional: M	SaaS
	H	M	Y	Essential :H	IaaS
	H	M	Y	Essential: M	SaaS
	H	M	Y	Optional: M	SaaS
	H	M	N	Essential :H	PaaS
	H	M	N	Essential: M	PaaS
	H	M	N	Optional: M	FaaS
	H	M	Ns	Essential :H	PaaS
	H	M	Ns	Essential: M	PaaS
	H	M	Ns	Optional: M	SaaS
	H	L	Y	Essential :H	SaaS then IaaS
	H	L	Y	Essential: M	SaaS
	H	L	Y	Optional: M	SaaS
	H	L	Y	Not needed	
	H	L	N	Essential :H	FaaS and PaaS

Initial Recommendation	Budget	Time-to Market	Commonly Available SW	Needs & QoS	Final Recommendation
	H	L	N	Essential: M	FaaS and PaaS
	H	L	N	Optional: M	FaaS
	H	L	N	Not needed	
	H	L	Ns	Essential :H	SaaS and PaaS
	H	L	Ns	Essential: M	SaaS and PaaS
	H	L	Ns	Optional: M	SaaS
	H	L	Ns	Not needed	
SaaS	M	H	Y	Essential :H	IaaS
	M	H	Y	Essential: M	SaaS
	M	H	Y	Optional: M	SaaS
	M	H	N	Essential :H	PaaS
	M	H	N	Essential: M	PaaS
	M	H	N	Optional: M	FaaS
	M	H	Ns	Essential :H	PaaS
	M	H	Ns	Essential: M	PaaS
	M	H	Ns	Optional: M	SaaS
	M	M	Y	Essential :H	IaaS
	M	M	Y	Essential: M	SaaS
	M	M	Y	Optional: M	SaaS
	M	M	N	Essential :H	PaaS
	M	M	N	Essential: M	PaaS
	M	M	N	Optional: M	FaaS
	M	M	Ns	Essential :H	PaaS
	M	M	Ns	Essential: M	PaaS
	M	M	Ns	Optional: M	SaaS

Initial Recommendation	Budget	Time-to Market	Commonly Available SW	Needs & QoS	Final Recommendation
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	M	L	Y	Essential: M	SaaS
	M	L	Y	Optional: M	SaaS
	M	L	N	Essential :H	FaaS and PaaS
	M	L	N	Essential: M	FaaS and PaaS
	M	L	N	Optional: M	FaaS
	M	L	Ns	Essential :H	SaaS and PaaS
	M	L	Ns	Essential: M	SaaS and PaaS
	M	L	Ns	Optional: M	SaaS
SaaS	L	H	Y	Essential :H	SaaS
	L	H	Y	Essential: M	SaaS
	L	H	Y	Optional: M	SaaS
	L	H	N	Essential :H	FaaS
	L	H	N	Essential: M	FaaS
	L	H	N	Optional: M	FaaS
	L	H	Ns	Essential :H	SaaS
	L	H	Ns	Essential: M	FaaS
	L	H	Ns	Optional: M	FaaS
	L	M	Y	Essential :H	SaaS
	L	M	Y	Essential: M	SaaS
	L	M	Y	Optional: M	SaaS
	L	M	N	Essential :H	FaaS
	L	M	N	Essential: M	FaaS
	L	M	N	Optional: M	FaaS
	L	M	Ns	Essential :H	SaaS

Initial Recommendation	Budget	Time-to Market	Commonly Available SW	Needs & QoS	Final Recommendation
	L	M	Ns	Essential: M	FaaS
	L	M	Ns	Optional: M	FaaS
	L	L	Y	Essential :H	SaaS
	L	L	Y	Essential: M	SaaS
	L	L	Y	Optional: M	SaaS
	L	L	N	Essential :H	FaaS
	L	L	N	Essential: M	FaaS
	L	L	N	Optional: M	FaaS
	L	L	Ns	Essential :H	SaaS
	L	L	Ns	Essential: M	FaaS
	L	L	Ns	Optional: M	FaaS

