

# **Critical Investigation of Virtual Universities: Applying the UK Structure to Saudi Arabia**

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## **Declaration**

I declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification except as specified. This work is original work undertaken by me for the degree of Doctor of Philosophy, at De Montfort University, United Kingdom.

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## **Publications**

Throughout the course of the incremental study and research, the results have been reported and published in scientific papers:-

1. Albaqami, N., Dimitrov, J. and Nooh, N. (2014) A critical investigation into the information communication technology (ICT) architecture supporting virtual universities. *West East Journal of Social Sciences*, 2(3), 21-30.
2. Nooh, S., Janicke, H. and Albaqami, N. (2014) 'IT applications readiness using balanced score cards measurement', in *Proceedings of the 2014 WEI International Academic Conference*, Antalya, Turkey, 12-14 January, 2014.
3. Albaqami, N. and Dimitrov, J. (2014) The past, present and future of ICT in higher education: A survey of twenty UK institutions of higher education. *International Journal of Multidisciplinary Educational Research*, 3(12), 119-124.
4. Albaqami, N. and Dimitrov, J. (2014) UML analysis of a virtual university: A proposed model for Saudi Arabia, *International Conference on Communication, Media, Technology and Design (ICCMTD)*.

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## **Abstract**

The purpose of this study was to investigate the feasibility, practicality and desirability of establishing a virtual university (VU) using new technologies in Saudi Arabia and to explore how to apply the existing VU frameworks to the Saudi Arabian education system. This is desirable in order to accommodate the rapid growth in the number of secondary school graduates, and is regarded as one of the most important challenges currently facing Saudi Universities. The study traces the origins of VUs in the UK and Europe, then examines the tools, forums and methods in use, focusing on the main service-oriented architecture and the Simple Object Access Protocol framework.

Primary data were gathered by means of two sets of questionnaires, to explore the appetite for a virtual university in Saudi Arabia and to investigate the use of virtual learning in the UK. Three UK universities that strongly promote virtual learning (The Open University, the International Virtual University and Oxford University) were also researched online, providing an additional edge to the wider research on other universities. The investigation was motivated by a desire to produce a model that would widen learning opportunities for those who otherwise have no access to formal education in Saudi Arabia. The result is a virtual university model designed and developed to be a safe and secure Web-based educational system, providing online education for all, regardless of geographical position or time of day.

Data were gathered mainly from secondary sources, such as journals, conference reports and books. A literature review critically assessed several technologies and protocols, and a critical comparison of Web services was conducted. Evidence from the questionnaire, the literature review and informal discussions led this researcher to pursue further the concepts of messaging technology and distributed communication, focusing on implementing JMS and a message-passing system. As a result, a chat application which utilises the publish-and-subscribe messaging model and a translator are presented and recommended as essential elements in achieving virtualisation in higher education.

The thesis proposes a third-generation virtual university utilising cloud computing, offering integrated services to learners and including different types of online learning materials, specialized virtual centres for the development of educational courses, library and administrative functions, an interactive environment and online collaboration.

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# Abbreviations

API	Application Programming Interface
BERA	British Educational Research Association
CIO	Chief information officer
CORBA	Common Object Request Broker Architecture
DBMS	Database management system
EAC	Enterprise Architecture Council
ESB	Enterprise service bus
ESTAB	Established
FE	Further education
ICT	Information and communication technology
IM	Instant messaging
IP	Internet protocol
IT	Information technology
JMS	Java Message Service
JNDI	Java Naming and Directory Interface
KACST	King Abdul-Aziz City for Science and Technology
KAU	King Abdul-Aziz University
KSU	King Saud University
MEP	Message Exchange Pattern
MIME	Multipurpose Internet Mail Extension
MIT	Massachusetts Institute of Technology
ODOE	On Demand Operating Environment
PC	Personal computer
PKI	Public Key Infrastructure
QoS	Quality of service
REST	Representational State Transfer
RMD	Reliable Messaging Destination
RMI	Remote Method Invocation
RMS	Reliable Messaging Source
RPC	Remote Procedure Call
SI	Service integration
SMTP	Simple Mail Transfer Protocol
SOA	Service-oriented architecture
SOAP	Originally: Simple Object Access Protocol
SSL	Secure Sockets Layer
STC	Saudi Telecom Company
SYN	Synchronize
TCP	Transmission Control Protocol
TP	Transport Protocol
TS	Transport Service
UDDI	Universal Description Discovery and Integration
UK	United Kingdom
UML	Unified Modelling Language
URI	Uniform Resource Identifier
UT	Tabuk University
VLE	Virtual learning environment
VU	Virtual university
VUKSA	Virtual University of Saudi Arabia
W3C	World Wide Web Consortium
WS	Web service
WSDL	Web Services Description Language
WS-RM	Web Service Reliable Messaging
XKMS	XML Key Management Specification
XML	Extensible Mark-up Language
XSD	XML Schema Definition

# Chapter 1: Introduction

Accessing higher education in the Kingdom of Saudi Arabia has proved to be a challenge, for a range reasons, religious, cultural and administrative. This is evidenced by the large number of Saudi students taking up university studies in other countries; for example, there were 34,139 Saudis studying in the United States in the academic year 2011-2012 (Jiffry, 2013). However, there are attempts to widen learning opportunities for those who otherwise have no access to formal education in Saudi Arabia.

A religious and cultural barrier restricts women from pursuing university education, which in turn limits how far they can climb the career ladder. This is compounded by the fact that Saudi women are prohibited from driving cars, while public transport is limited, since most local travel uses privately owned vehicles. Consequently, females are dependent on male members of the family for commuting. Saudi women have displayed great potential for education and interest in it, evidenced by the sharp increase in female literacy. Meanwhile, the entry of females into the Saudi workforce has been facilitated by the recent introduction of training for professional women, allowing qualified women to update their knowledge and skills with a view to re-entry into the labour market (Jiffry, 2013, citing the Saudi Gazette, 2012).

Another factor to consider is Saudisation, which refers to the national policy of Saudi Arabia to encourage the employment of Saudi nationals in all sectors of the economy. This accelerating process represents a major challenge for the public and private sectors and for young people who have left school too early and now wish to improve their education and employability. With Saudisation, the demand for a highly educated national workforce is increasing, while supply remains constant, creating a worrisome skills gap as demand far exceeds supply.

In this researcher's opinion, one of the many logically possible solutions to these new problems and old constraints is the introduction of a virtual university (VU). A VU would open up access to higher education for all those people of Saudi Arabia who have

a strong appetite for education, success and nation building. With a VU, lectures and classes can be delivered to any location, utilising webinars, webcasts and online teaching materials. This mode of learning would support and advance the role of women in the community and workplace, because it does not require any physical contact between employees or students, one of the reasons behind the Islamic constraints on women in public.

The need to virtualise higher education is compounded by the recent sharp increase in the number of students applying for admission to universities (Saudi Gazette, 2012; Jiffry, 2013). The number of applicants greatly exceeds available capacity and is rising constantly with the ever-growing national population. Thus, many would-be students are denied the opportunity to obtain a university education. The increase in population compounded by greater demand for a skilled workforce has contributed to this discrepancy (Jiffry, 2013). The rise in the number of applicants to universities has caused intense pressure and workload for administrative and academic staff. The lack of tangible infrastructure to address rising demand is cited as a systemic impediment. However, universities across the Kingdom have tried hard to find constructive solutions to this problem, including the introduction of e-learning (Alshwaiver et al, 2012).

Meanwhile, according to statistics published in recent years (Al-Ani and Abraham, 2012; Alshwaiver et al, 2012; Jiffry, 2013), a revolution is taking place in the field of general education in Saudi Arabia. Quantitative and qualitative development and growth in education require the allocation of resources to higher education institutions and for research to focus on the problem of the increasing number of citizens dissatisfied with their restricted access to higher education.

In the light of this limited access to higher education, the need to empower women and the value of supporting Saudisation of the economy, this thesis presents fresh practical thinking on the provision of higher education through a virtual university. In proposing the introduction of a VU, this researcher was motivated by Al-Shehri (2003), whose doctoral thesis recommends further investigation of the influence of certain types of technology on the success of the VU model and the study of ways in which the current models could be standardised. These recommendations are consistent with the observation of Sneed (2006) that a majority of organisations which had been using

information technology (IT) for more than five years had realised positive growth, both financially and operationally.

It is reasonable to conclude that there is a great need for innovative and improved ways of utilising IT to meet national education and training needs, by means of the concept of a VU. The aim is to encourage, enable and promote secure interaction between the university and its main stakeholders, i.e. students, academics and administrators, without limitations of distance or time. With sufficient support from key decision-makers in Saudi Arabia, this online method of managing and providing education is expected to reduce the cost of education, since very limited physical structures will be needed. The virtual university is expected to greatly extend educational opportunities, as evidenced by the research of Ondari-Okemwa (2002) and Alshwaiver et al (2013).

Pursuing the agenda of virtualising university education, the present research argues that the VU should provide benefits such as expanding the time, place and pace of education, enabling learning to become more individualised, which feeds into the national policy of Saudisation. Therefore, there should be a strong emphasis on interaction and collaboration between students and academics. The aims and questions guiding this research are as presented in the following section.

### **1.1 Research Problem**

Among the most important and problematic issues emerging during recent years in relation to the limited access to higher education in Arab countries is the rapid growth in numbers of secondary school students. According to Al-Rashdan (2009), higher education in Arab countries faces many problems that hamper its ability to catch up with the demands of modernity and overcome its current weakness. He notes that as a result of the rapidly growing youth population, universities in most Arab countries are unable to absorb the growing numbers, in terms of either space or faculty. Although the increase in student enrolment in Arab countries hardly stands out from the trend in most developing countries, the authorities in these countries have tended to impose “specific admissions conditions on universities to reduce the number of students wishing to enter. Many have done so without providing an academic setting that can properly accommodate these numbers, while excluding certain groups from entering the

university system. All of these factors have had a negative impact on the level of education in Arab universities. Additionally, the centralization of most Arab universities in national capitals and the larger cities limits access for peripheral regions. As a result, citizens are offered unequal opportunities, severely hampering development and educational progress in the countryside”. Al-Rashdan (2009).

In Saudi Arabia, there has been rapid growth in numbers of secondary school students and a persistent need to connect the input and output of higher education institutions with the aims and strategies of the national development plans. These issues were raised by scholars attending the International Conference on e-Learning and Distance Learning in Riyadh in February 2011.

The *Saudi Gazette* (2012) quotes Dr. Mohammed Al-Ohali, Deputy Minister of Higher Education for Academic Affairs, as stating that Saudisation “requires a concerted effort among educational institutions, both public and private, to benefit the areas of e-learning and distance learning”. This indicates that there is a strong appetite for virtualising higher education within the corridors of power in Saudi Arabia. At the same conference, the Deputy Minister also described e-learning as “a source of vital support in the Kingdom’s educational system” (Saudi Gazette, 2012). This recent academic and pedagogical attention to e-learning through state-sponsored conferences is evidence of an awareness of a growing need for new frameworks and modes of learning to take the learning population beyond the constraints of the current bricks-and-mortar universities. More recently, this was expressed officially in the Ninth Development Plan (2010-2014) as one of the main concerns of the government; under the heading of ‘Basic Issues’, the plan lists:

1. Capacity

Because of the accelerated growth of secondary school graduates and limited access to higher education, the higher education institutions face a great challenge. This necessitates focusing on efforts to find solutions which best solve their problems. The higher education institutions then available were able to accommodate about two thirds of secondary school graduates. Recognising the importance of the problem of limited capacity that universities now face, the Saudi government has recently adopted new policies. In the past few years, under King Abdullah, Saudi Arabia has spent lavishly on higher education. About a quarter of each annual budget goes toward education, including the



establishment of more educational institutions and universities. The number of public universities in the country has risen to 28 in the past twenty years, while existing ones are expanding in capacity and many more colleges scattered throughout the kingdom, offering onsite course with limited online facilities. Despite the rapid expansion of university provision, the growth in demand for tertiary education still outweighs supply meaning that some prospective students still find it difficult to obtain a university place in Saudi Arabia.

## 2. Balancing Need with Available Specializations

The great pressure on the universities forced them to accept students beyond their capacity. This resulted in an imbalanced situation between the scientific and theoretical specializations since about two thirds of the students were admitted to the theoretical facilities. In the present context of the Saudisation of the national economy and the continual need to connect the input and output of higher education institutions with the aims, objectives and strategies of the national development plans, there is an urgent need to restore the balance in the specializations in higher education as this has become a need to meet the current circumstances and the development requirements. According to Mona AlMunajjed (2005), Saudi society has unique social characteristics; therefore, education needs revision and diversification. He noted, “The Saudi government should invest more in specific specializations and skills, so as to build a balance between tradition and demands for the productive participation of women in society”. There should be some departments ready to give women a more specialized higher education and grant them the possibility of employment. Dr. Abdulfattah Mashat, Dean of Admissions and Registration at King Abdulaziz University, reported at the Second International Exhibition and Conference on Higher Education in Riyadh (2011) that at his university, net enrolment (for both males and females) in theoretical specializations had increased significantly in the last ten years, resulting in an imbalance between scientific and theoretical specializations.

### 1.2 Research Questions

According to Walliman (2011), concurring with Denscombe (2010) and Kumar (2005), every research study should have aims and questions to help the researcher and readers to follow a specific topic of interest. Bearing in mind that the current study is an exploratory one, it has research aims and questions which are also exploratory in nature.

This research attempts to answer the following three related research questions or sets of questions. The first question relates to pedagogical challenges: What are the likely advantages that might support the exploitation of digital technologies in delivering

higher education in Saudi Arabia? The second relates to planning and politics: What other practical and reasonable options might be available for decision-makers to solve the problem of rapid growth of students seeking higher education places? The final set of questions is related to technological problems: What are the likely limitations that may impede the utilisation of virtual university technologies in delivering higher education? What is the virtualising of university education? What are its benefits and challenges? Within the SOA framework, how can a virtual university be a service provider? What are the services that a virtual university can provide, request and register in a service-oriented architecture? How can available technology be utilised to improve the virtualising of university education?

### **1.3 Purpose of the Study**

The predominant challenge facing Saudi universities is to accommodate the increasing numbers of secondary students. The higher education decision-makers have made great efforts to meet this challenge by increasing the number of students being accepted, but this is beyond the capacity of the existing universities. Among the solutions attempted have been the founding of new universities, the development of a new set of admission regulations and the awarding of overseas scholarships in the name of King Abdullah. Despite these efforts, the problem persists and will continue to do so unless there is fundamental change. This study addresses this need, seeking a logical solution to what has become a national problem.

### **1.4 Aim of the Study**

The aim of this study is to investigate the feasibility, practicality and desirability of establishing a virtual university based on suitable technologies, to deliver higher education. This would constitute an alternative to the solutions previously attempted by the Saudi Government to cope with the proliferation of potential higher education students in Saudi Arabia. This aim can be expressed in terms of three subsidiary aims. The first, within the realm of virtualising university education, is to critically explain the concept of the VU and identify its benefits and challenges as it relates to Saudi Arabia. The second is to critically investigate and explore the use of service-oriented architecture (SOA) in the support and implementation of a VU. The third is to provide

novel compositional theory and an approach to the integration of online services for the coherent endorsement of the VU in enhancing the benefits and addressing the challenges identified.

### **1.5 Objectives of the Study**

The current research thus seeks to expand and develop the distance learning scene in Saudi Arabia, to incorporate the possibilities of virtual universities and extend facilities to all who have need of them in different situations. In line with these interests, it has several main objectives:

- To find the most suitable technology for supporting virtual universities;
- To understand SOA and the various key standards that enable the realisation of web services, such as SOAP, WSDL and UDDI;
- To assess the efficacy of virtual universities in the UK and Europe;
- Finally, and most pertinently, to help further develop virtual university systems alongside the traditional educational system in Saudi Arabia, in particular by studying current virtual universities and applying the outcomes of the first two objectives to the process of implementation.

These objectives will be achieved by:

- a) investigating the major aspects of technologies which currently exist to support virtual universities;
- b) examining current VU models in UK universities, which deliver higher education by using new technology, in order to suggest a VU model for Saudi Arabia.
- c) exploring the key components of the communication technology infrastructure currently existing in UK Universities and establishing an internet-based VU in Saudi Arabia.

### **1.6 Research Hypotheses**

The following two hypotheses have been formulated for this study in order to examine their validity:

1- Establishing a virtual university based on new technology has the potential to extend higher education opportunities to all applicants.

2- Establishing a virtual university based on new technology has the potential to provide both male and female students with equal educational opportunities.

These were tested by analysis of the questionnaire responses.

### **1.7 Limitations of the Study**

During the past ten years, the Saudi Higher Education system has experienced rapid growth in the number of both private and public universities, and in enrolments. Most universities are for men, but some are exclusively for women. This study will consider only three public universities that are overseen by the Ministry of Higher Education: King Saud University, King Abdulaziz University and Tabuk University.

Other identifiable limitations of this study are as follows. First, the approach taken to investigating virtual universities is to focus on virtual learning environments (VLEs). It is reasonable at this point to acknowledge that the VLE is a small element of university administration and therefore some recommendations here may be affected by other aspects of university administration such as the availability of finance and technical skills. The second limitation is that as much as technological development is appreciated, there has been no research to establish whether the intended beneficiaries of the VU technology would benefit from this approach, considering that Saudi Arabia is a conservative society. In this researcher's opinion, it is neither easy nor straightforward to import an idea from the Western world and implement it in an Islamic country such as Saudi Arabia. Therefore, there is a need for research to show if the intended recipients of virtual education, such as women, would be receptive to virtual education or whether they would feel even more closed off from the interactive outside world.

### **1.8 Thesis Contributions**

This thesis proposes a third-generation virtual university which utilises cloud computing and offers all of its services to its learners in an integrated way. These services include the provision of online learning materials of different types, specialised virtual centres

for the development of educational courses, library and administrative functions, an interactive environment for synchronous and asynchronous communications, and online collaboration. The three contributions of the thesis which are repeatable in any other country with similar religious and cultural issues are: first, to the best of the researcher's knowledge, this is the first study of its kind that suggests establishing a virtual university in Saudi Arabia. Therefore, the ensuing blueprints may be used as a foundation for the future construction of the proposed virtual university in the Kingdom Saudi Arabia and any other country by identifying the current structures and infrastructures of virtual universities and comparing them to Saudi Arabia's educational needs and to its cultural and religious background. Secondly, this study provides a detailed and structured approach to establishing a VU model based on respondents' opinions, a literature review, the researcher's knowledge and existing virtual university models, such as the Open University and the International University, to create an architecture that can be used as a model for implementing a VU in Saudi Arabia, or in any other country with a similar background. The third contribution is a case study in the form of a prototype which will work with the developed model.