نموذج لتطبيق السحابة الإلكترونية في التعليم الإلكتروني

مشاعل عبدالله محمد السويل

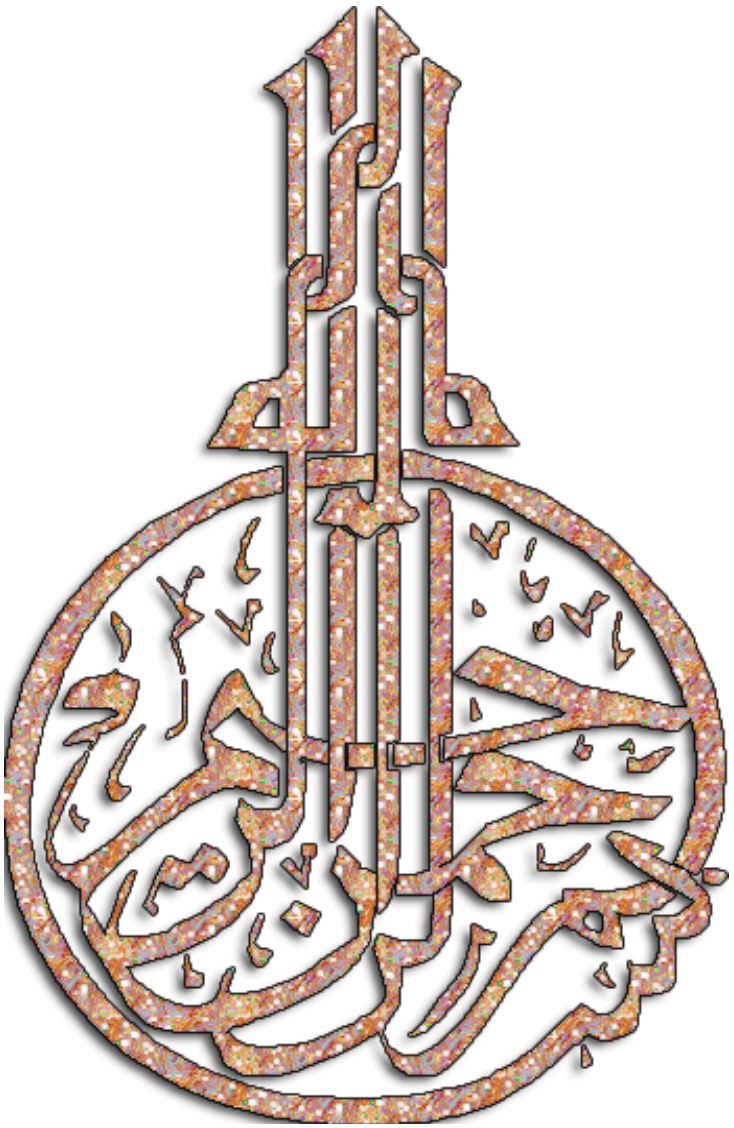
بحث مقدم لنيل درجة الماجستير في علوم الحاسبات

كلية الحاسبات وتقنية المعلومات

جامعة الملك عبدالعزيز

جدة – المملكة العربية السعودية

شعبان ١٤٣٥ هـ / يونيو ٢٠١٤ م



بسم الله الرحمن الرحيم

[وَقُلِ اعْمَلُوا فَسَيَرَى اللَّهُ عَمَلَكُمْ وَرَسُولُهُ وَالْمُؤْمِنُونَ] سورة التوبة آية 105

نموذج لتطبيق السحابة الإلكترونية في التعليم الإلكتروني

مشاعل عبدالله محمد السويل

بحث مقدم لنيل درجة الماجستير في العلوم (علوم الحاسبات)

أشراف

د. رضا محمد سلامه خليفه

أ.د شهاب أحمد جمال الدين

كلية الحاسبات وتقنية المعلومات

جامعة الملك عبدالعزيز

جدة – المملكة العربية السعودية

شعبان ١٤٣٥ هـ – يونيو ٢٠١٤ م

نموذج لتطبيق السحابة الإلكترونية في التعليم الإلكتروني

إعداد

مشاعل عبدالله محمد السويل

تمت الموافقة على قبول هذه الرسالة استكمالا لمتطلبات درجة الماجستير في علوم الحاسبات

لجنة المناقشة و الحكم على الرسالة

	الاسم	المرتبة العلمية	التخصص	التوقيع
عضو داخلي	د.عبدالله الطيب سعد عبدالله الغامدي	أستاذ مشارك	نظم معلومات	
عضو خارجي	د.عبدالمجيد الصادق عبدالرزاق	أستاذ مشارك	هندسة البرمجيات	
مشرف مشارك	أ.د.شهاب أحمد جمال الدين	أستاذ	نظم معلومات	
مشرف رئيس	د.رضا محمد سلامه خليفه	أستاذ مشارك	تقنية معلومات	

جامعة الملك عبدالعزيز

شعبان ١٤٣٥ هـ – يونيو٢٠١٤ م

نموذج لتطبيق السحابة الإلكترونية في التعليم الإلكتروني

مشاعل عبدالله السويل

المستخلص

لقد أصبحت الحاجة ملحة للتحول إلى أنظمة التعليم الإلكتروني نظراً لندرة الموارد المتاحة ضمن أنظمة التعليم التقليدية. وبالتالي ، فلقد أصبح العديد من المؤسسات التعليمية والتدريبية مدركة لأهمية القيام باعتماد أنظمة التعليم الإلكترونية. إضافة إلى ذلك ، فلقد بدأت مؤسسات التعلم الإفتراضية البحتة بالظهور بشكل كثيف.

ومن جهة أخرى ، فلقد ظهرت تقنية جديدة في الفضاء الإلكتروني هي الحوسبة السحابية Cloud Computing. لقد قامت المؤسسات التجارية باعتماد هذه التقنية ، كما قامت بتطوير نماذج للأعمال التجارية تقوم على الخدمات السحابية والتي توفر كلاً من البُنى التحتية وكذلك التطبيقات البرمجية حيث يمكن استئجار تلك الخدمات بكل سهولة وبتكاليف تشغيل منخفضة. لقد أدى ذلك إلى اتاحة استخدام البنى التحتية المكلفة وكذلك التطبيقات البرمجية من دون الحاجة إلى تكبد تكاليف الإعداد العالية.

يتناول البحث الحالي كيفية توظيف الحوسبة السحابية في مجال التعليم الإلكتروني. لقد تمت دراسة الأنواع المختلفة لمؤسسات التعليم الإلكتروني ، بالإضافة إلى خدمات التعليم الإلكتروني التي يقدمها كل نوع من تلك المؤسسات التعليمية. كما تم أيضاً مناقشة "النموذج السحابي" الذي يتناسب بشكل جيد مع طبيعة كل نوع من تلك الخدمات وفقاً لقدرة كل مؤسسة من مؤسسات التعليم الإلكتروني على تحمل تكاليف الموارد ، كما تم تناول الإمكانيات التي تقدمها البيئة التكنولوجية أيضاً. وهكذا ، فلقد تم وضع تصنيف لمزيج من النماذج السحابية لكل نوع من مؤسسات التعليم الإلكتروني المختلفة ، كما تم تطوير نظام خبير يستند على القواعد SCCeLE وذلك لمساعدة تلك المؤسسات على تحديد مزيج النماذج السحابية الذي يتوافق بشكل جيد مع الأهداف ومع الوضع الحالي للمؤسسة.

من ناحية أخرى ، فإن هذا التصنيف سوف يشجع مقدمي الخدمات السحابية CSP على الدخول إلى مجال التعليم الإلكتروني حيث سيساعد هذا التصنيف في رسم صورة كاملة لسوق التعليم الإلكتروني ، كما سيساعد أيضاً في التعرف على السوق المستهدفة ، وعلى تطوير باقات الدعم الخاصة بمجال التعليم الإلكتروني.

علاوة على ذلك ، فإن البحث الحالي يقترح نموذجاً سحابياً آخر يعمل على تقديم خدمات التعليم الإلكتروني بصورة اقتصادية حيث ترتكز خدمات هذا النموذج على الخدمات المجانية المقدمة لمستخدمي شبكة الإنترنت. لقد اطلقنا على هذا النموذج المقترح الجديد اسم "الخدمات المجانية " FaaS. يقترح نموذج "الخدمات المجانية" تقنية جديدة يتم فيها تقديم خدمات التعليم الإلكتروني عن طريق إنشاء واجهة مستخدم مخصصة تتلائم مع متطلبات نظام التعليم الإلكتروني ، في حين تقوم تلك الواجهة على أساس خدمات الإنترنت المجانية باعتبارها المحرك لأداء تلك الخدمات ، ولكنها تعمل على الخوادم الخاصة بمقدمي الخدمات المجانية على شبكة الإنترنت. وهكذا ، فإن نموذج "الخدمات المجانية" المقترح سوف يساعد على تطوير خدمات البرامج التعليمية بشكل سريع وبصورة غير مكلفة من الناحية الاقتصادية حيث لا تحتاج إلى تكاليف تشغيل من قبل المستفيدين.

لقد تم تنفيذ النظام الخبير SCCeLE باستخدام منصة الجداول الإلكترونية Excel ومنصة (ميكروسوف دوت نت Microsoft .Net). كما تم إجراء استطلاع وتوزيع استبانة من أجل التعرف بشكل أكبر على سوق التعليم الإلكتروني ، وعلى مؤسسات التعليم الإلكتروني ، بالإضافة إلى الخدمات الخاصة بها. وعلاوة على ذلك ، فلقد تم تنفيذ بعض النماذج الأولية وذلك من أجل تجربة التقنيات المقترحة FaaS من قبل نموذج "الخدمات المجانية" ومن أجل إثبات جدوى الفكرة.

نموذج لتطبيق السحابة الإلكترونية في التعليم الإلكتروني

مشاعل عبدالله السويل

الملخص

١ مقدمة

تعتبر الموارد البشرية والموظفون المؤهلون والأكفاء هم الأصول الحقيقية ومفاتيح النجاح والقوة لكلٍ من المؤسسات والدول. وبالتالي ، فإن التعليم والتدريب يلعبان دوراً مهماً في عملية التقدم والتطور التي تشهدها الأمم. وعلى الرغم من ذلك ، إلا أنه ما تزال هناك العديد من التحديات (أنظر: Whitehurst, Powell, and Izatt, 98) ، والتي يمكن التغلب عليها عن طريق استخدام تكنولوجيا التعليم الإلكتروني الذي يُعتقد بأنه يمثل مستقبل التعليم بشكل عام. لقد أصبحت الجامعات والمؤسسات التعليمية مدركة لمزايا وفوائد التعليم الإلكتروني ، كما أنها أصبحت مدركةً أيضاً إمكانيات قيام التعليم الإلكتروني بدعم تلك المؤسسات من خلال تقديم خدمات جديدة أكثر فعالية ، تعمل على تحسين كفاءة العملية التعليمية.

يقدم التعليم الإلكتروني ، في الواقع ، العديد من الخدمات الإلكترونية التي تقوم بدعم كافة أنواع أنظمة التعليم و التدريب. كما أن معظم الجامعات ومعاهد التدريب قد عملت على تبني بعضاً من تلك الخدمات الإلكترونية باعتبارها أحد المكونات الأساسية لأنظمة التعليم لديها. وعلاوة على ذلك ، فلقد ظهرت مؤسسات تعليمية تعتمد على أنظمة التعليم الإفتراضية فقط ، حيث تقوم تلك المؤسسات بتقديم كافة أنشطة التعليم المختلفة عبر شبكة الويب وذلك باستخدام خدمات وتقنيات التعليم الإلكتروني.