In addition, the study makes a contribution to knowledge by presenting a Web-based virtual university model that can be implemented in the Kingdom of Saudi Arabia and any other country. This thesis also presents new ways of utilising existing technologies, which is a first in the Saudi Arabian education system. The proposed model utilises a protocol in the form of SOAP which will be used by systems to communicate with each other. One of the major strengths of this study is to derive a better understanding of the potential opportunities and challenges of using the new technology as an educational delivery mechanism through a detailed review of the literature related to using internet-based technology in e-learning.

For maximum benefit, all services must also be described in a machine readable form using Web Service Description Language (WSDL), where the names of the functions, their required parameters and their results can be specified. Clients, comprising users and businesses, would have to utilise Universal Description, Discovery and Integration (UDDI) to find the services they need. Further important contributions to knowledge are that this thesis proposes a third-generation VU which utilises cloud computing, offering

all its services to the learners in an integrated way, and that these services include online learning materials of different types, specialized virtual centres for the development of educational courses, and administrative functions.

## **1.9 Thesis Structure**

The remainder of this thesis is divided into eight chapters, covering respectively a literature review, the research methodology, the rationale and preliminary findings, application-to-application technologies, the proposed architecture, an illustrated blueprint of the proposed VUKSA, evaluation and findings, and conclusions. Some of the more important sections of the thesis are outlined below.

The **literature review chapter** covers a number of themes, including the concept of virtual universities, service-oriented architecture and approaches, technologies and research issues, the impact of SOA, comparison of web services, Java Remote Method Invocation (RMI) and the Common Object Request Broker Architecture (CORBA), and comparative studies of SOAP versus Representational State Transfer (REST). From the literature review it is established that the advantages of virtualising universities outweigh the disadvantages, using the already available architecture and technologies.

The **questionnaire results section** puts into perspective the real benefits and challenges of virtual learning environments by analysing data collected from organisations where e-learning was being practised, using Blackboard and Moodle. The questionnaire results generated suggestions which are built into the proposed model.

The **historical perspective section** briefly spells out the history of e-learning and SOA from the days of two-tier architecture, comprising a mainframe and a dumb terminal, the contemporary three-tier architecture, consisting mainly of a database tier, middle tier and front-end tier. The section concludes that this three-tier architecture is ideal for a VU, as it utilises Extensible Mark-up Language (XML), SOAP (originally Simple Object Access Protocol), UDDI and WSDL.

The **section on application-to-application technology** critically discusses web services, the fundamentals of SOA, service integration, remote procedure call, transport protocols, sequencing network services, SOAP and the concept of XML. It concludes

that the available technologies are ideal for a VU, as they provide reliable and secure messaging technologies.

The **section on registering and discovering web services** is divided into service registry and service discovery, which are two core functions of SOA. UDDI is presented as a registry that contains relatively lightweight data with the prime purpose of providing network addresses to the resources it describes. Then the messaging technology section explains the Java Message Service (JMS) and transactions, a message-passing system and Web Service Reliable Messaging (WS-RM). It establishes that end points provide four basic delivery assurances: at-least-once delivery, at-most-once delivery, exactly-once delivery and in-order delivery.

Following the registering and delivering section is the **section on securing web services**, addressing issues pertaining to security, securing and protecting system contents, threats, authentication, authorisation and session control. It concludes that for a VU to be successful, its security features should ensure that system users have confidence and trust in the system. The recommended strategies are form-based authentication and database privileges. A **case study** is then presented as an implementation of an instant messaging application, enabling two or more participants to exchange messages in an asynchronous manner.

## **Chapter 2: Literature Review**

### **2.1 Introduction**

Lee and Lings (2008) concur with Bell (1995) that a literature review serves to look again at what has already been written on a topic, demonstrating one's own understanding of that which has been done before and pointing to where that particular research is deficient in some way. Fink (2005: 3) states more formally that a "literature review is "a systematic, explicit and reproducible method for identifying, evaluating, and synthesizing the existing body of completed and recorded work produced by researchers, scholars and practitioners".

Therefore, after a short section on the contextual background to the present study, this chapter systematically and explicitly identifies, evaluates and synthesises the existing body of literature on virtual universities, with particular reference to the works of Carbonnier G et al. (2014), Benatallah et al (2011), Bieberstein et al (2005), Sneed (2006), Papazoglou and van den Heuvel (2007) and Wagh and Thool (2012). In reviewing these published works, this researcher critically explains how his own work adds to the existing body of knowledge and overcomes the shortcomings of that literature by bringing together disparate fields of research and extending them (Lee and Lings, 2008).

### **2.2 The Kingdom of Saudi Arabia: A Brief Overview**

The Kingdom of Saudi Arabia is the largest country in the Middle East, occupying almost four-fifths of the Arabian Peninsula, which is located in south-western Asia. The country has undergone a rapid, radical and comprehensive transformation since the discovery of oil in the 1930. Its history can be said to begin in 1902 when it was founded by King Abdulaziz, who established his capital at Riyadh, in the centre of Saudi Arabia. Other major cities include Jeddah, a port on the Red Sea; Mecca, the holy city of pilgrimage for all Muslims; Medina, another holy city for Muslims; Dammam,



an oil city on the Arabian Gulf; and Al Jubal and Yanbu, which are new industrial cities (Alrawaf, 1990).

### **2.2.1 Higher Education System in Saudi Arabia**

In any modern society, higher education plays an important role, and equipping professional personnel with the necessary qualifications, knowledge and skills to contribute to building their societies and maintaining economic growth and social development. Therefore, the objective of the Saudi Ministry of Higher Education is to develop educational provisions which reflect precisely the kingdom's social and educational needs. Its students should attain the highest possible standards and universities should be uniformly administered.

Higher education in Saudi Arabia can be seen as the highest rung of the educational system, encompassing all types of education beyond secondary schools, in colleges, universities, and technical and vocational training colleges.

Formal education in Saudi Arabia dates back to King Abdulaziz, who first introduced and made accessible formal education and the facilities required for its effective working more than a hundred years ago. It has, as one would expect, developed gradually over time, and higher education began in Saudi Arabia in the 1960s. King Abdul-Aziz University (KAU) was established in 1967 and its name honours the patron of Saudi Arabian formal education. Smith,L.and Abouammoh,A.(2013) .

The Saudi higher education system is extremely centralized and is governed by the Ministry of Higher Education, which was established by royal decree in 1995. It is designated as the highest educational authority, responsible for all educational activities. Its main tasks are planning, education policy, governing higher education affairs, developing higher education, monitoring all activities, coordinating its entire organisation, and allocating appropriate funding to all its educational institutions. However, each university has a council to oversee and to execute all general educational policies and all administrative and financial functions. Thus, the council has considerable influence over most education-making processes concerning its organization (www. Ministry of higher education).

### **2.2.2 The Study System in Saudi Universities**

The study system in Saudi Universities is indistinguishable from university systems in most parts of the world today. Every full-time student has to commit him/herself to undertake a full schedule in order to meet the overall requirements of the study plans set by their colleges. Saudi universities have practised two different study systems: a yearly system and a half-yearly or semester system. However, most universities in the Kingdom currently use the semester system, which replaced the old system based on credit hours. Students have to complete eight semesters (four years) successfully in order to be eligible for a Bachelor's degree in theoretical fields, and five to seven years in some scientific fields such as medicine. The dominant teaching language in theoretical subjects is Arabic, while English is used at different levels in scientific fields. Some universities offer external study or distance learning (Intisab); the philosophy underlying the creation of this system was to meet the needs of students who did not have any sort of access to higher education. The first to offer this system in 1965 was Imam Mohammed Bin Saud Islamic University. The programme was later extended to encompass most universities in some specialties such as Islamic studies and Arabic language. Students are able to join the programme today, depending on their type of study, if they have obtained a total GPA of at least 60%. At the start of the first semester each year, the university organises a two-month orientation programme for all potential students (Smith and Abouammoh, 2013).

At King Abdul-Aziz University, for example, there is a great need to expand capacity. There is a very high cut-off requirement for students seeking entry to universities and a low number of seats in proportion to the number of applicants every year. KAU's total roll of about 3,000 students in 1967 at its inception has since multiplied to more than forty thousand students, due to an increase in population and an accompanying increase in the amount of applications received for entrance to higher education. With the limited availability of resources in relation to demand, this situation necessitated urgent attention. A temporary solution was to extend the admission numbers for students. This situation could not be sustained much longer and the option of distance learning soon entered the socio-cultural framework. KAU was a pioneer of its kind in distance learning in Saudi Arabia. It was started in the early 1980s without internet or

communications technology, using contact classes, end-of-term examinations and interviews. Since then, it has witnessed several changes in its structure and regulations (www.kau).

Initially, the proposal was for students to attend the first two or four weeks of the academic year on campus. They would attend lectures, gain access to basic information about all their modules for the semester and be given their notes, study material and resources for the year. The students would then be required to return for end-of-course examinations and progress reports. The duration of this initial period depended on which college the student attended, of the two offering distance learning courses at the time.

### 2.2.3 IT Infrastructure in Saudi Arabia

The Internet in Saudi Arabia was opened to public access in 1997. All Internet use is filtered, and all connectivity must be accessed through the King Abdul-Aziz City for Science and Technology (KACST). All methods of access must subscribe to this condition (Sait et al., 2002:1). KACST is an independent scientific organisation, overseen by a supreme committee of ministers (of defence, education and planning, economy etc), chaired by the Prime Minister (the King). KACST is charged with formulating the national science and technology policies of the Kingdom, and with promoting and coordinating research activities among scientific institutions and research centres. As Table 2.0 shows, in June 2012, there were estimated to be 13 million Internet users in Saudi Arabia, i.e. close to half of the population (Internet World Stats, n.d.).

Table 2.0: Saudi Arabia Internet usage statistics

YEAR	Users	Population	% Pop.	Usage Source
2000	200,000	21,624,422	0.9 %	ITU
2003	1,500,000	21,771,609	6.9 %	ITU
2005	2,540,000	23,595,634	10.8 %	C+I+A
2007	4,700,000	24,069,943	19.5 %	ITU
2009	7,761,800	28,686,633	27.1 %	ITU
2010	9,800,000	25,731,776	38.1 %	ITU
2012	13,000,000	26,534,504	49.0 %	IWS

Source: Internet World Stats

The Sixth Development Plan for the Kingdom of Saudi Arabia includes a clear vision of the role of technology to develop the country along the lines of international standards in order to enhance local capabilities for bridging the technological gap between Saudi Arabia and the developed world by 2020. Strategies have therefore been developed for investing in fields of technology. The Saudi government has played a major role in introducing IT into the Kingdom, to connect all public offices with the latest technologies, to improve the quality of work and to encourage all private agencies to adopt and apply highly developed technology. These efforts are an exact reflection of the long-term objectives expressed in the Development Plan.

KACST provides the following network services:

**KACST NET:** A dial-up communication network connecting scientific and research centres within government organisations in Saudi Arabia with the KACST central computer system. KACST NET is also linked to the computers at the National Computer Centre in Riyadh via a leased line.

**GULFNET:** KACST was the first academic computer network in the Arab world, founded in 1985 by governments of participating network members to provide information support for academic institutions and scientific research. The network consists of fourteen nodes: eleven in Saudi Arabia and three in Kuwait) [www.kacst, n.d.](http://www.kacst.n.d)

**CD-ROM Net:** This is being used by a growing number of institutions and business enterprises because of its vast storage capabilities, which do not require any telecommunication infrastructure or additional expense. In 1991, KACST formed a CD-ROM network to provide research centres with direct multiple access to bibliographic, numeric and full text compact disk databases in science, technology and business through a LAN.

**Telecoms, Mobile, Broadband and Forecasts:** The Saudi government regards development of the ICT industry as a national priority that offers many opportunities for the future use of recent technological developments in cloud computing and smart technologies. “There is a strong ICT market, which is growing year-on-year. In mid-2013, in a move towards liberalisation, three virtual telecoms licences were awarded in

Saudi Arabia. In addition, there are growth opportunities in data services for both fixed and mobile devices. Data fees will become more and more important to overall revenues in the future. Fixed broadband penetration is growing strongly in the kingdom. Broadband is available via ADSL, fibre and wireless. Mobile broadband has also become a feasible proposition and viable alternative to fixed broadband following substantial investments in 3G and LTE technology". (BuddeComm, n.d.).

**Fibre-Optic Technology:** Today, most Saudi communications companies provide fibre-optic broadband to most parts of the country, with super high speeds of up to 2 Gb/sec and high bandwidth, offering easy and seamless bandwidth upgrades with high source connectivity solutions. The technology provides telecommunication services at the highest quality standard as well as the most up-to-date broadband services and applications (Saudi Telecom Company [STC], 2015).

According to Engineer Saad Al-Qahtani, vice president of the Saudi Telecom Company (STC) for the Residential Services Sector (cited by Saudi Gazette, 2015), STC has launched a home fibre-optic service providing Internet speeds up to 100 Mb/sec. The homes would be linked to a modern fibre-optic network with high capacities. STC's success in launching this service is considered to be a qualitative change and a huge leap in Internet services, including visual services, developed conversation services, satellite TV transmission services that will enable viewers to watch TV programmes with high quality and clarity, besides downloading videos, electronic games and recreation services (Saudi Gazette, 2015).

**Saudi Net** is the name of the ongoing IP network in Saudi Arabia. The aim is to outline the infrastructure required for KACST to be connected via the Internet to all educational institutions and the government (www. kacst, n.d.).

#### **2.2.4 National Telecommunications Infrastructure**

The Saudi telecommunications sector is growing at a remarkable rate in terms of amenities and services. The national telecommunications infrastructure and its regulation are the responsibility of the Ministry of Post, Telegraph and Telephone, which has played a major role in establishing various networking facilities and services, as described below:

### **Switching network**

The switching network consists of three switching nodes, in Riyadh, Dammam and Jeddah; 95 concentrators (Advanced Network Nodes) in 45 locations; and an international X.75 link to more than 50 foreign data networks (www.kastc).

### **Transmission network**

As well as the fibre-optic cable system, coaxial cable systems carry many national telephony circuits between Riyadh and Dammam, and between Riyadh and Jeddah.

### **Mobile networks**

In the Kingdom, there are two paging systems, POCSAG and ERMES that have been installed to serve most of cities. The ERMES-based digital paging network is connected with the packet switching network to provide personal computer (PC) users a means of sending alphanumeric pages from their individual computers. Additionally, a more advanced GSM 900 digital network has been in place since 1996.

### **Submarine cables**

Submarine cables complement Saudi Arabia's wire and satellite network to make the country an international hub for communications. Saudi Arabia is linked with Egypt by a 70 km coaxial submarine cable and there are two other cables linking the country with Bahrain and Djibouti. These are connected to earth stations distributed around the country.

### **Analogue and digital network**

Saudi Arabia has a wireless network (analogue and digital) with a current capacity of about 200,000 lines, in addition to the wire-based phone lines. The backbone of the existing Saudi long-distance network was formed by an extensive, mostly analogue, microwave radio system.

According to (Carmel, n.d.) “Wireless network includes approximately 4000 km of analogue coaxial cables between Riyadh and Dammam and between Riyadh and Jeddah, approximately 1200 km of digital coaxial cable, and approximately 2000 km of optical fibre systems, including a multimode fibre system between Makkah and Taif ”. In addition, new microwave links with Arab countries have been opened to strengthen regional communication. There is also a domestic microwave network between smaller towns which supplements the 9300-mile 550-station microwave system (Carmel, n.d.).

### **2.2.5 Readiness of ICT in the Education Field**

The readiness for integration of ICT in education and other fields of study is discussed by Ramady (2010), who notes that the Saudi Government has many projects on the integration of ICT in education. There are comprehensive plans to integrate ICT in general education, including the following:

- The Prince Abdullah Computer Project for students (Watany) connects public schools with the national network, in addition to providing a LAN service in each school and one computer per ten students.
- School libraries are developing into learning resource centres, using computers and other ICT to access all sources of information, and integrating them into the curriculum.
- The computer-lab project gives students first-hand experience in using educational software applications and computer sensors. In this technology, the components of scientific experiments are integrated with the computer.
- The Ta’heel training project for secondary school students includes training course in most of areas of computing to better align computer hardware and software. The project aims at preparing schools graduates in the field of computers, in cooperation with the private sector and the Saudi Computer Association.
- Digital technique centres have been established in most educational regions. The aim of this project is to support educational needs in the areas of digital

content and educational applications. The centres are supported by a unit for the production of digital interactive educational aids to supplement the school curriculum (Ramady, 2010).

### **2.3 Virtual University Concept**

In the literature, several authors have attempted to define the concept of the virtual university. Therefore, the VU is not a new concept, but it can still bring new experience to the Kingdom of Saudi Arabia. Similar projects have been introduced in countries including Pakistan, the UK and the USA, but not yet in Saudi Arabia. Where the concept has been introduced, studies by Subramani and Ryan et al. (2012), Carbonnier G et al. (2014) and Giertz (2010) all indicate that among the benefits of virtualising university education are lowering costs and opening up access. Ryan et al. (2012) describe the virtual university as “one which loses much or its entire geographical locus (geographical virtuality)”.

Means et al. (2010: 34) found that “students in online conditions performed modestly better, on average, than those learning the same material through traditional face-to-face instruction.” The same research also concluded that “the learning outcomes for students who engaged in online learning exceeded those of students receiving face-to-face instruction”. Therefore, in terms of educational provision in Saudi Arabia, virtualising university education would add value to the existing system.

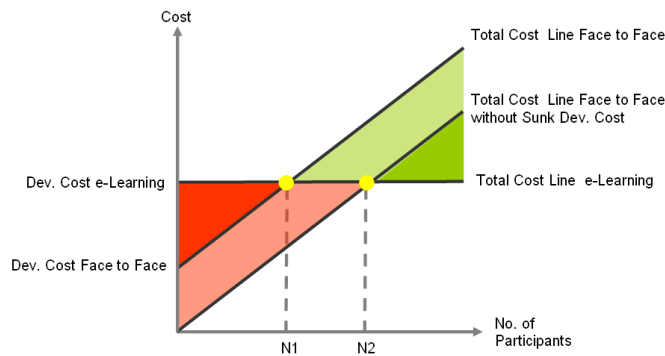
This research acknowledges that existing virtual universities provide online educational facilities, such as making available online documents, student handbooks, module guides and application forms. To be successful, a VU system should be secure, interactive and dynamic enough to satisfy the learning needs of a growing population with a strong appetite for tertiary education. The short history of virtual education started in the UK, according to Rowntree (1992).

In addition to virtual universities per se, most universities and other educational institutions now provide e-learning facilities. Subramani and Walden (2001) studied the impact of e-commerce on the market value of firms, questioning the returns to shareholders in firms engaging in e-commerce. They addressed the following question: “How does the return to conventional, brick and mortar firms from e-commerce



initiatives compare with returns to the new breed of net firms?” Their findings from a survey of 251 e-commerce initiatives suggest that such initiatives do indeed lead to significant positive cumulative abnormal returns to shareholders. Based on these findings, this researcher is persuaded that educational institutions and the Kingdom of Saudi Arabia at large will benefit from e-learning, just as commercial firms benefit from e-commerce.