وعلى الرغم من أن عملية اعتماد أنظمة التعليم الإلكتروني تعمل على تقديم حلول للعديد من التحديات التي تواجه أنظمة التعليم التقليدية بما في ذلك الحاجة إلى توفر استثمارات ضخمة ، إلا أنه ما يزال هناك حاجة إلى مزيد من تقليص التكاليف اللازمة ، وذلك من أجل تشجيع مؤسسات التعليم الحالية والمستقبلية على تبني واعتماد أنظمة التعليم الإلكتروني ، وخصوصاً في ظل زيادة الطلب على عمليتي التعليم والتدريب.

لقد أدى ظهور الحوسبة السحابية خلال السنوات الأخيرة إلى إثارة اهتمام العديد من المؤسسات والمعاهد المختلفة ، وإلى إثارة اهتمام المستخدمين أيضاً للاستفادة من الخدمات التي توفرها. تعد الحوسبة السحابية بإحداث نقلة نوعية لدى المؤسسات ، من مؤسسات تحتاج إلى استثمارات ضخمة في موارد محدودة لتقنية المعلومات ، إلى نموذج يمكن للمؤسسات من خلاله شراء أو استئجار الموارد التي يديرها مقدمو الخدمات السحابية ، حيث يمكن للمؤسسة السداد مقابل الإستخدام فقط.

تقدم الحوسبة السحابية العديد من المزايا لمؤسسات الأعمال ، وخصوصاً للمؤسسات الإفتراضية والهجينة. كما تعمل على خفض تكلفة الاستثمارات المطلوبة خلال عملية التجهيز الأولية للبنى التحتية الخاصة بتجهيزات تقنية المعلومات ، بالإضافة إلى اختصار سرعة إنزال الخدمات إلى السوق ، وكذلك توفير أداء متوازن وقابل للتكييف ، بالإضافة إلى مميزات أخرى. كما أننا نعتقد بأن الحوسبة السحابية قادرة على تقديم مزايا مماثلة لمؤسسات التعليم الإلكتروني. وبالتالي ، فإن البحث الحالي يتناول توظيف تقنية الحوسبة السحابية في مجال التعليم الإلكتروني.

تعتبر الحوسبة السحابية أحد النماذج الحديثة التي يمكن من خلالها مشاركة البُنى التحتية الحاسوبية والتطبيقات البرمجية بطريقة أكثر فعالية. كما أنها تمكن مجموعات مشتركة من الموارد الحاسوبية القابلة للتشكيل من الوصول إلى الشبكة عند الطلب ، مثل الشبكات والخوادم ، وأنظمة التخزين ، والتطبيقات ، والخدمات. من الناحية التجارية ، يظهر هناك مجال أعمال جديد ومربح حيث يتمثل في ثلاثة نماذج لأعمال تجارية يمكن أن تنطلق من خلال هذه الخدمة ، وهي بالتحديد :

(خدمات البُنى التحتية (IaaS) ، و (خدمات المنصات (PaaS) ، و (خدمات التطبيقات البرمجية (SaaS). تقدم كافة خدمات الحوسبة السحابية للعملاء في الوقت الحاضر بشكل عام وبدون تخصيص أو وفقاً لاحتياجات فئة محددة من الأعمال ، بمعنى أن مقدمي الخدمات السحابية (CSP) يقومون بتصميم الخدمات والمنتجات التي يقدمونها من دون التركيز على أسواق أو

مجالات أعمالٍ محددة. وبعبارات أخرى ، فإن مزودي الخدمات السحابية لا يستهدفون من خلال العروض التي يقدمونها ، أو بالأحرى لا يخصصون العروض التي يقدمونها لتلبي متطلبات مؤسسات التعليم الإلكتروني. لا يشجع هذا الأسلوب المؤسسات التعليمية في الشروع في التكنولوجيا السحابية باعتبارها فرصة لتقديم خدمات التعليم الإلكتروني مقابل تكاليف استثمار مقبولة. ولمزيد من التفصيل ، فإن عدد الخدمات البرمجية المقدمة من قبل أنظمة التعليم الإلكتروني تعتبر كبيرة نوعاً ما. وكل نوع من تلك الخدمات تتطلب برامج متخصصة ومكلفة ، حيث يتطلب إنشاء مؤسسة تعليم الكتروني استثمارات ضخمة نسبياً ، بالإضافة إلى وقت طويل للوصول إلى السوق المستهدفة (أي قبل أن تستطيع المؤسسة العمل وتقديم خدماتها للسوق المستهدفة).

وبالتالي ، فإن على مقدمي الخدمات السحابية العمل على حل مثل تلك المسائل في حالة كانت لديهم الرغبة في اجتذاب مؤسسات التعليم الإلكتروني إلى صفوف عملائها المحتملين.

وبالرغم من ذلك ، فإن مقدمي الخدمات السحابية لا يدركون بعد أهمية استقطاب هذا المجال الجديد والواعد ، أي مجال التعليم الإلكتروني. يتمثل أحد أسباب تجاهل مقدمي الخدمات السحابية تقديم خدماتهم لمجال التعليم الإلكتروني في انعدام وجود خارطة مكتملة لسوق التعليم الإلكتروني ، ونوع الخدمات التي يحتاجها ، و طبيعة مؤسسات التعليم الإلكتروني ، و حجم وأنواع الإحتياجات والمتطلبات الخاصة بها .... وغير ذلك. وبالتالي ، فإن البحث الحالي يهدف إلى مساعدة كلاً من مؤسسات التعليم الإلكتروني وكذلك مقدمي الخدمات السحابية في تعزيز مجال التعليم الإلكتروني من خلال ربط خدمات التعليم الإلكتروني بالخدمات السحابية ، بالإضافة إلى توفير خدمات التعليم الإلكتروني ذات التكلفة الأقل عن طريق الإستفادة من الخدمات السحابية.

٢ استعراض الفرضية الأولى والنموذج المقترح Hypothesis 1 & Conceptual Model

من ضمن فرضيات هذا البحث ، هو ‘الفرضية الأولى’ "هل بالإمكان استخدام تقنية برمجية لتعزيز نشاط وتجارة التعلم الإلكتروني من خلال تشجيع كلاً من المؤسسات التعليمية ومقدمي الخدمات السحابية في تبني التعليم الإلكتروني؟" أو بمعنى اخر:

"هل بالإمكان تخصيص عروض مقدمي الخدمات السحابية لتتلائم مع الإحتياجات الخاصة بأسواق معينة ، وعلى وجه التحديد ، بمجال التعليم الإلكتروني ؟". يتمثل الهدف من هذه الفرضية في تطوير نموذج يساعد مؤسسات التعليم الإلكتروني على استخدام التقنيات السحابية في تعزيز خدماتها وعروضها ، ومن جهة أخرى ، البحث عن طرق تعمل على تشجيع مقدمي الخدمات السحابية على النظر في المجال الواعد المتثمل في مجال التعليم الإلكتروني.

ولتحقيق هذا الهدف ، تم القيام بعدة خطوات.

أولاً: تم القيام بإجراء استطلاع يضم عدداً من الأنشطة كالمقابلات ، ومراجعة الدراسات السابقة ، و الاستبانات ، حيث تم إجراؤها لفهم مجال التعليم الإلكتروني ، والتعرف على الخدمات المقدمة في مجال التعليم الإلكتروني ، وكذلك المعايير المرتبطة بتقديم تلك الخدمات ، بالإضافة إلى التعرف على معايير الأداء المتوقعة من تلك الخدمات.

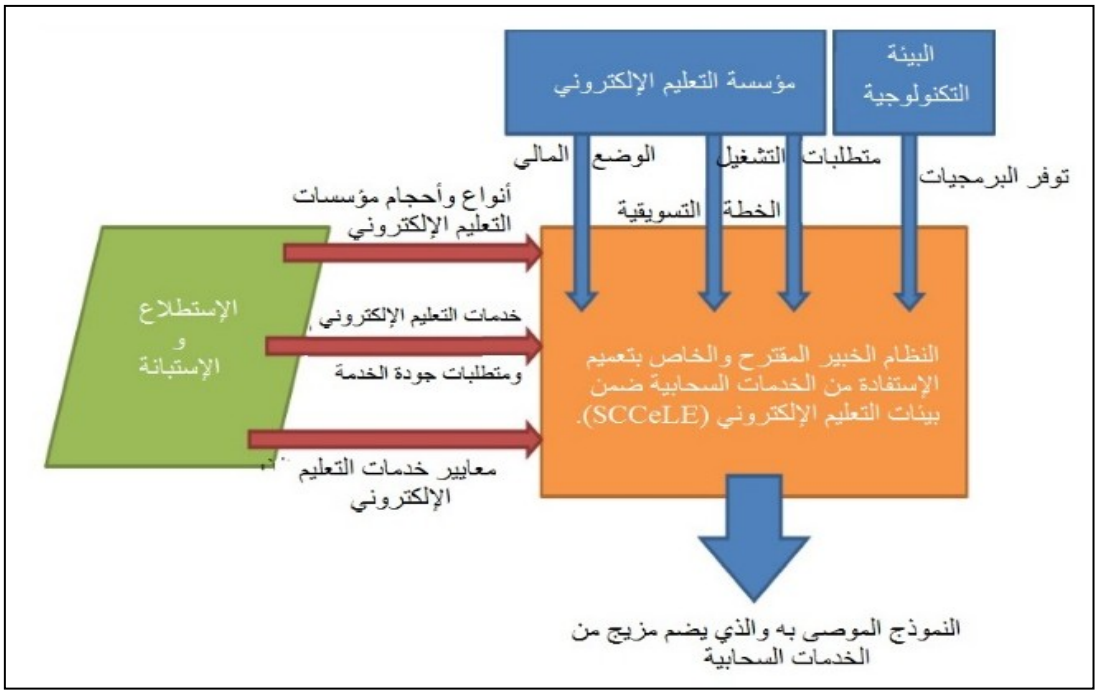
يقوم الإستطلاع بالمساعدة في وضع تصنيف للفئات الخمس التي تندرج تحتها مؤسسات التعليم الإلكتروني ، حيث تم تصنيف مؤسسات التعليم الإلكتروني بناءً على مدى اعتمادها على تقنية التعليم الإلكتروني ، وعلى مقدار الخدمات المقدمة ضمن أنظمتها التعليمية.