The findings of Subramani and Walden (2001) match well with the cost analysis published by Giertz (2010), illustrated in Figure 2-1 below;



**Figure 2-1: Cost comparison (Giertz, 2010)**

Giertz (2010) explains that both traditional and online courses have fixed development costs and that the development cost of face-to-face training is lower than that of e-learning. However, once developed, an e-learning course does not incur any further costs, resulting in long-term benefits. Figure 2-1 above shows that the total cost line for e-learning is horizontal, whereas the traditional course entails such variable costs as the cost of the trainer, so that the total cost line of the face-to-face course continues to rise after development.

An important difference between the work of Subramani and Walden (2001) and the present research is that the former focused on commercial institutions, whereas this research is concerned with the provision of education. However, in this researcher’s opinion, the findings of Subramani and Walden (2001) are not limited to commercial enterprises, but can be extended to all other institutions.

In research related to that of Subramani and Walden (2001), Newtonraja and Nafde (2004) studied an online course registration system in order to explore the data modelling concepts that are used in real-time scenarios and to implement a fully functional database system which would interact with frontline end users. The findings of this and other related research indicate that there are more advantages than disadvantages. For example, Anderson (2008) argues that VLEs “offer a wide range of advantages over traditional environments, including convenience, flexibility, lower costs, access to current materials, increased retention of knowledge and the elimination of geographical boundaries”. The same researcher adds that virtual universities expand the time, place and pace of education; enable learning to become more individualised; and facilitate interaction and collaboration between students and academics. All these advantages motivated this researcher to critically investigate virtual universities.

Among the similarities between the work of Newtonraja and Nafde (2004) and this project are that the proposed model is anchored on SOA with a front-end web interface middleware and a back-end database. Another similarity is that both projects use SQL. Writing on virtualising university education, Georgieva et al. (2003) explain that most VUs offer mainly Internet-based educational courses, considering themselves virtual environments for the development, editing and reading of learning materials. According to the same researchers, these are first-generation virtual education facilities, which are characterized by a web interface for the learner, a database of learning materials, a testing system, a discussion forum, an email system and so forth.

According to Georgieva et al. (2003), a second generation of virtual education systems comprise an administrative system of an integrated database and a platform for e-learning with a structured educational process. A good example of a second-generation VU is the University of Phoenix Online, which has pioneered many of the facilities that its online students enjoy. These include “evening classes, flexible scheduling, continuous enrolment, a university-wide academic social network, online classes, a digital library and computer simulations” (University of Phoenix, 2013).

The third generation of VUs, which is proposed in this thesis, has no physical buildings. It is a model of a real university in the virtual space and offers all its services to learners in an integrated way through the Internet. These services include the provision of online

learning materials of different types, specialized virtual centres for the development of educational courses, library and administrative functions, interactive environments for asynchronous and synchronous communications and online collaboration (Georgieva et al., 2003). A good example is the UK-based International Virtual University (IVU), which claims to provide a unique method of studying supported by virtual learning. This means that students can set their own timetables to suit the way they live (IVU, 2013).

Examples of third-generation VUs which are purely virtual are difficult to identify, as most institutions which claim to be VUs are real-world universities offering selected online facilities, including the University of Phoenix, Michigan Virtual University and a number of other VUs listed by UNESCO (2013).

#### **2.4 Definition of Virtual University**

The term ‘virtual university’ is relatively new. The VU is assumed to be similar in its basic functions to its counterpart, the traditional university, with the difference that it offers education through e-learning and gives students the opportunity to learn at their own pace, space and place. Ryan et al. (2013 :3) describe a virtual university as:

“An institution which is involved as a direct provider of learning opportunities to students and uses information and communication technologies to deliver its programmes and courses and provide tuition support; and

An organisation that has been created through alliances/partnerships to facilitate teaching and learning to occur without itself being involved as a direct provider of instructions”.

Benatallah et al (2011: 23) state that

“The online or virtual university has emerged as a potent vision for the future of higher education, utilising new information and communication technologies (ICTs) to radically restructure higher educational provision and to re-equip the university for its new environment”. What is generally envisaged in this scenario is a university without walls, a virtual institution consisting of little more than global connections of potential students (recruitment), learners and teachers (students and staff), employers (the careers’ function), and alumni, in terms of teaching and learning, and researchers, and research users, in terms of the institution’s research mission, all held together by ICT applications.

Lyanovic,M, and Jan,L (2013) hold that there is a paradigmatic structure for all universities, just as there is for any society or community. In many respects then, drawing on Lyanovic,M, and Jan,L (2013) ,

a university is a learning society or community of practice with research-oriented goals. If the university is a spatiotemporal field where people study the application of knowledge to problems at an advanced level, (then) what constitutes the society, knowledge and problems, who are the teachers, students and researchers and how the quest for knowledge is pursued depend upon the episteme within which the university exists.

Thus the virtual university is no different in terms of goals and practices, but only in the management and the structure in which the process takes place.

## **2.5 Boundaries and Definitions of Terms: E-learning, Virtual University and Traditional University**

For the sake of consistency, clarity and the avoidance of confusion, the researcher will use certain terms very frequently in this study. Therefore, it is crucial to identify and define these precisely and accurately, as follows:

E-learning is the option of learning from outside the classroom. Several attempts have been made to concisely and comprehensively define distance learning. However, in its most important difference from the virtual university, distance learning is a method of pursuit of higher studies in which learning only ever happens in conjunction with a traditional classroom setting and under the umbrella of the traditional university. It is a way in which the traditional university maintains its structure and offers modules, or even courses sometimes, using many different communication and distance operation methods.

The virtual university is an entire system. It can stand alone and it operates autonomously. The VU includes the already existing content and classrooms, libraries, teachers, students and communities, but the education is through the Internet. Thus, students may consist of default grade students in Australia, Malaysia, Brazil, Saudi Arabia and the United States attending a lecture by means of the Internet given by a

Professor in Britain. They are able to interact within the virtual university at any time or place convenient to them.

The previously cited definitions by Ryan et al. (2013) and Benatallah et al (2011) stand as valid. However, a virtual university is distinguished as much by its similarities to a distance learning course as its differences. The primary difference, as pointed out above, is the totality and individuality of its functioning and operation. It is an entire academic body, collegiate or otherwise, standing on its own; it does not necessarily depend on the existence of a covering body, such as a traditional campus university.

Moreover, distance learning offers students the option of meeting tutors. Tutorials can be set up between students and lecturers. Students can request a meeting for a book or advice or comments on their work to date. The lecturer must have a timetable with many possible meeting times for his assigned students or tutees to choose from. By contrast, virtual universities do not offer such a possibility. The only communication is by email or ‘blackboard/whiteboard’ systems designed for specific courses or student-list mailers. This can be a disadvantage, because any clarification or inadequate teaching input will remain unresolved. This study will analyse the advantages and disadvantages of virtual universities in full in a later chapter.

Despite the aforementioned differences, it must be pointed out that distance learning and the virtual university are similar also in some respects. They differ in management, degree and scale, but often apply the same concepts in their methods and pedagogy. Therefore, throughout this dissertation there will be much discussion of distance learning and of the tools and interactive interfaces used already in the rather more tested arena of e-learning. Communication modes in virtual universities and distance learning courses are also similar. Materials such as hand-outs and presentations must be made available online in both cases. In Malaysia, for instance, there are universities offering distance learning courses with e-classroom settings. Karim and Ufuktepe (2012) discuss the shape of a “future classroom” with a learning interface for use in the Malaysian academic culture. In their trial course, Harsh and Sohail (2012) encouraged student-student communication online as well as face-to-face. They made all student-student communication on the course available for access by the instructors, and communication by email was also shared. Although it would not be viable to include

face-to-face communication in a virtual university scenario, it is possible and also commendable that interaction such as this might enable distance education students to gain confidence in the interaction and hands-on experience that they might lack.

A virtual university has a participative element that is not necessarily a component in distance learning. Distance learning is often through mail, electronic or otherwise, and interactive interfaces such as Blackboard or WebLearn may be lacking. “Many skills from teachers and learners are required to achieve informed interaction, however, an open discussion is difficult to attain if a critical number of students become actively involved in the process” (Stein, 2011:3).

Traditional universities are run conventionally with hands-on practice and direct contact in a classroom setting. The technologies used in teaching, as listed by Bates and Poole (2013:53), are: “Direct face-to-face contact; Text (including still graphics); (Analogue) Audio ; (Analogue) video; and Digital Multimedia”. Bates and Poole (2013:53) define these technologies as “ways of mediating and interpreting knowledge.” With the exception of direct face-to-face contact, all can be used by both traditional and virtual universities. The difference lies in the intention with which they are used. In traditional universities, technology is used to enhance input and make teaching more effective. In fact, this is the pedagogy that Bates and Poole (2013) start from in their discussion of technology use in higher education. However, an expansion of the definition of these teaching tools becomes incumbent when interpreted in the light of virtual universities. The tools become media essentials as well as enhancers. In addition to being “ways of mediating and interpreting” the subject-specific knowledge, they are also means of communication. In fact, Bates and Poole move on to classify them into ‘broadcast applications’ and ‘communication applications’ (2013:55), then demonstrate how they perform a dual function and have specific roles according to the type of university structure concerned.

## **2.6 Historical Background**

Distance learning has very early origins. It started at a university level when the University of Queensland, Australia, began to extend degree courses through distance learning options to its students (Harry and Magnus, 1993). However, the very first of its

kind at any level in Europe, introducing course material and teaching input through correspondence, was in England in the mid-19<sup>th</sup> century. Early methods of distance learning naturally used the postal system to make available higher education to those students who were unable to or unwilling for some reason to attend conventional classroom-type teaching courses. Rowntree (1992:8) reports that “Isaac Pitman started to teach shorthand by post in 1840 and in 1856, language teaching by correspondence started in Germany. During the second half of the 19<sup>th</sup> century, correspondence education became well-established in the USA and Europe.”

The introduction of educational radio in the 1920s and the advent of television in the 1940s created important new forms of communication for use in distance learning. Greater reliability and advances in telephony in the early 20<sup>th</sup> century increased the potential and availability of distance learning options and the efficacy of such methods also improved. The demand for information and education expanded and spilled out of the four walls of conventional universities but telephone systems were not yet popular. It was the advent of teleconferencing technologies in the 1980s and 1990s which made it possible for teachers to talk with their students, as well as see them and hear them in real time and with no delays in transmissions, regardless of location. It was then that telephony in distance learning came to stay.

Next, computer conferencing greatly bolstered distance learning, because with the communication network it afforded, large numbers of people gained access to educational facilities. With the endless communication possibilities such networking offered, larger numbers of people had potential access to these facilities. Today, most institutions around the world offer distance learning content (Mann and Robinson, 1987).

The Internet was the result of some visionary thinking by people in the early 1960s. Allowing computers to share information opened up very exciting new possibilities in scientific and military research and development. Most historians agree that the Internet originated in the United States of America (Ackermann and Ernest, 1999) when the Advanced Research Projects Agency started a network called ARPANET in 1969. The Internet was derived from this military-based research to produce a professional, social and communication network that would not break down, even in difficult conditions

such as total isolation or emergency situations. The idea was that all computers or terminals on a particular network would share all information and therefore also the responsibility for ensuring effective vital communication. This is evidenced in that, based on the same model, no single computer on the Internet is more important than others or assumes a controlling or moderator position. During the 1970s and 1980s, other institutions began using the Internet protocol to connect their networks, and the attempts continued to expand globally.

One of the major criticisms of the early distance learning media, such as radio and television broadcasts and videocassettes, were that these technologies are one-way communications which do not permit interaction and collaboration in a distance learning environment. The new technology resources have overcome these problems and have introduced a variety of technologies for mobile phones, which have the ability to deliver courses either asynchronously through some technologies such as chat, forums, email and social media, or synchronously through the use of presentations, virtual classes and e-conferencing. The technology revolution has played a significant role in changing the methods of traditional education, permitting interaction between learner and learner, learner and peers, learner and instructor, thus promoting collaborative working.

Current technologies mean that courses are no longer constrained by geographical boundaries. This puts much pressure on e-learning to design and develop courses that can travel and gain acceptance across nations whose cultures differ widely. Takle and Taber (2000), Lee et al. (2000) and Atkinson (2002) list several advantages of the World Wide Web which might encourage the use of these technologies in a virtual learning environment, including ease of use, flexibility, quick updating of materials, and materials that can be distributed across multiple platforms. The simplicity of using the Web is attracting and motivating distance learners to enrol in virtual classes without fear. In recent years, the computer has come from relative obscurity to become an integral part of everyday culture, with a speed of growth resembling a catapult effect. Using a computer, one can successfully achieve many educational tasks such as research. In fact, technology has made education faster, more accessible and more convenient, personal computers have increased our ability to access information, and in



recent years, revolutions in information technology have increased the worldwide spread of distance learning.

Having provided an overview of the research topic and given reasons for the study, the next section presents definitions of a virtual university.

## **2.7 Virtual University Models**

Virtual universities have many advantages, especially for non-resident, part-time, financially disadvantaged or physically disabled students. The new technology makes the idea of virtuality applicable and widespread through the Web, using different learning methods and techniques, regardless of place or time. Moreover, the outcome of these universities is very similar to those of real ones. However, VUs are not suitable for all subjects, including medicine, because of the need to be in a lab or real-life situation, but are available and applicable for a wide range of other subjects. Perhaps in the future we will see virtual universities covering all subjects, using new technologies not available at present. The social and functional role of technology is continually growing and its influence is therefore easily felt in all walks of life. But at present, realistically tracing the conditions and operations of virtual universities must involve an acknowledgement of their limitations.

One of the most comprehensive studies of virtual education models and the development of virtual learning in general is that of Farrell (1999), who identifies the factors that influence the development of virtual learning models as follows: increasing capacity of new technology with suitability of educational applications and decrease in the cost of hardware, capacity of the new technologies, growth of knowledge, and realisation that quality of the learning can be enhanced by applying communication technologies. In addition, Farrell, categorises types of virtual education as follows: multi-institutions, offering e-learning on a (traditional) university campus; single-mode, usually print-based but using ICT to support distance learning; broker-type organisations, which deliver programmes from other institutions; information and facility provider-type organisations such as the University for Industry in the UK; and institutions created with no intention to supplement learners with direct instructions, one example being the Western Governors University in the United States.

The second dimension that has fostered the emergence of new virtual education models is the growth of the private sector and the technological revolution. Universities of this type are increasing in number day by day because of their low cost of operation, flexibility of interaction, widespread range, and easy-to-access methods. This has created three models of virtual universities, as identified by Guruz (2011):

“For-profit universities such as The University of Phoenix and Jones International University that were created to deliver direct instruction to a more focused target rich market, corporate organisations that established network training for internal training needs and are striving to gain official recognition (one example is South Africa Telecom), and for-fee service organisations that concentrate on providing certain kinds of service such as project management, technical support and so on”.

Guruz (2011) identifies four main types of virtual university: single-model universities, where the main focus on distance learning; dual-mode institutions (traditional and non-traditional); mixed-mode (traditional and non-traditional), supervised by the same academic members; and consortia (partnerships), offering multiple teaching methods under a single management unit.

These virtual universities are a by-product of Internet usage and are instrumental in higher education today. They reduce the use of many facilities in traditional universities and are one of the outcomes and consequences of the current technological revolution. It can be observed that the concept of a virtual university implies the following common characteristics:

- They have no campus; instead they rely on new technologies which are capable of performing the same functions as traditional universities.
- Revolutions in information technology have made distance learning a rapidly growing phenomenon worldwide and will have a major impact on the adoption of e-learning methods.
- The mission of a virtual university is to increase educational opportunity, which means great solutions for those students who are unable to continue in education because of a disability or because of the high fees of traditional universities.

## **2.8 Limitations and Challenges of Virtual Universities**

A great deal of research has also been conducted on the limitations and challenges of virtual universities and e-learning worldwide. Much of this work has centred on the pedagogical curriculum and technical, cultural and ethical issues. Ryan (2013), for instance, studied specifically the new way of designing and delivering the curriculum. Garrison and others (2013) discuss virtual universities from a more global perspective, focusing on global interaction. Naslund's focus is on the European Open University and virtual university initiatives. These authors and others have identified limitations and challenges affecting e-learning which any research in the area cannot afford to ignore, which are now considered under four main headings: pedagogical, technical, cultural and ethical issues.

### **2.8.1 Pedagogical Issues**

The validity of pedagogical censorship seems to be rather controversial. It is anticipated that the argument about whether or not there is a need for pedagogical censorship will continue whilst it is still in practice, in one way or another. Researchers have raised some concerns about student discipline and evaluation in virtual universities. Gosper et al. (2013) warns that a lack of self-discipline and no fixed timetable may negatively affect students' work. Students and lecturers are separated by time and space, but it is the online lecturer's responsibility to ensure the commitment of students. A possible solution to these issues would be to create a students' area; this would be an environment or interactive area where they could access their courses, assignments, email, virtual tools and facilities such as Blackboard and WebLearn, online tutorials, library and tools to interact with teachers.

Natriello (2005) argued that another problem is that several faculties have refused to accommodate e-learning courses into their curriculum. As a result, many of the university lecturers interviewed regarded virtual education environments as a new challenge for them, because their teaching methods had to meet the needs and expectations of many different participants. In addition, they had to be able to develop an understanding of the capabilities, goals and needs of the students without personal contact, which was difficult. Natriello (2005) pointed out the notion that teaching online

requires the development of new skills and sets of pedagogies which has led researchers to study the roles that online instructors take in online education environments.

Espasa (2010) indicated that “educators and organizations around the world are becoming more involved in e-learning although the growth in faculty involvement and acceptance has been modest, accompanied with a limited change in the availability of online pedagogies”. Salmon (2012) highlighted a number of problematic issues associated with e-learning, including information overload on the net, which could lead to learners becoming frustrated or disappointed due to the time constraints placed on them. Indeed, students could easily be overwhelmed by the amount of information available on the net without the appropriate level of guidance from the lecturer. Therefore, the lecturer should identify a number of useful sites that can be accessed by students in order to avoid such disappointment. Moreover, information overload can occur as a result of increasing the amount of e-mail messages that students may receive at once, or through class discussion in large groups. Some possible solutions to these issues are to secure students' e-mail addresses and to limit the number of participants in the online class.

Lockwood and Gooley (2007) pointed out that convenience is another advantage of education based-internet, which is the order of the day for most ‘consumers’ in the service sector, and the education sector ought to be no different. Self-paced and individually adapted learning is possible, as noted before. There is also the possibility of the virtual interactive forum or ‘classroom’ to facilitate interaction between the students and also teachers and students. Further, the most current materials and resources can be made available centrally on the electronic database and accessed by all students immediately. Moreover, there is also accessibility for those with restricted mobility (e.g. the handicapped, injured, elderly) as well as accessibility for those with family responsibilities (e.g. parents with young children at home). He indicated that internet-based education extends learning beyond the classroom to learning communication, including creating an environment where learners are supported in developing independent learning skills. The web provides many opportunities and advantages to

teachers and learners in terms of its capacity to provide access to information, support collaborative learning and enable communication between learners.