ثانياً: تم التعرف على الخدمات الرئيسية المطلوبة من قبل مؤسسات التعليم الإلكتروني ، حيث تم إجراء استطلاع يهدف إلى وضع خريطة تهتم بجودة الخدمة (QoS Map) حيث تحدد مدى جودة الخدمة المطلوبة لكل خدمة من خدمات التعليم الإلكتروني على النحو المطلوب من قبل كل فئة من مؤسسات التعليم الإلكتروني ضمن التصنيف المقترح.

ثالثاً: تم التعرف على معايير التشغيل والأداء لكل خدمة من الخدمات المطلوبة ، كما تم وضع مجموعة من القواعد التي تخص النموذج السحابي الأنسب لتلك المعايير.

لسوء الحظ ، تهتم تلك القواعد بمعايير خدمات التعليم الإلكتروني فقط ؛ بمعنى أنها لا تهتم بالسياقين المؤسسي والتكنولوجي. ولذلك ، فلقد قمنا رابعاً : بوضع مجموعة قواعد أخرى تهتم بالمعايير الأخرى كميزانية المؤسسة المخصصة لعملية اعتماد التعليم الإلكتروني ، و كذلك الوقت المطلوب للوصول إلى السوق ، بالإضافة إلى جودة الخدمة من حيث المميزات والأداء المطلوب ؛ وكذلك مدى توفر برامج الدعم الخاصة بالخدمة المطلوبة.

يمكن أن تعمل الخطوة الثانية من القواعد على ترجيح أو خفض النموذج الأولي الموصى به نظراً لاعتبارات استثمارات المؤسسة ، والتسويق ، و المتطلبات التشغيلية ، بالإضافة إلى وضع البيئة التكنولوجية. يعتبر النظام الخبير المقترح والخاص بتعميم الإستفادة من الخدمات السحابية ضمن بيئات التعليم الإلكتروني (SCCeLE) نظاماً يعتمد على القواعد حيث تم وضعه لاختبار جدوى الفكرة ، و لمساعدة المؤسسات التعليمية في تحديد الاستراتيجية الأكثر ملائمة لتنفيذ بيئة التعليم الإلكتروني عن طريق استخدام مزيج من النماذج السحابية. يوضح الشكل رقم (١,١) المدخلات والمخرجات ضمن النظام الخبير المقترح والخاص بتعميم الإستفادة من الخدمات السحابية ضمن بيئات التعليم الإلكتروني (SCCeLE).



الشكل رقم (١,١) نموذج النظام الخبير (SCCeLE)

٣ استعراض الفرضية الثانيه والنموذج المقترح Hypothesis 2 & Conceptual Model

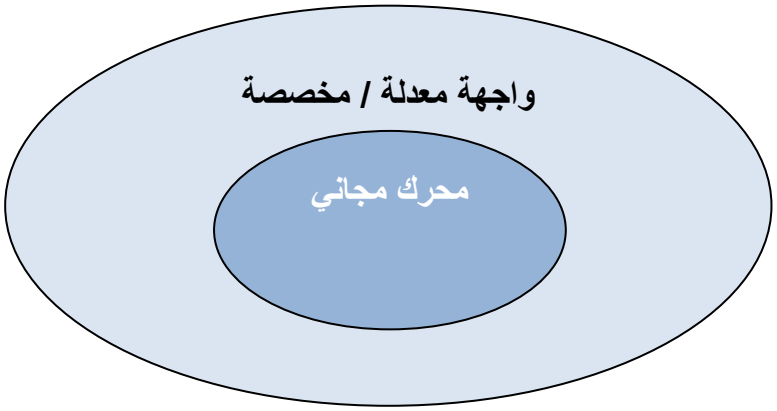
الفرضية الثانية ضمن هذا البحث هي: "هل تعتبر نماذج الأعمال الثلاثة المعروفة والمقدمة من قبل مزودي الخدمات السحابية وهي بالتحديد (خدمات البُنى التحتية (IaaS) ، و (خدمات المنصات (PaaS) ، و (خدمات التطبيقات البرمجية (SaaS) هي النماذج الوحيدة الممكنة فقط ، أم أن التكنولوجيا تعمل على إتاحة فرصاً جديدة أمام نموذج رابع؟".

يقترح البحث الحالي استخدام خدمات الإنترنت المجانية مثل خدمات الدردشة ، و خدمات البريد الإلكتروني ، في دعم خدمات التعليم الإلكتروني المطلوبة.