Stella (2004) outlines the integration opportunities provided by learning with personal computers and points to the dilemma facing distance education because of the fine line between accessibility and quality. In addition he raised some concerns about the quality of e-learning and how to ensure this is at an adequate standard. Therefore, most institutions have developed benchmarks to ensure the quality of distance-learning education. He revealed that the Institute for Higher Education Policy in the USA has produced 24 benchmarks that cover seven aspects which are considered essential to ensure excellence in internet-based distance learning. These are: Institutional Support, Course Development, Teaching/Learning, Course Structure, Student Support, Faculty Support and Evaluation and Assessment.

Stella stated that in the UK, new guidelines for e-learning and distance learning in higher education have been published by the Quality Assurance Agency (QAA). The guidelines are arranged under some headings: Program Design, System Design , The Management of Program Delivery, Student Communication and Representation and Student Assessment”.

Finally, the duty of the government is to practise a degree of control with regard to education content, to preserve social and cultural values and maintain social cohesion. The Ministry of Higher Education should be the body responsible for exercising government powers and evaluating the effectiveness of the virtual university as a teaching method.

### **2.8.2 Technical Issues**

There is no doubt that there are some technological issues associated with using the Internet in a virtual learning environment, such as the technical knowledge of both tutors and students. Adequate technical knowledge is essential in order for the tutor to deliver the course successfully via computers and the Internet. Pfeffer (2012) notes that one of the most serious obstacles to the development of effective educational and instructional software is considered to be the lack of adequate collaboration and co-

ordination among educators and technical professionals, including between online instructors and software developers, which can result in poor courses or poor material. Another problem is that some trends in the use of the Internet can already be observed. The researcher proposes the extensive and intensive use of the Internet to make e-learning a comprehensive and effective means of knowledge transmission.

Another potential problem with the virtual university is the level of software available within the organisation. Thus, Fulford (2013) cites Johnson et al. (2008) as warning that some organisations are unable to adapt to repeated changes in the business environment due to the difficulties of reconfiguring their systems depending on new technologies; they therefore have continued to run outdated versions of software. In order for virtual universities to run successfully, having the right technology is of paramount importance.

Ryan (2013) indicate that despite these issues, e-learning is an economically profitable venture which must be understood as more and more students express their preference for it. The universality of the Internet as a means of communication for students worldwide expands the bounds of the classroom and makes global and multicultural transference a distinct possibility. It has now become commonplace for a university to set up an exclusive portal for its students and other members to use for e-learning and database access. This proves very useful for students seeking academic literature and available research resources. International students can take advantage of the language options and translation in university intranets and portals.

### **2.8.3 Cultural Issues**

One of the most important problems within culture is resistance to change, even in developed countries. Some highly experienced lecturers are rather unwilling to use virtual learning environments, preferring the traditional approach of interacting physically with their students. This finding is consistent with the reported difficulties of establishing an African Virtual University in the face of resistance from those preferring to use traditional teaching methods: “The chalkboard is still a very common and popular feature in lecture halls in many universities across Africa” (Ondari-Okemwa, 2002:326). Apparently, fear and reluctance to deal with cultural change caused by the advent of new teachings methods is a universal phenomenon; people often resist change as they feel threatened and intimidated by any new movement that might change their stability

and the daily routine of their job. Indeed, all of the challenges mentioned above are consistent with the research of Ondari-Okemwa (2002), who concludes that the heavy reliance of all virtual organisations on ICT exposes them to technical challenges. In developing countries, such organisations, including the African Virtual University, operate in ‘technological deserts’ and are peripheral to the global knowledge revolution.

#### **2.8.4 Ethical Issues**

Violation of ownership and intellectual property rights is one of the most fundamental issues facing virtual universities and must be addressed and resolved before any e-learning courses or programmes can be implemented. Brey,(2004) explains that copyright is the legal concept of ownership over the things that a person creates to protect his or her intellectual property. It permits a limited use of the original works after obtaining permission from the copyright owner. In order to avoid possible copyright violations, e-learning providers must take proactive measures and have clear statements which are displayed appropriately on the website of the university. Online students must be provided with specific guidelines and policy information regarding copyright laws and the ownership of materials. Finally, plagiarism may be a problem, because identifying users of computers is extremely difficult; the most serious problem in this regard is related to examinations and how students may be reliably tested over the Internet. Brey,(2004: 3 ) revealed that “ universities do not just teach knowledge and skills, they also transfer cultural values, such as academic values like honesty, collegiality, respect and openness, and other core social values such as individualism, competition, civic engagement, responsibility and loyalty”.

#### **2.9 Service-Oriented Architecture**

Papazoglou (2008: 22) defines SOA as “a logical way of designing a software system to provide services either to end-user applications or to other services distributed in a network via published and discovered interfaces”. The researcher further explains that the essential aim of SOA is to enable general-purpose interoperability among existing technologies and extensibility to future purpose and architectures.

According to Bih (2006) and Arsanjani (2004), SOA software design and software architecture design patterns are based on structured collections of discrete services

which collectively provide the complete functionality of a large software application.

They go on to explain that

the purpose of SOA is to allow easy cooperation among a large number of computers connected in a network, where each can run an arbitrary number of services which are able to exchange information with any other service within the network without human interaction and without the need to make changes to the underlying program itself.

On the same subject, Lewis and Smith (2007:10) state that the “common goals for the adoption of SOA are to eliminate redundancy, assemble new functionality from existing services, adapt systems to changing needs, and leverage legacy investments”.

It follows from the above explanations that the development of a virtual university requires the present researcher to investigate critically a basic SOA which involves two services requiring a means of interconnection. With SOA, this researcher believes that system development will overcome many of the challenges of distributed enterprise computing, including application integration, transactional management and security policies, while allowing multiple platforms and protocols, and leveraging numerous access devices and legacy systems.

### **2.9.1 Historical Perspective**

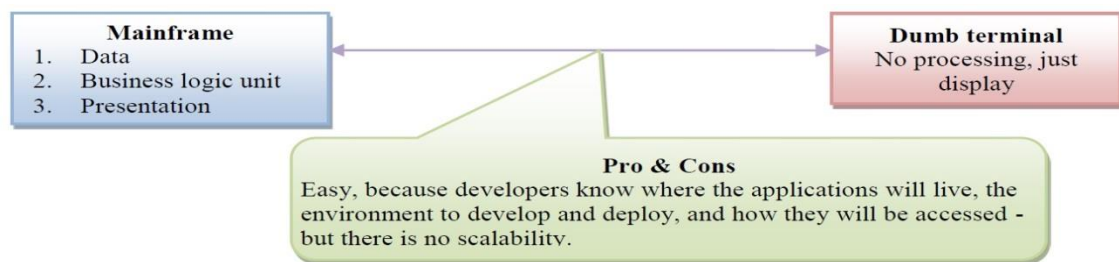
The historical view of service-oriented architecture and its supporting technologies begins with the origin of SOA in the 1960s, when it was simple two-tier architecture, with the mainframe doing all the work and the dumb terminal only tapping into the server to display the results. Research and development resulted in improved two-tier architecture in the 1980s, when personal computers could handle some of the computations and validations. Further improvements around the turn of the century resulted in a three-tier architecture, comprising database, business logic and client tiers. The advantages and disadvantages of each architecture are discussed as relevant to the present work.

In this researcher’s opinion, Ostrowski (2009) presents an easily understood account of the history of SOA in three phases, prefaced by a definition of the term ‘software architecture’ as specifying the relations among the parts of a computer system and how



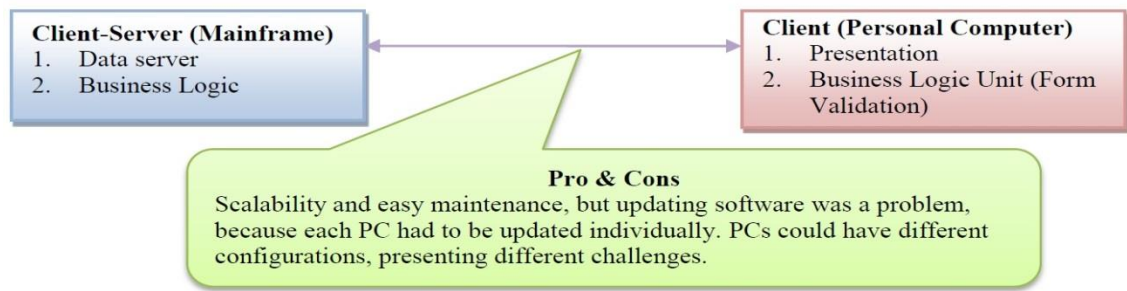
its applications are layered. Bass et al (2013:4) concurring, define the software architecture of a system as “the set of structures needed to reason about the system, which comprise software elements, relations among them, and properties of both”.

Ostrowski (2009) states that in the early days, during the 1960s and 1970s, software architecture had a two-tier structure comprising a mainframe and a dumb terminal, as presented in Figure 2-2.



**Figure 2-2: Basic Two-tier Architecture, adapted from Ostrowski (2009)**

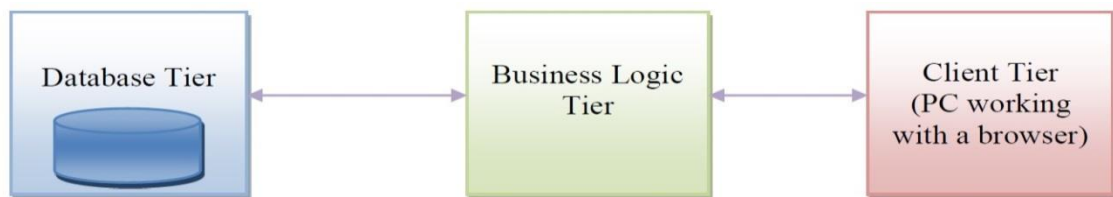
With this two-tier architecture, according to Ostrowski (2009), the mainframe did all the work of data storage, business logic unit operations and presentation, while the function of the dumb terminal, as its name suggests, was simply to connect with the mainframe and display the results of the mainframe processing in a form readable by human beings. The basic advantage of this architecture was its ease of use for developers, as noted in Figure 2-2, while its greatest problem was its lack of scalability. In this instance, scalability refers to how applications will be handled when more users come aboard and when new applications and functionalities are developed. For example, form validation was done at the mainframe level, while the dumb computer could only display. The two-tier architecture was then improved in the 1980s, resulting in the production of PCs, which could do presentation and some business logic unit operations, such as form validation, while the mainframe maintained its core function of holding data, and these are illustrated in Figure 2-3.



**Figure 2-3: Improved Two-Tier Architecture, adapted from Ostrowski (2009)**

An example of form validation is checking whether a specific field has been completed with the correct response. For example, in a gender field, the acceptable responses might be F for female and M for male. Checking for this could be done before the form could be sent to the server; this is called client validation and is a key component of Web-based systems such as virtual universities.

Further software developments in response to the challenges of earlier versions resulted in the three-tier architecture shown in Figure 2-4.



**Figure 2-4: Three-tier Architecture, adapted from Bass et al (2013)**

The three-tier or multi-tier architecture, as explained by Bass et al (2013), concurring with Ostrowski (2009), involves the addition of a layer called the business logic tier, service tier or middle tier, between the two layers of the early architecture. In the two-tier client-server solution, the client handled the business logic, which made the client 'thick'. A thick client means that it required heavy traffic with the server, which could make it difficult to use over slower network connections like the Internet and wireless. This thinking client is an important aspect of virtualising systems.

The solution, which remains in use today, was to introduce a middle layer to deal with business logic, so that the client handles only presentation logic. Thus, relatively little communication is needed between the client and the middle tier, making the client thin

as opposed to thick. An example of a thin client is an Internet browser, which provides users with information very rapidly; indeed, with almost no delay.

As more users access the system which is synonymous with virtual universities, a three-tier solution is more scalable than its predecessor. Among the advantages of this architecture, which is practicable with a VU, is that many more middle tiers can be added as needed, each running on its own server, to ensure good performance. This is called n-tier or multiple-tier architecture. Three-tier architecture offers better security, because the middle layer protects the database tier. Maintenance is also improved in the sense that in the event of new applications and/or debugging, there is no need to work on each PC individually, as everything can be done on the application server. However, n-tier architecture has one major drawback which this researcher is aware of as it relates to virtualising university education: the additional tiers increase the complexity and cost of the installation.

The account given above allows the provisional conclusion that the architecture for web services and in particular virtual universities is founded on principles and standards for connection, communication, description and discovery. This leaves the question of where in the three-tier architecture the code resides. The simple answer is that the PC level handles some form validation, using JavaServer Pages in the browser, for example, while some validation goes on in the application server and some database validation occurs in the server.

### 2.9.2 Fundamentals of SOA

To be clear on what this project entails, it is the researcher's intention to present a simplified SOA as shown in Figure 2-5 (Bih, 2004), where a service consumer on the left sends a service request message to a service provider on the right, which in turn sends a response.

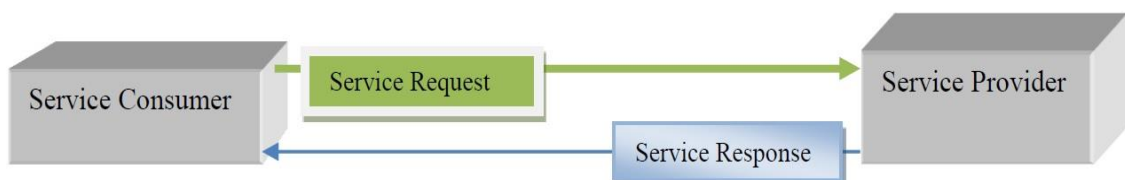


Figure 2-5: Basic Service-oriented Architecture, adapted from Bih (2004)

The request and subsequent response are defined in a way that is understood by both consumer and provider. Bih (2004) emphasises two important facts concerning SOA: that a service consumer can also be a service provider and vice-versa, and that there are usually three primary parties: the provider, the consumer and a directory of services, as shown in Figure 2-6.

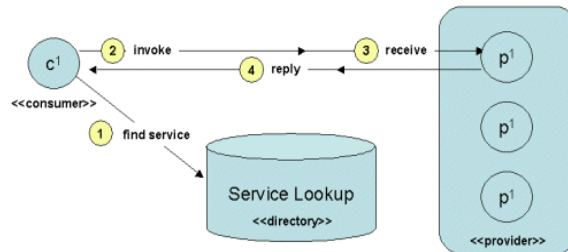


Figure 2-6: Service Provider, Consumer & Directory, Bih (2004)

Bih (2004) cites an alternative depiction given by IBM (2004), whereby SOA consists of three participants (service provider, service requester and service broker) and three fundamental operations (find, bind and publish), as shown in Figure 2-7.

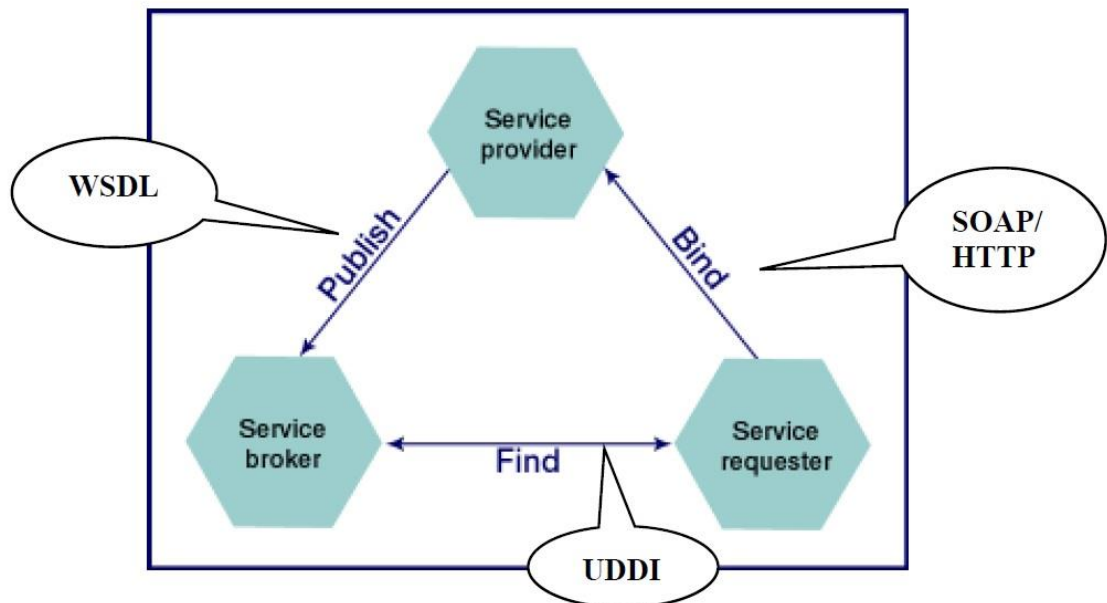


Figure 2-7: Components of SOA (adapted from IBM, 2004)

Adopting another variant nomenclature, Moller and Schwartzbach (2008) agree with Weerawarana (2008) in referring to the service user or client, a network component that uses a service made available by a service provider through an exchange of messages.

The service registry or broker is a metaservice using UDDI to allow providers to publish their services and users to find appropriate services. “All communication between the components is performed using SOAP” (Moller and Schwartzbach, 2008:470). Papazoglou (2008) concurs with Weerawarana (2008) and Moller and Schwartzbach (2008) that service providers are software agents responsible for publishing a description of the services they provide in a service registry, whereas clients are defined as software agents that request the execution of a service. Clients must be able to describe the services they require and bind to them.

Explaining the arrows in Figure 2-7, Bih (2004:3) states that “providers publish services to a service broker. Service requesters find required services using a service broker and bind to them”. The focus of this interactive process which is important for a VU is on the service components, in contrast to the objects, as in the object-oriented paradigm. In a similar explanation, Papazoglou and van den Heuvel (2007) state that the service requester (client) communicates with a service provider via a service request. Bass et al (2013) also explain that services largely stand alone, are usually deployed independently and often belong to different systems or even organisations. “Components have interfaces that describe the services they request from other components and the services they provide ... quality attributes can be specified and guaranteed with a service-level agreement ... in some cases these are legally binding” (Bass et al, 2013: 222).

According to Papazoglou and van den Heuvel (2007: 392), “service brokers are trusted parties that force service providers to adhere to information practices that comply with privacy regulations, or in the absence of such laws, industry best practices”. The same researchers further explain that service brokers maintain an index of available service providers and serve as intermediaries. This indicates that broker-sanctioned service providers are guaranteed to offer services that comply with local regulations, while creating a relationship of trust with customers and partners.

Wac et al (2010) agreed that SOA requires service providers, a service registry and service users to interact through publishing, finding and binding operations, which involves acting upon service artefacts: “service description and service implementation. “A service provider is responsible for publishing a description of its services in the

service registry ... a service user finds a suitable service registry and binds to this service in order to utilise the service” (Wac et al., 2010: 179).

To summarise this subsection, it appears that from a business perspective the WS provider is the organisation that owns the Web service and implements the business logic which underlies it. Since the provider is responsible for publishing the services it provides in a registry hosted by a service discovery agency, then it is structurally responsible and practicable for virtual universities to work with different WS providers.

Secondly, the service requester or client from a business perspective is the enterprise that requires certain functions to be satisfied and from an architectural perspective is the application that looks for and subsequently invokes a service. The requester searches the service registry for the desired WS, discovering its description in a registry provided by a discovering agency and using the information in the description to bind to the service (Papazoglou, 2008).

The third participant in SOA is the service registry, a searchable directory where service descriptions can be published and searched. It is here that requesters find service descriptions and obtain binding information (Papazoglou, 2008).

Considering the functions of these three components, the present researcher draws the preliminary conclusion that a virtual university would ideally act as a service registry, because it would be able to provide sufficient information for service requesters to contact or bind to the services providers, making use of their services. A virtual university, as a Web service discovery agency, should be responsible for providing the infrastructure required for the three basic operations of SOA, enabling providers to publish Web services and requesters to search for and invoke these services.

## **2.10 Comparison of Web Services**

Gray (2004) compares Web Services, Java-RMI and CORBA solutions to performance problems identified in earlier WS studies, asserting that newer WS application programming interfaces (APIs) “realize a model that has significant overlaps with distributed object technologies, allowing in some cases for the use of a common code base in either a readily deployed WS or in a higher-performance distributed object style

implementation”. Gray (2004) presents his comparisons in terms of three criteria: costs associated directly with communication protocols, cost of document transfer, and costs of XML generation and parsing, in common implementation for WS and Java-RMI.

Having reflected on this treatment of the topic, the present researcher concludes that there is no definite and clear-cut answer to any of the questions and problems which Gray (2004) addresses. The paper nevertheless has some strength, such as providing clarity on the definition of a Web service and on how the performance of a framework or a specific web technology can be measured, as well as distinguishing between Web services and distributed object technologies. Defining his terms clearly, Gray states that a service is defined simply by an end-point that supports various operations. “In terms of Java-RMI or CORBA, a Web Service is like a singleton server object. The singleton server character of a Web Service means that a stateless-server architecture is preferred” (Gray, 2004:52). He further explains that while there are mechanisms allowing the implementation of stateful servers, WS implementations sustain different client-side application program interfaces. This, according to Gray, is possible because “the client code may work by constructing ‘call’ objects that are dispatched to the server, or may use a higher level interface that hides the communications level entirely through the use of client-side stub objects with an operational interface which mimics that of the server”.

The second apparent strength of the paper lies in how Gray (2004:54) presents and explains the results of the study, using five different technologies: “JAXRPC from Sun’s Java Web Services Development kit (JWSDP), Tomcat 5 as incorporated in JWSDP, Java RMI from Java 1.4 SDK, Java CORBA from Java 1.4 SDK and Ethereal network traffic analysis program”. He then explains step by step the technologies used, how the tests were performed and the measures taken. His tests were performed on a network system with 100 Mb/sec Ethernet backbone utilising a Sun v480 (1030 MHz) server and a group of SunBlade 150s (650 MHz) running client applications.

Gray (2004) also explains that network “traffic analysis was conducted using the Ethereal tool to capture packets transferred over the 100 Mb/sec Ethernet between a SunBlade 100 server and a client 2 GHz Dell Optiplex GX260 machine running Win2000”. All of this detailed explanation is consistent with recommendations by

Wisker (2008) “that research methodology should be designed in such a way that confidence can be had in its findings, which includes incorporating or accounting for all important influences on the issues or variables being investigated”. While Gray (2004) expresses his findings in a very technical language, consistent with the nature of the conference where the paper was originally presented, he does so in a way which is easy to follow and understand, with appropriate use of tables, pieces of code and clear English explanations.

Comparing the costs associated directly with communications protocols, Gray (2004) found that in terms of total data transferred in bytes, Java RMI excelled at 7670, which was more than double the figure for CORBA and name server (3340) or WS (3338) and seven times greater than CORBA (1111). In terms of total latency and packets, it is also clear that Java RMI transferred more packets (48) in less time (0.32 s) than CORBA, which transferred only 8 packets in 0.48 s (Table 2-1).

**Table 2-1: Cost of single shot request using various technologies**

Technology	Total Latency	Total Packets	Total data transferred in bytes
WS	0.11 s	16	3338
CORBA	0.48 s	8	1111
CORBA	0.86 s	24	3340
Java-RMI	0.32 s	48	7670

Source: adapted from Gray (2004)

Gray (2004) concludes from the data in Table 2-1 that the Java-RMI solution appears better than CORBA, even though the former has the most complex mechanism, involving the establishment of a connection to the RMI registry, the submission of a lookup request, the establishment of a connection to an HTTP server, the posting of a request to download a class file, then finally, exchanges with the actual server. On the criterion of cost of document transfer, however, Gray (2004:59) reports that “CORBA implementation performed best with the large data transfer example. Here CORBA has an advantage over Java-RMI primarily because of its use of an 8-bit character encoding for data transfers as opposed to Java-RMI’s 16-bit coding”. Nevertheless, Java-RMI has a generally superior performance; a secondary factor is Java-RMI’s inclusion of some class metadata in responses that include class instances such as strings. presented by Gray (2004).



Table 2-2 reproduces the comparison in terms of cost of XML generation and parsing, as presented by Gray (2004).

**Table 2-2: Measured CPU times for client and server**

Application	Calculator		Data		Large Data	
	Client CPU	Server CPU	Client CPU	Server CPU	Client CPU	Server CPU
WS	15.0 s	6 s	22.8 s	8.4 s	1087 s	551 s (436 s)
Java-RMI	2.3 s	0.8 s	4 s	1.1 s	148 s	212 s (97 s)
CORBA	3.2 s	1.9 s	3.6 s	2.1 s	54.2 s	250 s (136 s)

Source: adapted from Gray (2004)

This researcher agrees with Gray (2004) that in term of CPU usage, the data in Table 2-2 show Java-RMI to be the best of the three technologies studied. However, Gray (2004:60) cautions that the Java-RMI solution “requires 2.8 times as many packets as the CORBA solution and this seem to be impacting client-side performance more than server-side performance”. In the same explanation, Gray (2004) makes a very useful comparison, pointing out that “the JAXRPC solutions require up to six times as much CPU power on the server and that the client-side parsing of large data documents has an even higher cost. On the other hand, the Java-RMI solution was consistently the best in terms of overall runtimes (actual time elapsed for the client to complete its sequence of requests), while the CORBA solutions took about 10% longer”.

Another strong point of the study is that the findings are communicated clearly, responding to the research questions and presented in the same order as the research themes. This researcher was also impressed with the conclusions drawn by Gray (2004) because they are consistent with the statement of Murray and Beglar (2009:113) that “a conclusion is a way to round off a discussion ... the purpose is always to draw together all strands of the discussion up to that point and provide a resolution of some kind.” In my opinion, Gray (2004) draws conclusions directly relevant to the study and clearly derived from its findings. For example, Gray (2004) concludes that “the substantial commonality of code base for the various technologies makes dual deployments possible”. He further concludes that “some problems associated with very large responses from a Web service can be alleviated through the use of a stateful iterator approach”.

Finally, it should be acknowledged that reviewing this paper has shown the present researcher how study reports should be presented and allowed him to learn three technical lessons. The first is that:

“Web Service implementations support different client-side application programmer interfaces and client code may work by constructing “call” objects that are dispatched to the server, or may use a higher level interface that hides the communications level entirely through the use of client-side stub objects with an operational interface that mimics that of the server”(Gray, 2004:52).

The second lesson is that if a service has heavy internal use on an intranet, and external Internet users, then one possible approach is to use a common implementation for Java-RMI services which extends `java.rmi.server.UnicastRemoteObject`. The third and final lesson learnt is that of the three application technologies, WS, Java-RMI and CORBA, Java-RMI has a generally superior performance supported by “the inclusion of some class meta-data in responses that include class instances such as strings” (Gray, 2004:59). The next subsection reviews a comparative study of SOAP and REST.

### **2.10.1 Comparative Study of SOAP and REST**

A very short journal article by Wagh and Thool (2012) comparing the SOAP and REST WS provision techniques for mobile hosts is relevant to this research for two main reasons. First, Web services are now moving towards wireless technologies for mobile applications, evidenced by the ever increasing number of users (Wagh and Thool, 2012). The second reason is that mobile devices are operating as WS providers, thanks to advances in their capabilities and in wireless communication techniques. Therefore, it is imperative to critically review this article for the purpose of gaining knowledge on how SOAP compares with other technologies.

The researchers declare two clear aims: to provide a detailed comparison between two frameworks used for providing Web services through SOAP and REST, and to critically discuss the problems and challenges associated with these two frameworks. Wagh and Thool (2012) present this comparison in the form of a table, whose five key points in this researcher’s opinion are listed in Table 2-3 below.

**Table 2-3: SOAP/REST Comparison**

<b>SOAP</b>	<b>REST</b>
Is the prevailing standard for web services and hence has better support from other standards (WSDL, WS) and tooling from vendors.	Lack of standard support for security, policy, reliable messaging, etc., so services that have more sophisticated requirements are harder to develop.
SOAP is more secure because it uses WS-Security, which was created because the SOAP specification is transport independent and no assumptions could be made about the security available on the transport layer.	REST assumes that the transport will be HTTP (or HTTPS) and the security mechanisms that are built in to the protocol will be available.
Changing services in SOAP web provisioning often means a complicated code change on the client side.	Changing services in REST web provisioning requires no change in client-side code.
SOAP is not wireless infrastructure friendly and its web services always return XML data.	REST is wireless infrastructure friendly and its web services provide flexibility in regard to the type of data returned.
SOAP uses HTTP-based APIs, i.e. APIs that are exposed as one or more HTTP URIs and typical responses are in XML/JSON. Response schemas are custom per object.	REST adds an element of using standardized URIs, while also giving importance to the HTTP verb used (e.g. GET / POST / PUT)

Source: adapted from Wagh and Thool (2012)

The work of Wagh and Thool (2012) is consistent with a comparison made by Bass et al (2013), addressing three questions: how to compare the two technologies, what each technology is good for and “what are the road hazards you need to be aware of?” (Bass et al, 2013:108). In replying to their own questions, Bass et al (2013) explain that through SOAP, four standards are defined, the first being infrastructure for service composition, where SOAP can employ Business Process Execution Language as a way to let developers express business processes that are implemented as WS\* services. The second is a WS standard to ensure that transactions are properly managed and the third concerns service discovery. Bass et al (2013) explain that through the service discovery standard, UDDI enables businesses to publish services listing and discover each other. The fourth standard is reliability. Bass et al (2013:109) warn that “SOAP, by itself, does not ensure reliable message delivery. Applications that require such guarantees must use services compliant with SOAP’s reliability standard: WS-Reliability.”

Differentiating SOAP from REST, Bass et al (2013:109) explain that “REST ... is a client server-based architecture style that is structured around a small set of create, read, update, delete (CRUD) operations.” They add that REST imposes few constraints on an architecture offering simplicity, while SOAP offers completeness. REST is also distinguished as being concerned with state and state transfer, viewing the Web and services that service-oriented systems can string together as a huge network of

information that is accessible by a single URI-based addressing scheme. Therefore, in REST there is no notion of type and hence no type checking, so it is up to the application to get the semantics of the interaction right (Bass et al, 2013).

Another difference, according to Bass et al (2013), is that REST is meant to be self-descriptive and in the best case is a stateless protocol. The researchers give a very good example of a piece of code for a VUKSA directory service that allows someone to look up a student, given some unique identifiers for that student. The same simple lookup, implemented in SOAP, would be specified as something like the SOAP lookup code (see appendix). This example suggests that REST is simpler and more direct, with less standardisation and fewer characters than SOAP, but it must be considered that SOAP messages are correspondingly more structured, giving more quality of service. According to Bass et al (2013:110), implementing SOAP “has greater support for security, availability and type of functionality”.

Contributing to the SOAP vs. REST debate, Peterson and Davie (2012) concur with Wagh and Thool (2012) that the SOAP approach to a network application problem is to make solving it more feasible and generate protocols that are customised to each network application, whereas REST would approach the same problem by regarding individual Web services as World Wide Web resources identified by URIs and accessed via HTTP. Wagh and Thool (2012) note that the two technologies also have similarities and both the SOAP and REST frameworks are used to deploy Web services on mobile devices, because they are identical in terms of architecture and have four main core components. The first of these is HTTPListener; with the help of this block of Web services, clients can send requests to or receive responses from mobile hosts.

According to Wagh and Thool (2012:165) “The second component is the request handler, whose main function is to process incoming requests from clients and send responses to the client, although it works differently in each framework. In a SOAP-based framework, the request handler will remove the incoming HTTP POST request to extract the hidden SOAP envelope, then it will dispatch to the parser module, whereas in a REST-based framework, the request handler will extract the HTTP request directly and send it to the message parser”.

The third component is the parser module, which is responsible for invoking WS parameters such as the name of the service. This invoked information is sent to the WS servlet block. “In a SOAP-based framework, the parser sterilizes the SOAP object and maps the data type into service name and other parameters, but in REST, the message parser maps the data type into service name and other parameters” (Wagh and Thool, 2012:15).

The fourth component is the WS servlet module, which according to Wagh and Thool (2012) is the most important module in mobile web provisioning, because it deploys the new web services on a mobile host and supports the invoking of requested services. Having presented a balanced comparison, Wagh and Thool (2012) conclude that “the SOAP framework is more secure than REST and cheaper, because for the purpose of reducing the payload size, SOAP technology uses different compression techniques”. However, they also acknowledge that “a REST-based framework is more suitable for handheld, resource-constrained mobile devices and wireless networks”.

This researcher is impressed by the concluding remarks of Wagh and Thool (2012) regarding their proposal for future research to design a hybrid framework to support various interfaces for mobile hosted web services such as HTTP, Bluetooth and SMS on SOAP and REST. These proposals are practicable, especially given that the WS frameworks compared were developed for static servers, making them heavy in nature and not very suitable for resource-constrained mobile devices, which require a continuous running environment, consuming resources heavily and thus discharging battery power rapidly. Therefore, “hosting web services on mobile devices requires a lightweight framework, which should allow ease of deployment, thereby providing efficient and continuously executing web services” (Wagh and Thool, 2012).

From the comparison of the two architectures I learned two lessons. First, SOAP is basically a standard protocol for communication in WS technology, where service providers and consumers interact by “exchanging request/reply XML messages typically on top of HTTP” (Bass et al, 2013:223). The second lesson is that when employing REST, service consumers send non-blocking HTTP requests which rely on four basic http commands—post, get, put and delete—to tell the service provider to create, retrieve, update or delete a resource (Bass et al, 2013). Finally, on the two

comparative studies, by Gray (2004) and Wagh and Thool (2012), it is clear that the examples used did not involve sophisticated features such as encryption and transaction, which in my opinion can greatly affect a technology's performance. In the modern business environment, network security is of paramount importance in terms of authentication, certification and digital signature. Therefore, I believe that an identical study should be conducted, taking security needs into account.

## **2.11 Summary**

From the background work on this research and the literature critically reviewed here, it has been established that SOA is based on the concept of services and messages, where applications orchestrate message exchanges between their constituent services. It has also been established that the underlying services and message abstraction form the basis for constructing loosely coupled systems which are scalable and reliable. The cost comparison illustrated in Figure 2-1 indicates that the existence of a virtual university would result in cheaper education in the long run, because once developed, e-learning facilities do not incur further large costs as compared to conventional universities. Based on the potential advantage of lower running cost, this researcher concludes that providing a virtual university should be a top priority not only in Saudi Arabia but in all other parts of the world.

It has also been established that based on three-tier architecture, SOA which will be utilised by a virtual university, supports service requests, service provision and registry formatted in SOAP, allowing RPC-like calls over the Internet using a variety of transport protocols. It was also established that SOAP is by nature a platform- and vendor-neutral standard, ESB having been designed to provide interoperability between large applications and other components via standard-based adapters and interfaces, making it ideal for virtual universities.

From a reading of Bieberstein et al (2005) it was established that SOA impacts on three themes: enterprise systems, organisational structure and individuals, as it facilitates the alignment of existing ICT infrastructure and systems to achieve end-to-end enterprise connectivity by removing redundancies, generating unified collaboration tools and streamlining IT processes. SOA's facilitation capabilities feed well into the concept of

lowering higher education costs and securing online communication, which are all vital for a virtual university.

A detailed comparison of SOAP and REST has shown that the SOAP approach to network application problems is to make solving problems more feasible and to generate protocols that are customised to each network application. It was also established that SOAP is more secure because it uses WS-Security, which was created to satisfy its transport-independent specifications. Satisfying the data transport-independent specification will add value in virtualising university education in the sense that authorised system user can access the secured system from anywhere at any time. The established facts and presented opinions address how the available technology can be utilised to improve the virtualisation of university education.

The overall conclusion that this researcher has drawn from the material reviewed in this section is that it addresses issues consistently with those of earlier sections, i.e. that virtualising universities is a viable way forward in the twenty-first century and in Saudi Arabia. It is also reasonable to conclude that a virtual university will help in opening up access to higher education by offering online courses based on the fundamentals of SOA: service provision and consumption.

The following chapter sets out the research methodology.

## **Chapter 3: Research Methodology**

### **3.1 Introduction**

One of the most fundamental principles in any research design is the selection of an appropriate methodology. A well-designed research phase embraces both a method and extensive tactic planning to investigate, sample and collect the data that will be needed for the investigation. This chapter presents and justifies the methods used in this research study, including the tools and processes used for collecting and analysing data. Bernard and Russell (2000) state that “one of the most fundamental principles in any research design is the selection of an appropriate methodology of research because failure on the part of the researcher to choose an effective method will end with impractical and unrealistic outcomes” (p. 33).

The specific means of acquiring data in this study were through interviews, a questionnaire survey and a case study. This chapter explains the methodology which was used in this research and which formed its framework. The researcher obtained information from different sources, including textbooks, official websites and journal articles, on the subjects of software engineering and designing, java message services, SOA and SOAP. Doing this provided the researcher with a clear perspective on what has already been achieved and identified gaps left to explore, as well as providing clues and inspiration for further research (Murray and Beglar, 2009). Only journal articles with a direct bearing on this research were critically reviewed, which helped this researcher to contextualize and interpret other research results and discussions (Murray and Beglar, 2009). The findings of the reviewed research aided the planning and full implementation of a virtual university project in this study, with a clear understanding of the requirements to satisfy, alongside a balanced and in-depth knowledge of virtual university systems.

### **3.2 Survey Research**

In a descriptive study, the survey research method attempts to identify, diagnose and draw out information about the attitudes or opinions of the particular group of people



being studied by asking them a number of similar questions. Bryman and Bell (2011) describe this as “the systematic gathering of information about individuals and collectivities, using questionnaire methods, to collect data and analyse the resulting data by means of statistical analysis”. The present researcher adopted this approach in order to probe the patterns of the relationships between the variables based on the responses given by the study participants at the time the questions were asked.