وعلى الرغم من أن مثل تلك الخدمات ليست مصممة لخدمة التعليم الإلكتروني بشكل خاص. وبالتالي ، فإن البحث الحالي يحاول إثبات أن بالإمكان تحوير تلك الخدمات بحيث تعمل على توفير بيئة متوافقة مع متطلبات التعليم الإلكتروني ، وباستخدام الحد الأدنى من تكاليف التطوير. لقد أطلقنا على هذا الأسلوب "أسلوب تطوير البرامج باستخدام الخدمات المجانية". لقد تم تطوير العديد من النماذج الأولية لإثبات جدوى الأسلوب المقترح. على سبيل المثال ، تم تطوير قائمة بريد إلكتروني مغلقة الدائرة تشبه أنظمة إدارة التعليم الإلكترونية (LMS) ، وذلك باستخدام خدمة البريد المجاني (Gmail) المقدم من شركة جوجل.

علاوة على ذلك ، فلقد تم تطوير نظام يهتم "بالساعات المكتبية" و نظام يهتم "بالإجتماعات الإفتراضية التعاونية" و "الفصول الإفتراضية"، كل ذلك باستخدام خدمة الدردشة المجانية المتاحة من قبل شركة جوجل والتي يطلق عليها (Hangout chat). يمكن استخدام هذا الأسلوب من قبل مقدمي الخدمات السحابية لتطوير بيئات تعليم إلكترونية أقل تكلفة ، حتى وإن كانت ذات جودة أقل ومميزات محدودة ، إلا أن ذلك سوف يعمل على التغلب - وبشكل سريع ومجدي من الناحية الاقتصادية - على العديد من التحديات التي تواجه مؤسسات التعليم الإلكتروني. جدير بالذكر بأن أسلوب "الخدمات المجانية FaaS" يمثل أسلوباً مجدياً من الناحية الاقتصادية ليس في مجال تطوير البرمجيات فحسب ، بل من حيث تكاليف التشغيل والإتاحة أيضاً ،حيث أنها تعمل في العادة على خوادم الشركة المقدمة للخدمة. فهل بالإمكان إعتبار هذا الأسلوب والخدمات التي يقدمها هو "النموذج السحابي" الرابع؟ وقد تحقق هذا الهدف من خلال اقتراح نموذج جديد (FAAS)

لتطوير خدمات التعليم الإلكتروني على قمة خدمات الإنترنت المتاحة مجانا. يوضح الشكل (١,٢) الفكرة القائمة وراء أسلوب تطوير "الخدمات المجانية" المقترح .



الشكل (١,٢) تقنية إنشاء نموذج "الخدمات المجانية FaaS"

٤ تنفيذ النموذج المبدئي Prototype Implementation

لقد تم تطوير نماذج أولية لإثبات جدوى الفكرة المقترحة في هذا البحث. كما تم تنفيذ النظام الخبير المقترح والخاص بتعميم الإستفادة من الخدمات السحابية ضمن بيئات التعليم الإلكتروني (SCCeLE) ، وذلك باستخدام برنامج "الجداول الإلكترونية Excel" (وذلك لتسهيل عملية عرض ومعالجة الجداول) ، وباستخدام منصة "ميكروسوفت دوت نت Microsoft .Net " (لتنفيذ المحرك المعتمد على القواعد). كما تم أيضاً تنفيذ نماذج أولية أخرى للتحقق من تقنية إنشاء نموذج "الخدمات المجانية FaaS". لقد عملت النماذج الأولية على تنفيذ سيناريوهات محددة تتعلق بالتعليم الإلكتروني ، على سبيل المثال ، تنفيذ قائمة بريد إلكتروني مغلقة الدائرة تعتمد بشكل كامل على البريد الإلكتروني المجاني (Gmail) المقدم من شركة جوجل. كما تم أيضاً تنفيذ عدد آخر من الخدمات مثل الخدمة المختصة "بالساعات المكتبية" و خدمة "الإجتماعات الإفتراضية التعاونية" ، و خدمة "الفصل الدراسي الإفتراضي" ؛ كل تلك الخدمات تقوم بالأساس على خدمة الدردشة المجانية (Hangout) وعلى التطبيقات المجانية المقدمة من شركة جوجل. يوضح الشكل (١,٣) الصفحة الرئيسية لنموذج نظام السحابة الذكيه لإدارة التعليم الإلكتروني الذي يقدم خدمات التعليم الإلكتروني في نموذج FaaS.

الشكل (١،٣) الصفحة الرئيسية لنموذج نظام السحابة الذكيه لإدارة التعليم الإلكتروني

٥ الإستنتاجات والبحوث المستقبليه Conclusion and Future Work

هناك إسهامان رئيسيان لهذا البحث العلمي. أولاً: لقد تم تطوير نموذج تعليم الكتروني سحابي جديد. كما تم تصنيف مؤسسات التعليم الإلكتروني ضمن هذا النموذج؛ بالإضافة إلى تصنيف خدمات التعليم الإلكتروني؛ وكذلك وضع خريطة للخدمات المطلوبة ضمن كل فئة من فئات مؤسسات التعليم الإلكتروني ، كما تم تحديد مستوى جودة الخدمة المطلوبة بناءً على الإستطلاع الذي تم إجراؤه على السوق؛ كما تم دراسة معايير الأداء الخاصة بكل خدمة ؛ بالإضافة إلى تصميم وتنفيذ نظام استشاري خبير يعتمد على القواعد (SCCeLE).