The context for this study was provided by three United Kingdom (UK) universities that strongly promote virtual learning: the Open University (OU), the International Virtual University (IVU) and Oxford University.

### **3.3 Questionnaire Design and Structure**

The questionnaire used in this study contained questions that reflected the research objectives as specific questions (Thompson, 2012). To elicit as much data as possible in relation to the main research problem, the researcher used two sets of questionnaires. The first explored the KSA population to establish whether there was an appetite for a virtual university. The second attempted to understand the use of virtual learning in the UK, where questionnaires were emailed to different higher education institutions. The questionnaires consisted of nine questions forming three themes; network types, devices which could be connected to a network, and system functionality. The questionnaires also assisted in obtaining knowledge concerning the state of virtual learning environments and their benefits and challenges experienced by people actually using the systems.

Thompson (2012) emphasizes the importance of conducting a pilot study to ensure that the proposed questionnaire is understandable and clear to the target population, in order to cement the questionnaire’s reliability and validity. The initial draft of the questionnaire designed for the present study was used in a pilot study for this very purpose, as explained in section 3.6.

### **3.4 The Statistical Test**

In order to achieve the purpose of the research and to answer some of the questions put forward in chapter one, descriptive statistics, including frequencies and percentages,

were used to report the data obtained from the questionnaires. Additionally, the data were examined using the chi-square test, which is based largely on actual observed frequencies compared with those that could be expected to occur by chance. It is a non-parametric test, which makes no assumptions about the populations from which the sample has been drawn, in contrast to parametric tests, which require data to be drawn from a population with a normal distribution and homogeneity of variance. The higher the chi-square value and the greater the sample size, the more significant the result of the test. It is the most widely used non-parametric test, because it is relatively easy to follow and is pertinent to various research problems.

### **3.5 Background Data Variables: Group Distribution**

For the sake of description, respondents were divided into three main groups, as explained in sections 3.8 and 3.11. After conducting the analysis, it was discovered that the majority of respondents represented group B (63 N=110), while the remaining participants were in groups A (45 N=26) and C (11 N=21). There are a number of reasons for this: first, the sampling selection has to be equally drawn from each group; secondly, group A participants were more willing to respond than groups B and C; and finally, group B was numerically larger than the other groups, because its members were students at large universities attended by a large number of students. In addition, group C respondents were Saudi students studying in the UK, a relatively small population to draw upon.

### **3.6 Pre-Testing (Pilot Study)**

As noted above, a pilot study was carried out to check the satisfaction of potential participants with the questionnaire's wording and clarity. This pilot test was conducted on 20 staff members and students from King Saud University (KSU), Tabuk University (UT) and KAU (male and female) who were invited to participate in completing the questionnaire online. The researcher sent a link to all of these participants by email while he was in the UK. The questionnaires were returned automatically to the researcher, who then evaluated the responses in terms of question clarity, questionnaire length and the time required to complete it. Further questions were added and some

eliminated to correspond with the study's aims and objectives. This augmented the validity and reliability of the study.

### **3.7 Participant Population**

The population frame is the total number of factors that the researcher aims to investigate or examine within a specific time in a particular setting. The present researcher identified and selected the target participant sample as specifically as possible, taking into account the aims and objectives of the study. Its main objective was to investigate the practicality of establishing a virtual university model in Saudi Arabia. Therefore, the selection criteria for participants in the study were:

- Target participants were limited to academic staff officially listed at particular universities. The major reason behind the selection of academic staff as participants was because these are the individuals who would be expected to take the initiative and responsibility in establishing and running a virtual university. Therefore, their views on the feasibility of a virtual university are essential to this study.
- Three specific universities located in Saudi Arabia were purposively selected for the research study. These were KSU, UT and KAU. There were several reasons for this. First, each of these universities possessed relatively adequate information technology infrastructures and an Internet connection. Secondly, this particular choice included the two leading Saudi universities currently running external studies (Intisab) and also moving towards e-learning. The third reason was that UT, which is the largest of the new universities in Saudi Arabia, serves a great community of students. Finally, the researcher was restricted to a predetermined time frame in which to carry out the survey.

However, this study was not intended to present an exact enumeration of the whole population; instead, it aimed to provide an accurate qualitative representation of the general population.

### **3.8 Participant Sample Selection**

Thompson (2012) defines a research sample as “a subset of elements from the population selected according to a sample design, which specifies the rules and operations by which the sample is to be chosen from the population” (p.49). Proportionate stratified random sampling was applied in this study in order to represent the entire population as efficiently as possible and to obtain appropriate sampling units. The participant sample under investigation was divided into three main groups: group A represented members of staff at the three selected universities, group B represented students at the three selected Saudi universities and group C represented Saudi students studying at UK universities. The total official number of members of staff at the three chosen universities was 39. Systematic random sampling was used to select the target respondents from each group, while proportionate stratified random sampling was applied to twenty higher learning institutions which provided close to virtual education in the form of e-learning. Again, these were categorised into three main groups: group A represented the ten selected universities, group B represented the five selected colleges of further education (FE) and group C represented four selected private post-compulsory education colleges in the UK. Systematic random sampling was used to select the target respondents from each group.

### **3.9 Case Study Method**

The case study method is a form of qualitative research strategy known as the idiographic approach. Denzin and Lincoln (2013) state that “case studies allow a researcher to investigate a topic in far more detail than might be possible if they were trying to deal with a large number of research participants”. They identify three types of case study: an *intrinsic* case study is carried out to clearly comprehend a phenomenon; an *instrumental* case study is undertaken to examine a specific case, and a *collective* case study is used where the researcher is interested in studying a number of cases in order to gain a greater understanding.

The present researcher used the multiple case study type, as described by Denzin and Lincoln (2013), to investigate the conceptual models and compare them with the real-world problem that has been presented in previous research. The purpose of this

comparison was to discover any variance between the conceptual models and what exists in reality in order to identify possible distinct differences. Hence, the methods, facilities and operation of VUKSA were compared with those of the OU and the IVU in this study. The comparison was undertaken for the sole purpose of checking how VUKSA compares with internationally recognised existing universities.

### **3.10 Expert Review Panel**

After data had been collected from the 103 questionnaires returned (from a total of 176 distributed), the researcher invited Saudi Arabian education experts and a review panel to evaluate the proposed virtual university model. The experts were a number of key figures (N=5) who had direct involvement in the overall aims and objectives of this research. These experts presented their evaluations at King Abdul-Aziz University in Jeddah on 16/01/2014. The panel confirmed that the growing number of students in secondary schools is considered to be one of the most fundamental issues currently facing the higher education system in the Kingdom of Saudi Arabia

The researcher used the Delphi technique to evaluate the experiment, to identify the degree of disagreement among the experts and to ascertain whether the nature of the disagreements were real or purely semantic. A further purpose was to effectively establish the opinions of the experts, i.e., to validate the method properly. Linstone and Turoff (2002) describe the Delphi technique as “a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem” (p.06 ).

### **3.11 Data Analysis**

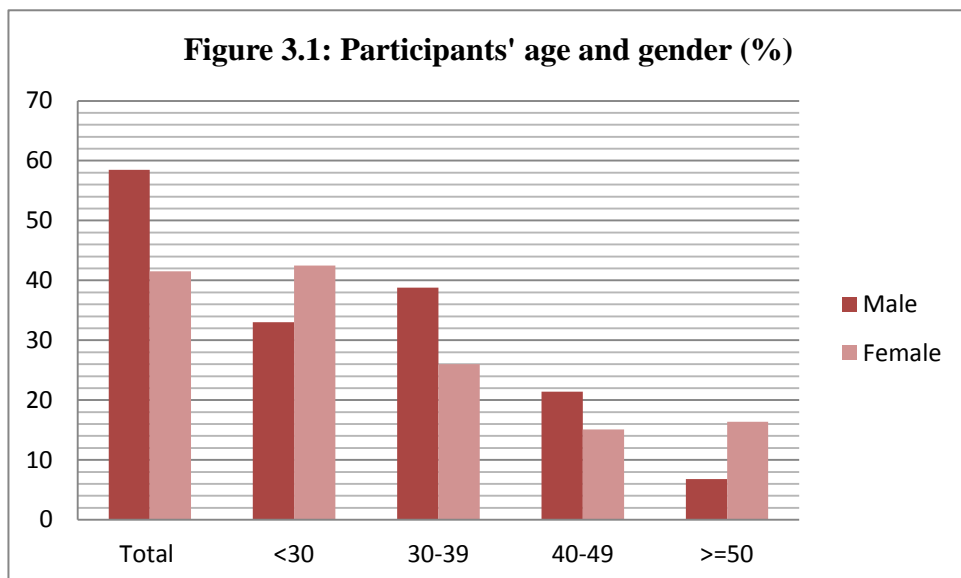
This results section is divided into two main subsections, the first referring to analysis of data generated by the questionnaire, based on which the researcher established a VU model to meet the needs of students and staff. Following the establishment of this blueprint, the researcher invited Saudi Arabian education experts and the review panel to evaluate the model, as reported in the second section of the results chapter.

### 3.11.1 Questionnaire Analysis

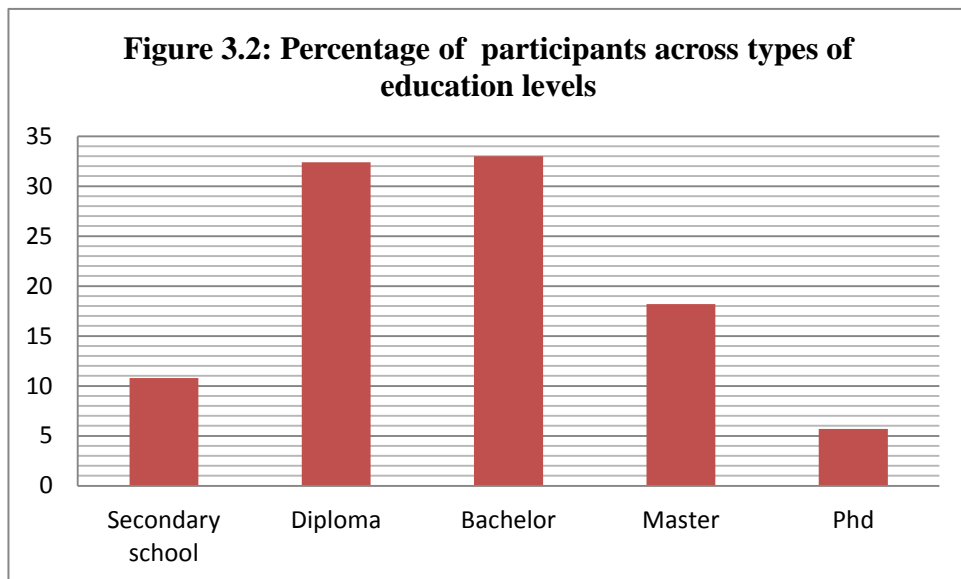
As a baseline, the research sought to assess the extent of acceptance among the Saudi students or university staff members of the establishment of a virtual university. This evaluation process was done through a number of questions. The first part of the questionnaire elicited demographic details (gender, age, education) of the participants; this was followed a by a question on the acceptance of a virtual university and the advantages that it might bring to the general population, then participants were asked about the types of assessments to be used and the types of degree to be offered. Data was mainly analysed using descriptive statistics (e.g. frequency and percentages), to provide an indication of the general acceptance of the concept and the readiness of Saudi Arabia to establish a virtual university.

### 3.11.2 Demographic Details

A total sample of 176 Saudi citizens took part in the questionnaire, of whom 103 were male (58.5%) and 73 female (41.5%). Although no item on nationality was included in the questionnaire, all participants were Saudi nationals and all were either staff or students at KAU, UT, KSU, or Saudi students at UK universities. The largest group of participants by age was below 30 years (36.9%), followed by those aged 30 to 39 years (33.5%), 40-49 years (18.8%) and 50 years or above (10.8%) (Figure 3.1).

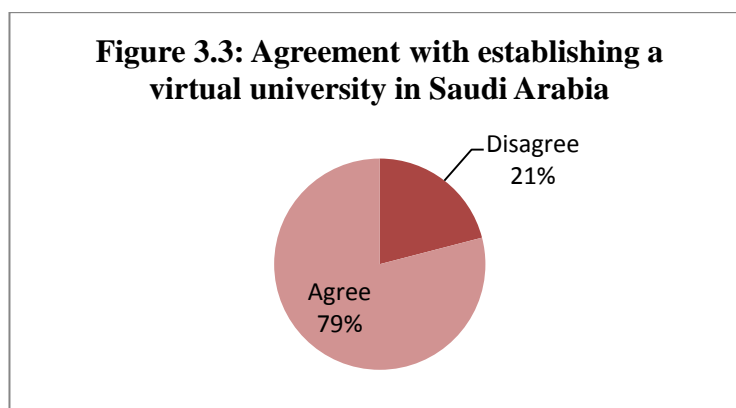


In terms of education, most participants had either a bachelor's degree (33%) or a diploma (32.4%), followed by those with a master's degree (18.2%), secondary school education (10.8%) and finally, a PhD level education (5.7%).



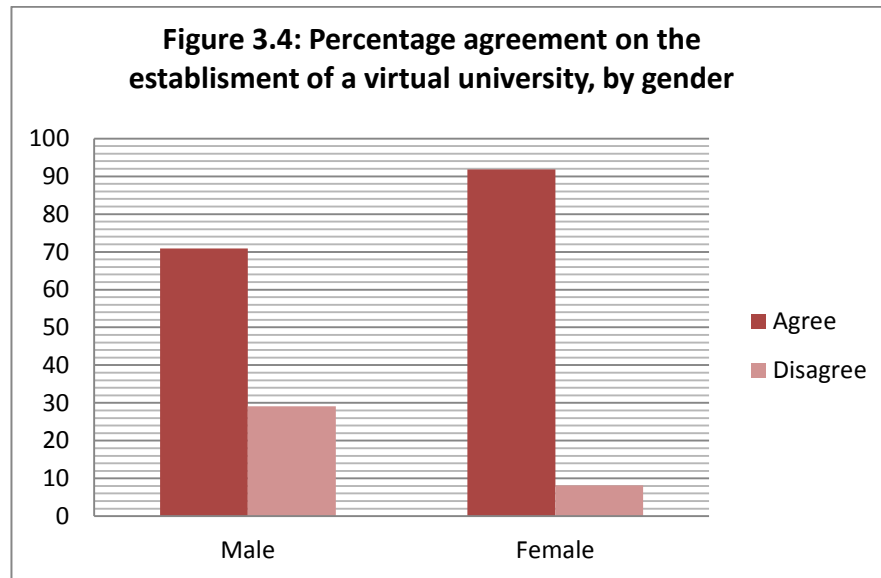
### 3.11.3 Establishing Virtual University

One of the main aims of the current research was to determine whether or not Saudi participants agreed with the concept of establishing a virtual university. This was done by a questionnaire item on their agreement or disagreement with the concept. In reply, a strong majority of participants (79%) appeared to agree with establishing such a university. This outcome clearly indicates acceptance of the VU concept among participants, whether students or members of university staff.



### 3.11.4 Gender Effect

The extent of any gender effect was assessed by comparing the results for the two genders in terms of their acceptance for the virtual university in Saudi Arabia. Figure 3.4 shows that there was proportionally greater agreement among female (91.8%) than male participants (70.9%).



### 3.11.5 Advantages of a Virtual University

Participants were next asked to express their agreement or disagreement with each of nine suggested advantages of the establishment of a virtual university, listed in Table 3-1.

The suggested advantage with which the largest proportion (77.8%) of participants agreed was that a VU would support women's access to higher education, followed by the claim that it would assist other universities in coping with the rapid growth in numbers of students seeking higher education (76.7%). A slightly smaller number (68.2%) felt that it would provide students with the required knowledge in IT. The least agreed upon advantage was that the virtual university would open up the economy and create new jobs through the expanded flows of foreign direct investment, thus supporting the Saudisation programme during increasing employment (52.8%), followed by the suggestion that government expenditure on higher education could be minimised (54.5%).

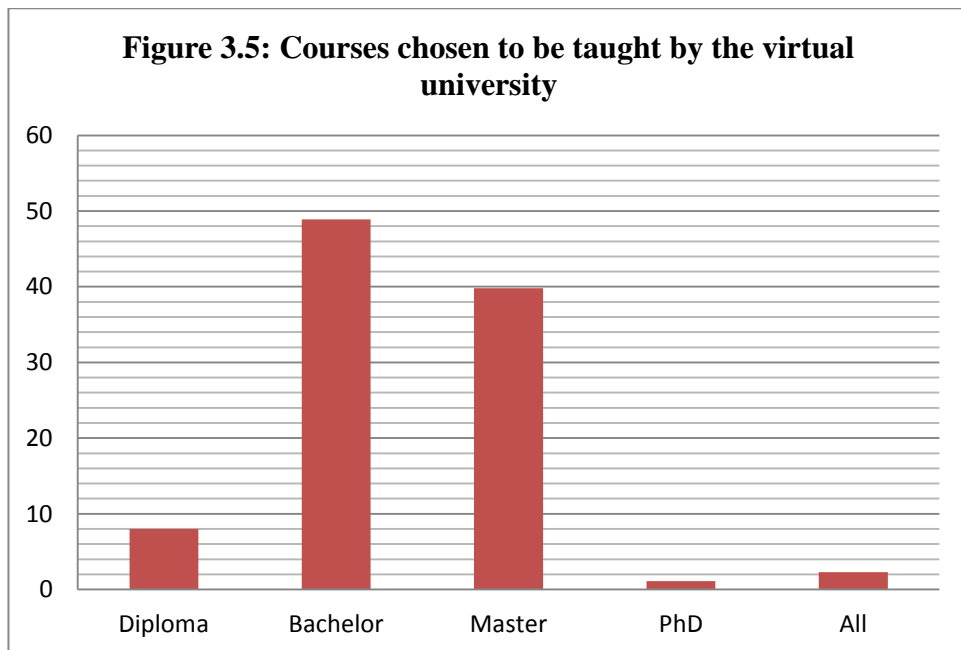


**Table 3-1: Extent of participants' agreement with a list of advantages of VUs**

<b>Advantages</b>	<b>Agree</b>	<b>Undecided</b>	<b>Disagree</b>
Equal opportunities	64.8% 114	23.3% 41	11.9% 21
Provide students with the required knowledge in IT	68.2% 120	19.9% 35	11.9% 21
Allow students who have dropped out of university to proceed with their studies	64.2% 113	22.7% 40	13.1% 23
Minimise government expenditure on higher education	54.5% 96	29.5% 52	15.9% 28
Assist universities in coping with the rapid growth of students seeking higher education	76.7% 135	15.3% 27	8% 14
Support for Saudisation within all sectors of the domestic economy by increasing the number of skilled and educated citizens	46.6% 82	42% 74	11.4% 20
Lower cost for students than traditional universities	67% 118	22.7% 40	10.2% 18
Support for women to access higher education	77.8% 137	14.8% 26	7.4% 13
Open up the economy and to create new jobs through the expanded flows of foreign direct investment to support the Saudisation programme during increasing employment	52.8% 93	32.4% 57	14.8% 26

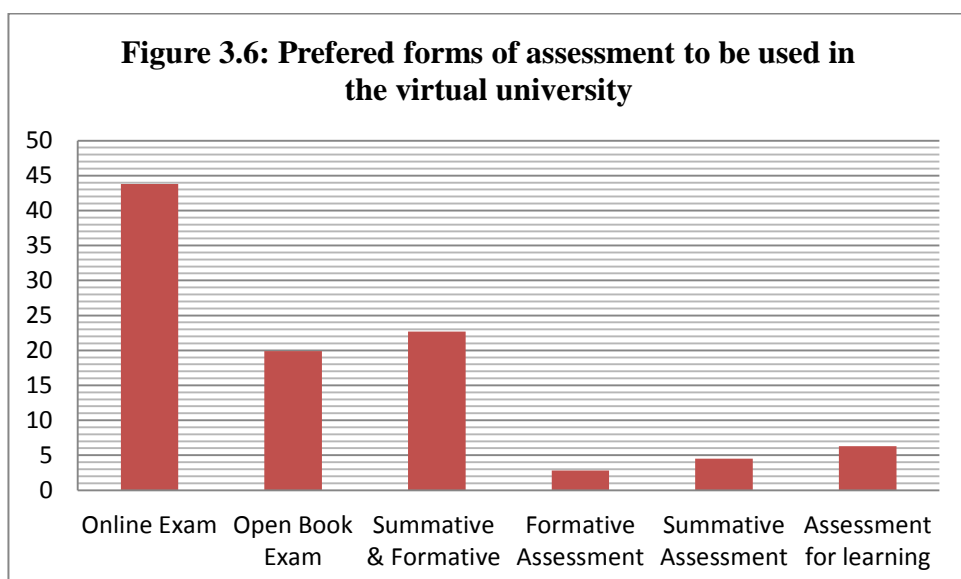
### **3.11.6 Qualifications Offered by the Virtual University**

When participants were asked to state which qualifications (diploma, bachelor, master, PhD or all degrees) should be offered by the virtual university in Saudi Arabia, almost half (48.9%) chose bachelor's degrees, followed quite closely by master's degrees (39.8%). Only 8% said that diploma courses should be offered, while 2.3% stated that the university should offer all degrees and only 1.1% felt that it should offer PhD courses. Figure 3.5 clearly indicates the strong preference for bachelor's and master's degrees to be taught by the VU.



### 3.11.7 Student Evaluation Methods

Similar to normal universities, virtual universities are expected to provide student assessment, so participants were asked to choose the most appropriate evaluation method that should be used in the virtual university. Figure 3.6 shows that almost half (43.8%) would prefer online exams, followed by a combination of summative and formative assessment (22.7%) and open book exams (19.9%). Not many participants chose assessment for learning (6.3%), summative assessment only (4.5%) or formative assessment only (2.8%).



### **3.12 Ethics**

Murray and Beglar (2009: 32) assert that “ethical considerations are an important part of conducting research and cannot be ignored”. This section therefore addresses the relevant ethical considerations, following the guidelines of Stahl (2007) on critical research in information systems. In the context of this thesis, the term ‘ethics’ refers to the standards of behaviour that guided the researcher undertaking this research study in relation to the rights of those who are the subjects of this research, especially in reference to data collection and evaluation, or indeed who have been affected by it, in accordance with Saunders et al. (2010).

Following the advice of Saunders et al (2012) and Denscombe (2010), the researcher endeavoured to protect participants from unwarranted harm as a consequence of their participation in this research and offered to inform them of the results of the study. This was in line with the guidelines of the British Educational Research Association (BERA, 2011), which aims to promote ethical practices in academic research.

BERA (2011: 19) recommends that “educational research be conducted within an ethic of respect for person, knowledge, democratic values, quality of educational research and academic freedom”. Therefore, following recommendations by Denscombe (2010) and BERA (2011), there was no participant deception and the necessary steps were taken to ensure that participants voluntarily gave their informed consent, that they had the explicit right to withdraw, that their privacy was protected and that disclosure was in accordance with guidelines. The researcher made efforts to ensure data security by preventing any unauthorised access, alteration, disclosure or loss and destruction of data and information.

Confidentiality and anonymity were respected and practised. Data were collected only after informed consent had been given and were protected as required by the EU Data Protection Directive (95/46/EC) and the UK Data Protection Act 1998.

### **3.13 Summary**

This chapter has explained the methodology of the study and reported the results of a pilot study of the acceptance and evaluation of a potential virtual university in Saudi

Arabia. The results indicate that the great majority, especially among female participants, would choose to see the establishment of a VU in the country. A number of advantages were also highlighted: most agreed that a virtual university would offer women an easier route to study, while helping the Saudi university sector to cope with the current high volume of students. The questionnaire outcomes gave the researcher a solid baseline on which he could further explore the readiness of the Saudi population for a virtual university.

The next step involved the design of a new virtual university model that would meet most of the needs of students, administration and staff members. The administration department would be responsible, for example, for recruiting students, issuing identification cards and dealing with library resources. Students would also be offered chat rooms and personal web pages for uploading assignments, downloading materials and accessing marks. Staff members would also have their own access to the university website and the resources; they would be able to upload the teaching materials to students and to download assignments, homework, marking and feedback. A PayPal facility would be provided for students to pay their fees.

Following the establishment of a blueprint, an expert panel was asked to evaluate the project. The next chapter elaborates on the rationale for the study and presents preliminary findings.

## Chapter 4: Rationale and Preliminary Findings

### 4.1 Introduction

This chapter is in two parts. First, the researcher sets out the rationale for this research, dwelling specifically on distance learning and virtual university models in the UK. The study is then further justified by the presentation of the results of a questionnaire administered to members of 20 higher education establishments.

To highlight the infrastructure of virtual universities in UK and to identify the best technologies used in higher education, the researcher focuses on three universities in the UK, two of them being non-traditional pioneers of e-learning. The first of these, the Open University, is the largest university in the world to use e-learning, while the second, the International Virtual University, is an emerging lifelong learning and non-traditional UK university. The third institution is Oxford University, which is one of largest and most prestigious universities in the world.

In order to examine in depth the UK model of virtual universities and to identify the best technologies, teaching methods, benefits and challenges, the researcher decided to collect as much data as possible in relation to the main research problem, in addition to the data collected from the questionnaire reported in Chapter 3. He therefore collected primary data by means of a questionnaire survey administered to twenty higher learning institutions which provided close to virtual education in the form of e-learning. For the purposes of avoiding bias (Murray and Beglar, 2009), the institutions were randomly selected. This approach was deemed not only reasonable but also appropriate, because it “can be very informative” (Murray and Beglar, 2009:43). However, the researcher was also aware that this is “not a good way to establish causality as cause and effect relationships can only be convincingly established through experience” (ibid).

## 4.2 Justification for a VU

The UNESCO (n.d), confirmed the importance of virtual universities in the developing countries, in particular, and therefore identified three major trends which highlight the importance of e-learning in these communities; a new demography: an increasing world population, growing urbanization, international migration globalization - technology, economic exchange, political integration and culture gaps between countries. Knowledge growth - information technology and revelation of technology. Therefore the e-education system is central to addressing these paradoxes and inequities. A well-functioning education system is essential to modern societies and higher education has a pivotal role to play in the renewal of education systems and development in general, given the influence of its institutions and programmes on all societal activities.

Mohamed, A (2009), indicated the importance of e-learning in Arab countries in over the last two decades and as such, concerted efforts have been made in the area of distance learning in the Arab countries. These endeavours can be classified into three modes: Distance learning, distance or open education institutions and a virtual university. She stated that most Arab universities have proved to be unable to meet the needs of all students desiring to pursue their goals because of dramatic increases in the number of graduates in secondary schools. While the Arab Regional Conference on Higher Education in Beirut (1998) stated “higher education in the Arab States is under considerable strain, due to high rates of population growth and increasing social demand for higher education, which lead states and institutions to increase student enrolment, often without adequate allocated financial resources”. The Beirut conference calls for harnessing modern technologies in higher education, thus breaking through the traditional barriers of space and time. Therefore, Arab countries have adopted radically new visions which rely on new technology, i.e. e-learning. Having secured an acceptable cost in many nations worldwide, it would be hoped that distance education can alleviate the pressures on higher education institutions in the Arab region (Mohamed A (2009).

Rehman, I (2015) stated that one of the main issues in developing countries is an unawareness of and a lack of education with regards to the use of appropriate technology. In addition, the need for appropriate learning strategies and learning theories and learning styles with technology, so that maximum utilization of technology can be achieved. Rehman discussed the advantages of technology strategies to support education methodology. He pointed out that the use of the technology in e-learning has many advantages over traditional education. Among these are easy updating and enhanced interaction, quick development time, and flexibility.

Al-Shehri (2003), confirmed that the continued rapid population growth in Saudi Arabia has already had an impact on the organisational, structural and managerial setup of universities. The increase in the number of people seeking higher education and the limited capacity is leading to the need to expand their existing structure in order to increase admissions, and this carries an enormous financial burden. Thus, universities in Saudi Arabia are facing tremendous challenges, such as an increasing number of students seeking admission, far exceeding their existing capacity. The increase in the number of students in classrooms also results in increased pressure and workload on academic and administrative staff.

The need for more skilled and educated people and the limited capacity of universities has necessitated the introduction of distance learning. This has helped thousands of Saudi citizens to improve their abilities and skills and to contribute to the development of their organisations. Further, the high demand for trained and skilled people to help in the Saudisation of all sectors provides more opportunities for Saudi women to gain more knowledge, skill and qualifications, and even to develop managerial skills through experience. The impact of distance learning on Saudi society can be seen in the large numbers of graduates who have brought the knowledge and skills they have learnt to different walks of life in the kingdom. A good example is that thousands of graduates have entered the teaching profession and now teach in schools.

Another important factor to be taken into consideration is the conservative or negative attitude of the majority of Saudis towards female education as a result of a cultural belief that women must play a traditional role within the home and should be respected in this sense. It is also sometimes difficult for women to access education in the traditional or conventional university set-up. Women do not drive, nor are they accustomed to travelling long distances, particularly when they are single, because of religious requirements and social standards. Moreover, because most commuters use private vehicles, public transport for women only is not widely available throughout the country. This makes distance education even more essential for the female sector of the population, of whom the majority live in rural areas, while universities are typically located in cities. Apart from the predicament of women, a large proportion of the population generally begin some form of unemployment at the completion of secondary school and are not able to or encouraged to proceed to higher education. The potential loss of a large number of higher education students and the large population of females who desire to study mean that there is a need to develop distance education into virtual universities, in order to fill the employment skills gap and provide the workforce essential to the continued development of Saudi Arabia.

In a study set in Saudi Arabia, Alrawaf and Saad (1990) identify key factors which affect higher education for females, including the conservative or negative attitudes of the majority of Saudis towards female education. They report that a poor quality of higher education was being offered to females via closed-circuit television, which was being used to maintain segregation between males and females and to overcome the shortage of female teachers. More recently, Smith and Abouammoh (2013) surveyed 134 randomly selected female students at some Saudi universities. The data analysis showed that only 23.7% of them believed that closed-circuit television is a useful method of instruction. Although CCTV classrooms are well equipped, this technique of instruction has been criticised for many reasons. Among the criticisms are difficulty in communication due to classroom noise, boredom, and the lack of positive participation and interaction between students and lecturers by landline phone.

In recent years, the Saudi government and society have become more aware of the urgent need to provide women with more educational opportunities. This was officially



raised in the Development Plans as a major issue, and the higher education authorities have begun deliberating with the provision of more opportunities in higher education for women, via the King Abdullah scholarship scheme. This decade has also seen the opening in the kingdom of many new universities and educational institutions in various cities, and the environment and culture are ripe for some expansion of the parameters of educational services in the country. Most universities are moving towards distance learning and the virtual university is an improvement that must necessarily come next on the educational and social agenda, in the view of the present researcher.

In Saudi Arabia, the cost of enrolment and study at any institute of research and continuing education is entirely free. The government supports and sponsors those students who have been accepted. However, the cost a student pays for participating in a course in a virtual university is relatively low and affordable compared to the actual cost of running a traditional higher education institution, private or otherwise. Taking into consideration the per capita income of the Saudi population and the proportion of education costs from an international perspective, the investment is highly rewarding. According to Sahab (2003), the total cost for a student to take a single module through distance learning is \$431, including hardware costs and Internet access. If such a student were to take more than one module in the same year, the hardware cost would be spread and the total cost would work out to less than \$237 per module. Moreover, Sahab's calculation includes the pay of trainers and instructors. There would be no contact teaching in a virtual university setting and instructor pay would be considerably reduced and spread over the many students enrolled on the course. As already mentioned, enrolment and study at any institute of research and continuing education is entirely free for students of those universities which are supported by the government, but not for those at private universities. The government supports and sponsors those students who have been accepted in its universities (those with high total average marks), and while there is a cost to distance learning programmes, according to Sahab (2003), it is less than the cost of study in any private university in the kingdom, which is very expensive in general.

One more important reason for applying the VU concept to the Saudi context is that current distance learning programmes in all universities in the kingdom are only

available and applicable to courses like business, management and the arts. They are not available and applicable for any subjects in the science field, whereas given time, VUs might be expected to cover all subjects, thanks to the deployment of new technologies not currently available.

Justification of the need for a VU in Saudi Arabia and the questionnaire results gave this researcher the conviction and motivation to design a new VU that would meet most of the needs of students, administrators and academic staff. To pursue the VU agenda, this researcher was curious to know more about virtual universities in the UK. The following section presents the findings of a study of British VUs.

### **4.3 Distance Learning and Virtual University Models in the UK**

The UK was a pioneer in distance learning. “In 1963, the National Extension College (NEC) was set up by Michael Young as a self-financing non-profit trust in order to give home-based adults a ‘second chance’ at academic or vocational studies, utilising specially written correspondence materials, broadcast television and local tutors’ support” (Rowntree, 1992:10). Later, in 1969, the Open University was established in the UK, the progenitor of twelve other leading open universities. It was “the decision of the British government to establish the Open University exclusively as a university for adult education” (Peters, 2000:193). This made it possible for people at different career levels, who would not normally qualify to enter higher education because of interrupted schooling, to join the area of study they preferred. The OU started with the use of television and radio to communicate information on various subjects to these students and the public. There were also several other positive tenets that the Open University system in the UK held to. Peters (2000) lists these and offers an evaluation after 25 years of even more improvements and advantages: the OU system now plays a “leading role in distance education research” and also supports distance learning ventures and open university start-ups in developing nations.

In 1971, the OU began to operate as an autonomous institution, funded largely by the government in the UK. The aim of the venture was to increase higher education among the UK population. The Open University also declared as one of its aims the provision of higher education to diversify and increase the proportion of the population leading

more fulfilled lives, using up-to-date methods such as communications technology, making learning easily accessible and low-priced as well. The foundation courses, for example, focus on preliminary levels, compensating for new students' lack of knowledge (Peters, 2000).

A new way of studying and undertaking research was established through several innovations which effected changes in the processes of teaching and learning. Peters (2000:197) lists these as:

The use of radio and television as additional media for transmitting and presenting teaching ... The professional development of structured printed study materials by ad hoc course teams ... The support for students in a large number of regional and local study centres ... The foundation of a university especially for mature students.

Peters presents case studies of universities in distance learning and naturally includes the Open University in the UK as a pioneer in distance education and the first of its kind. After deliberating upon its working methods, he concludes with his impressions of this pioneer venture and draws attention to “the optimism, zeal and confidence with which it is approaching the twenty-first century... the policy of open access... quality teaching [and] the readiness to provide real help and support for students” (Peters, 2000:198). The revolution in IT, in both hardware and software, had led to the development of the idea of the Open University in an endeavour to upgrade teaching tools and use the latest technology to facilitate learning regardless of location, so that the OU website, virtual labs and virtual classrooms serve as powerful teaching places in the place of real university buildings, labs and classrooms.

As a result of this development, Jonstone (1995) reports that “in 1994, Southampton University began allowing its students in Information Engineering to receive course material by email, while the Open University commenced offering two computer courses via the Internet to non-European students”. Jonstone’s article also refers to the first group to graduate from Birkbeck College on London’s first virtual university course.

The face of virtual universities and distance learning changed in the late 1990s. In 1999, the Massachusetts Institute of Technology (MIT) and the University of Cambridge

entered into a partnership to combine their resources and students, and share information across regional and administrative boundaries. This was crossing very exciting frontiers for the time and Lawrence Bacow, the then Chancellor of MIT, claimed that this partnership was “potentially historic”. It would transform the face of education and change decision levels and student choices. If adhered to, Bacow stated, it could “truly create a new model for the global research university in the 21st century” (Schmitt, 1999:6).

Today, this type of university is becoming increasingly common, because of the low cost of operation, flexibility of interaction, widespread range and ease of access. The University of Liverpool (<http://liverpool.ohecampus.co.uk>) has introduced an online master’s degree for students using a virtual campus in the following areas: Business Administration, Operations and Supply Chain Management, Public Health, IT, and Information Systems Management. The University claims that its virtual campus and worldwide reputation attract students and instructors from all over the world. On this course, students are not expected to be online at the same time as the rest of their class, and they can gain access to it from any Internet café in the world. No physical classroom attendance is required, and they have a flexible study schedule within a weekly deadline structure, during which all educational resources (lecture materials, library, grades, student lounge, etc) are always available.

One virtual university in the UK, the International Virtual University (<http://ivu.org.uk>),

offers non-resident lifelong learning programmes and other further education programmes on an international basis. Its programmes have been organised and developed using as a starting point the “off-campus” external education concept tried and tested by the various “education institutes “without walls”. Students can choose their own study. It is estimated that it is possible to complete 60 credits in one year (12 months). Students are given a maximum of 2 years to complete most courses, unless otherwise stated. A variety of media are used to help students in the learning process. Courses usually include a number of Tutor Marked Assignments, Course activities, Minor research, the writing of essays, and the final examination. (<http://ivu.org.uk> )

The Europe Virtual University, (<http://evu.ac>), whose main office is located in London, is probably one of the best known VUs in the world.

This University offers online courses to students from around the world in different areas (Arts, Sciences, Engineering, Mathematics, Business, Law, and Computer Sciences). Exams may be taken at any location geographically, of course. The certification process consists of 40-60 multiple choice questions to be answered by the student in a period of 40 minutes to 1 hour. On successfully clearing the exam, students' mark sheets will be displayed on the screen showing their scores. This mark sheet will be made available on the EV University website's job directory and can be shown to employers and clients. (<http://evu.ac>)

Interestingly, a new type of virtual university has recently appeared through the virtual gaming environment Second Life (<http://secondlife.com>), which is attracting a vast gaming population and even the uninitiated.