يقوم النظام الاستشاري الخبير باقتراح نموذج الخدمات السحابية لكل خدمة من خدمات التعليم الإلكتروني المحددة وذلك بالإعتماد على متطلبات معايير الخدمة وعلى الأوضاع الخاصة بكل مؤسسة من مؤسسات التعليم الإلكتروني وفقاً للميزانية المخصصة ، ووفقاً للخطة المعتمدة للوصول إلى السوق ، وكذلك وفقاً للمتطلبات التشغيلية لمستوى الجودة ، وبالإعتماد أيضاً على الوضع التقني الراهن ومدى توفر البرامج الداعمة للخدمة.

يوفر النظام الخبير الدعم لكلٍ من مؤسسات التعليم الإلكتروني ولمقدمي الخدمات السحابية حيث يعمل على تعزيز الأعمال في مجال التعليم الإلكتروني. كما يعمل على توجيه وإرشاد مؤسسات التعليم الإلكتروني إلى البيئات الأمثل من بيئات التعليم الإلكتروني من خلال التوصية بالمزيج الأنسب من نماذج الخدمات السحابية التي تتلائم مع الميزانيات المعتمدة ومع الأوضاع والأهداف الأخرى. ومن ناحية أخرى ، فإن هذا النظام يقوم أيضاً بتشجيع مقدمي الخدمات السحابية على الدخول إلى مجال التعليم الإلكتروني من خلال وضع خريطة لسوق التعليم الإلكتروني حيث تساعد تلك الخريطة مقدمي الخدمات السحابية في التعرف على احتياجات السوق المستهدفة ، وفي تصميم العروض المقدمة من قبلهم عن طريق توفير المعلومات اللازمة.

يتمثل الإسهام الثاني لهذا البحث في وضع أسلوب لتطوير خدمات التعليم الإلكتروني من خلال تحوير خدمات المتاحة بشكل مجاني على شبكة الإنترنت ، والتي لم يتم تصميمها بشكل خاص لخدمة التعليم الإلكتروني. يوفر هذا الأسلوب تكاليف التنفيذ والتشغيل الباهظة التي تتطلبها أنظمة التعليم الإلكتروني ، حيث يساعد هذا الأسلوب كلاً من شركات الخدمات السحابية الصغيرة بالإضافة إلى الداخلين الجدد إلى هذا المجال ، في الإنخراط في السوق المخصص للتعليم الإلكتروني. كما سيعمل هذا الأسلوب أيضاً على توفير خدمات التعليم الإلكتروني لمؤسسات التعليم

الإلكتروني الصغيرة بطريقة سريعة وغير مكلفة من الناحية الاقتصادية ، وهذا بدوره سيعمل على تشجيع وتعزيز الأعمال ضمن هذا المجال.

وعلى الرغم من كل ذلك ، فإنه لا تزال هناك بعض القضايا التي تم ذكرها سابقاً والتي تحتاج إلى مزيد من الدراسة والبحث. لقد تم التخطيط للقيام بالمهام التي تقع ضمن أبعاد هذا البحث ضمن الأعمال البحثية المستقبلية. على سبيل المثال ، هناك الحاجة لإجراء المزيد من الأعمال البحثية بخصوص تصميم بقية خدمات التعليم الإلكتروني باستخدام تقنية "الخدمات المجانية FaaS " ، تشمل تلك الخدمات: وضع الجداول الخاصة بالإجتماعات ، وبالحصص الإفتراضية ، وذلك عن طريق استخدام تطبيق "التقويم المجاني Google Calendar " المقدم من شركة جوجل. من بين المواضيع الأخرى التي بحاجة إلى مزيد من الدراسة هي : مهام التشغيل والبث ، والواجبات والإمتحانات ، بالإضافة إلى المنتديات ومجموعات النقاش ، وغيرها.

ومن ضمن الأبعاد الأخرى لهذا البحث ، والتي بحاجة إلى مزيد من الدراسة والبحث هي النظام الإستشاري الخبير الموجه لمقدمي الخدمات السحابية ، حيث يشبه النظام الخبير الذي تم تنفيذه ضمن هذا البحث والموجه لمؤسسات التعليم الإلكتروني. يحتاج النظام الجديد المقترح لتزويده بإمكانيات إضافية ، بالإضافة إلى تصميم خريطة للسوق والتوسع في مجموعة بيانات القواعد ، عن طريق طرح عدد من الأسئلة على مقدمي الخدمات السحابية تتعلق بخطط الأعمال الخاصة بهم ، و وبالإمكانيات المالية لديهم ، وكذلك النماذج السحابية المفضلة لديهم ، وغيرها ، حيث سيتم الإعتماد على إجابات تلك الأسئلة في تقديم اقتراحات وخطط تتناسب مع الأوضاع الخاصة بكل شركة من الشركات المقدمة للخدمات السحابية. نعتقد بأن كلا النظامان الإستشاريان الخبيران المقترحان ضمن هذا البحث الموجهان لمؤسسات التعليم الإلكتروني ولمقدمي الخدمات السحابية ، سيسهمان معاً في بناء نموذج أعمال جديد يتلائم مع السوق الجديدة والواعدة في مجال التعليم الإلكتروني.