Finally, the Virtual University of Edinburgh (<http://vue.ed.ac.uk>) is a virtual educational and research institute bringing together all those interested in the use of virtual worlds for teaching, research and outreach related to the University of Edinburgh.

#### **4.3.1 Tools and Interaction**

Many interfaces are available for virtual learning providers. Grange (2011) recommends an interdisciplinary approach to providing learner interfaces which accommodate all the experiential needs of a learner in a particular stream or field. He details a software package in which library materials and resources are provided for every student depending on his or her student profile. His thesis is specifically focused on a VU infrastructure for students of orthopaedic surgery. He insists on integrated training, which requires experimentation and practical training research, such as dissections, to be more environmentally conscious. Depending on the needs and requirements of the course, texts, images and graphics are also included in the database of references that every student has access to online. Simple downloading and reviewability is also made possible for students to use the resources effectively and satisfactorily.

Generally, virtual universities have very similar teaching environments, which include private areas for staff, students and lecturers, including all related teaching technology (blackboards, online courses and libraries, as online examination system, virtual private networks for clients and communication tools between students and their lecturers and

even between students themselves). A short description of each of these tools is presented below.

### **4.3.2 Blackboard**

The virtual blackboard is one of the most effective teaching tools used in many universities for e-learning. It offers a communication tool which enables both students and lecturers to communicate easily using it. The lecturer begins uploading his/her lecture notes after logging onto the system using a unique user name and password. The modules and sections also provide students with notes and assignments on the subjects which they are studying. Lecturers are able to post messages and announcements on the blackboard to their students.

The interactive blackboard is also very similar to a real board used in the classroom but online, in that the lecturer can draw and write whatever she/he wants to explain on the screen using a keyboard, mouse or e-pen; then all of this information will appear to those students attending the lecture. The lecturer can also use voice to explain the lesson. There is a provision for students to submit their work and assignments, which permits the easy recording of students' work and progress and also facilitates the monitoring of originality and research input from the students. There is the further possibility of the incorporation of electronic student applications and registrations, electronic submission of assignments, marking and recording, electronic tutorials and other interactions. Students should be able to fill in their details and give reasons for applying online. The acceptance and registration processes can also be carried out online. Electronic tutorials can incorporate practical training with specific members of staff, and more work-oriented assignments. Some departments, such as those of economics and statistics, for instance, can make good use of interactive whiteboard facilities and even one-to-one tutorials.

Students can interrupt the lecturer if they have any question or want information clarified by clicking on a special command which appears on their side of the blackboard. The lecturer can then answer the question and explain additional unclear ideas. All lectures can be saved for both students and lecturer by clicking on a special command for this purpose.

### **4.3.3 E-board**

Using the e-board tool, students and lecturers can familiarise themselves with any important events that are happening in the university (lectures, meetings, etc). This tool link appears to students and lecturers on their desktop; they can click on the link and then see all the events classified by course.

### **4.3.4 Online Classrooms and Libraries**

It should be made a condition that all students access the online classroom in the first month, for information and registration, particularly online classrooms for science and advanced technology subjects, and learn the practical and experiment or situation-oriented part of their course. The rest of the semester can be for self-access and study with an end-of-semester contact period and examination. In this case, the older model that the university used could be reverted to effectively.

By accessing their desktop, students can search within thousands of books using the online courses library. They can view two types of online courses: static and dynamic. Static courses contain written information with some illustrations of the related subject. All students are able to access library resources and electronic databases in addition to these facilities.

The dynamic course, which is a new type, allows the student to interact with the course, not just to read its contents. This type of course contains videos, demonstrations, questionnaires, self-tests or small exams, and flash technology. The user has to react to this material. Students also have access to thousands of online libraries which the virtual university allows students to access by using their user name and password.

### **4.3.5 Assessment and Online Examination**

The use of ICT in student assessment is fast becoming easier, even sometimes for essay type questions, with artificially intelligent systems. It is preferable in some ways, in that it enables a validated, rapid and objective value assignment (2002:124). Several programmes have been developed and tested in use. Steven and Zakrzewski (2002) provide a clear, comprehensive overview of the use of such tools and programmes in the testing and evaluation processes.

Assessment and evaluation in e-learning are very important issues. There is general agreement among researchers that assessment has a powerful impact on learning processes. It is also important to re-evaluate assessment in virtual learning environments. Although the primary goal of education remains the same for both traditional and virtual universities, because of the difficulties in distribution and the lack of body-language or informal interaction and the restriction on the teacher's knowledge of learner satisfaction, the focus and intention of VU assessment must be different at some level. If the teacher wants the student to possess a critical understanding of a concept or theory and wishes to test that knowledge, then fragmentary information of the sort that is obtained from objective-type questions would not suit the situation. Problem-based learning is a very effective form of assessment and evaluation.

Exams in virtual universities can be done by one of two ways, depending on the type of course and department or university policy. One way is by assignments, where students submit original written work on a specific chosen topic, previously discussed with the examiner or lecturer. The other is an online-type examination, which starts with the university exam manager sending emails to all affected students announcing the time at which the exam is scheduled to take place. Once students have opened their email and responded to the message from the exam manager, they can access a link (a special link for each student) to the examination website, which is a temporary website, not accessible except during the exam time). This site has a number of pages which contain different types of questions related to the subject: some are multi-choice, some require spaces to be filled and others need a detailed explanation written by the student. Once they have finished the exam within a specific period of time, students have to submit their answers. The exam is then finished, and students will be allowed to exit the exam website permanently.

Students can do the exam at home or anywhere else if it is an open exam. In this case the questions are of a special type so that students have to understand the course very well to be able to answer them; they are therefore allowed to have books or other reference material with them. Alternatively, exams may be sat at a venue regulated by the university; in the case of a VU, it will have to open a branch in each large city to deal with this type of exam.



#### **4.3.6 Communication Tools**

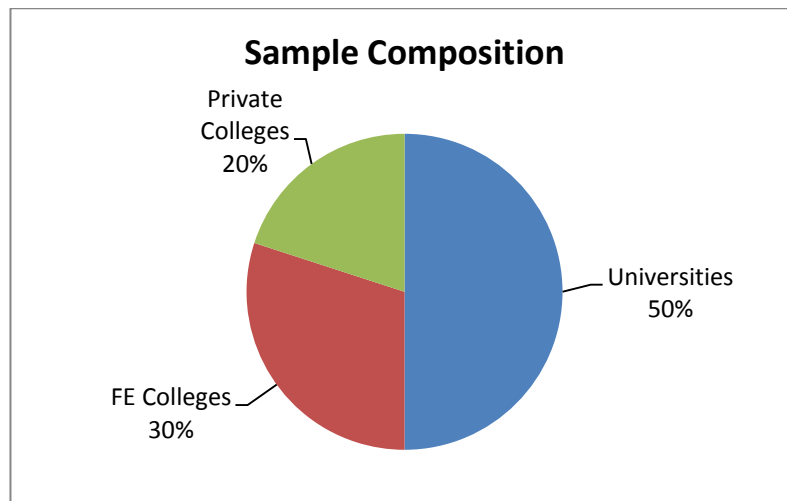
Students need to communicate and interact with each other by forum and to direct questions and debates to the lecturers and faculty. Such communication should be open and interactive so that debates and discussions are lively and inclusive, allowing interaction between all members of the class on the Internet.

The internet never closes. It is a mechanism that stays open to the students all day, every day and offers alternative teaching delivery tools with considerable implications for distance education courses. It is necessary to formulate appropriate curricula and model the syllabi according to the requirements of the medium. Many communication tools are available at the VU user's desktop, like the chatting systems (voice and type formats), emails and common public forums. These tools can be used at any time.

The next section reports the results of a questionnaire survey of UK universities offering e-learning.

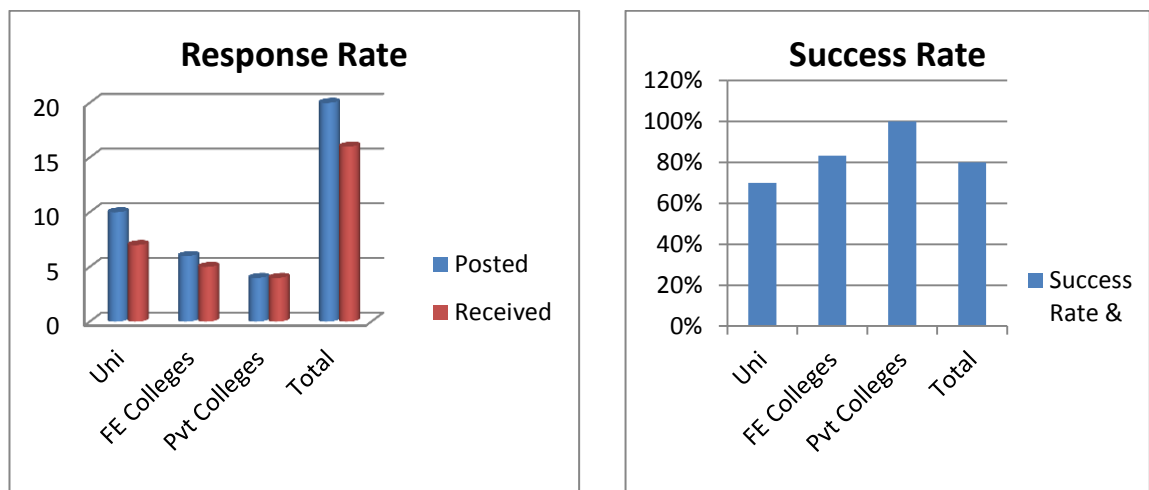
#### **4.4 Questionnaire Results**

In order to collect in-depth primary data in relation to infrastructure in UK universities, the researcher sent a questionnaire survey to twenty higher learning institutions which provided close to virtual education in the form of e-learning. For the purpose of avoiding bias, the institutions were randomly selected. This approach was deemed not only reasonable but also appropriate, because it "can be very informative" (Murray and Beglar, 2009:43). However, the researcher was also aware that this is "not a good way to establish causality as cause and effect relationships can only be convincingly established through experience" (ibid).



**Figure 4-1: Sample Composition**

Figure shows the breakdown of the sample of twenty institutions, which consisted of ten universities (one each in America and Africa, three in Saudi Arabia and five in the UK), six colleges of further education (FE) and four private post-compulsory education colleges, all in the UK. Responses were received from seven universities, equating to a 70% success rate, from five FE colleges (83%) and all four private colleges. Therefore, the overall success rate was 80%, as shown in Figure.

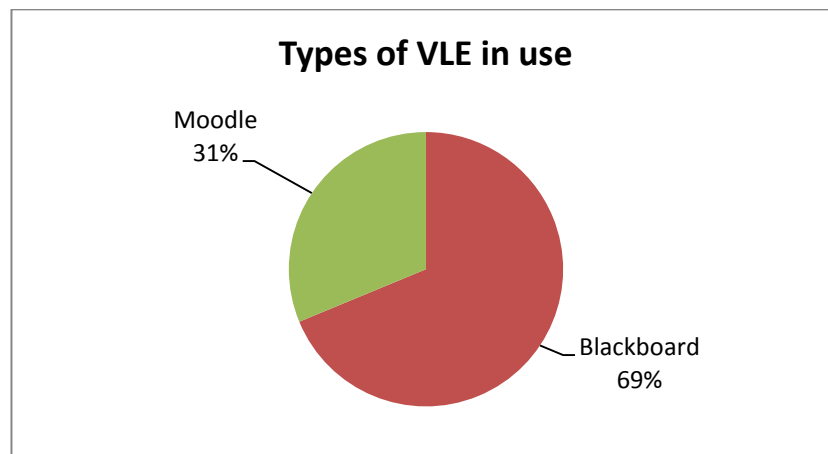


**Figure 4-2: Response and Success Rates**

The above institutions were considered because they were already providing higher education as well as virtual learning environments such as Blackboard and Moodle. The

questionnaire (reproduced in the appendix) comprised nine questions on three themes: network types, devices which could be connected to a network and system functionality.

The results from the 16 valid responses indicated that three different ICT network topologies were being used, the most common being bus topology (9), followed by star topology (5) and ring topology (2). When asked whether they were using a virtual learning environment, all 16 valid responses were affirmative. As to the type of VLE being used, eleven respondents indicated that they were using Blackboard and five Moodle, as shown in Figure 4.3.



**Figure 4-3: Types of VLE used by Respondents**

All respondents indicated that it would take a prospective new system user less than a week to learn the system, which in this researcher's opinion is a reasonable time. Responses to questions on the aspects of functionality and benefits are discussed below.

After analysing the data and synthesising it with informal academic discussions and other academic sources such as journal articles, this researcher concludes that there are both benefits and challenges associated with virtualising university education. In brief, the benefits most often mentioned are: the availability and timely delivery of educational resources; the equitable status of all students, regardless of their geographical location, as long as they have an Internet connection; the reduction of both financial and technological costs; standardisation and flexibility. This list is consistent with the finding of Ondari-Okemwa (2002:322) that "institutions of higher education can provide more cost effective mass education in disciplines that are critically needed

in sub-Saharan Africa, by using technology to share quality academic facilities, information resources and laboratory experiences available anywhere in the world”.

Similarly, Fulford (2013) cites an extensive evaluation of ICT projects by Grabski (2000), with benefits categorised as tangible and intangible. Among the tangible benefits are financial and technological cost reductions, as long as the ICT project originates from a strategic initiative. The same researcher argues that anchoring ICT projects to organisational strategic objectives increases revenue and profits, on-time delivery of services, integration of departments, standardisation of operations and flexibility, all of which were found to be among the needs and benefits of virtualising university education.

However, the present research also identified three challenges which emerged as being surprising closely linked to the above benefits: standardisation, restricting knowledge flow and negatively affecting interaction between students and their institutions. This researcher classifies these as technical and operational. The technical challenges identified are standardisation, scalability and distributed architecture, which is closely related to the focus of this research on service-oriented architecture.

First, standardisation is a technical challenge in that virtualising higher education requires certain potentially restrictive formats and procedures to be followed. Systems are set to predefined standards, so that it is not easy to accommodate new applications for reasons of compatibility. Thus, Fulford (2013) cites Johnson et al (2004) as warning that some organisations are unable to adapt to repeated changes in the business environment due to the difficulties of reconfiguring their systems. This researcher believes that some organisations therefore continue to run outdated versions of software, as evidenced by his observation that one top class university was still using Windows XP, an operating system three generations behind the latest version on the market, Windows 8.

On the question of restricting knowledge flow, one comment from the questionnaire reads: ‘Structured and procedural communication suits machines more than people.’ In my opinion, this comment is very pertinent, in the sense that it echoes Fulford (2013:91), who cites Morton and Hu (2004) as finding that “... applications were most

appropriate for machines bureaucracies and are a poor match with professional bureaucracies and divisionalised organisations.”

The second challenge is scalability, identified from the questionnaire responses regarding the requirement to support real-time interactions among large numbers of simultaneous participants distributed over a wide area network. Scalability here refers to the geographical and behavioural complexity of virtualising education. One respondent wrote of ‘many system bottlenecks. Large numbers of active participants generate a high volume of network traffic, updates and audio packets, which is too much for our server.’ On a similar scalability challenge, another respondent complained that ‘hardware and software updates do not come at the same time, therefore there is a problem with the “last-mile” network connection to each participant. Students’ computers may not be compatible with our servers.’

The third technical challenge is distributed architecture. VLEs have very many geographically distributed users and supporting all of these simultaneous system users is a challenge. This is confirmed by one questionnaire response which noted that ‘inappropriate and incompatible software and hardware compromises data storage and sharing, resulting in uncontrolled costs.’ This problem is related to the generic security challenges of ensuring the safety and security of any web-based system.

As to the operational challenges, the two identified here are isolation and detachment, and resistance to change. The first of these to emerge from the analysis of the questionnaire data is that engaging service consumers in a virtual world does not create as much value as a personal interaction would do. In other words, there is a strong element of isolation and detachment, a finding consistent with that of Kirkman et al (2002:72) that “the major disadvantage of virtual teams is the lack of physical interaction with its associated verbal and nonverbal cues... virtual teams struggle with creating synergy... building trust in virtual teams is extremely difficult, given the limited face-to-face interaction.” The researcher concludes that physical interaction brings with it some level of social interaction, which is essential in almost all jobs. Without it, workers feel isolated and ‘out of the loop’.

The second operational challenge was resistance to change. One respondent wrote that even in the UK, some highly experienced lecturers were rather unwilling to use virtual learning environments, preferring the traditional approach of interacting physically with their students. This comment is consistent with the reported difficulties of establishing an African Virtual University in the face of resistance from those preferring to use traditional teaching methods: “The chalkboard is still a very common and popular feature in lecture halls in many universities across Africa” (Ondari-Okemwa 2002:326). Indeed, all the challenges mentioned above are consistent with the research of Ondari-Okemwa (2002), who concludes that the heavy reliance of all virtual organisations on ICT exposes them to technical challenges. In developing countries, such organisations, including the African Virtual University, operate in ‘technological deserts’, are peripheral to the global knowledge revolution and suffer from unreliable, erratic and fragile telecommunications infrastructure and electricity supply.

Having become aware of the benefits and challenges of virtualising service provision, the present researcher was motivated to conduct further research to address the challenges and enhance the benefits of virtual learning. A review of the literature made him conversant with proposals to mitigate such challenges. Some of these solutions are proposed by Benford et al (2001), Kirkman et al (2002) and Lakhan and Kavita (2008).

Before turning to these proposals, it is appropriate to conclude this section by categorising the problems to be addressed by this research as national (limited access to higher education, the empowering of Saudi Arabian women and the Saudisation of the national economy), technical (standardisation, scalability and distributed architecture) and operational (isolation and detachment, and resistance to change). This section has thus clearly outlined the challenges facing the introduction of VLEs into the Saudi Arabian higher education sector. The following section begins the exploration of possible solutions by reporting an online study of three UK universities.

#### **4.5 Online study of Three Universities**

In addition to the above questionnaire, this researcher also examined the online presence of three UK universities: the OU, the IVU and Oxford University, all of which appear to have played a pivotal role in distance education, which is the foundation of virtual

education. This part of the study focused on the online functionalities offered by these three universities. The results are summarised in Table 4-1, which lists the top ten functionalities, in no particular order. These are all relevant to a VU in this researcher's opinion, because they are the key functions which form the basis of virtualising the provision of higher education.

**Table 4-1: Functions available online**

Function	Description / Explanation
Study method	Students learn in their own time by reading course material, working on course activities, writing assignments and working with other students.
Types of course	Short-term, long-term, professional.
Student registration	All students' personal and course details are captured and processed online.
Online support	Tutors and student service staff provide online support to all students.
Course materials	All study materials are made available online through a variety of media such as webcasts and podcast.
Assessment	There are two types: tutor and computer. In each case, students upload them on the system, then tutors or the computer system will access and assess them.
Student community forums	A variety of activities are available, which encourages students to keep in touch with each other.
Payment	All payments are made online
Student portal	This is an online source of information about course enrolments, handbooks, timetables etc
Online storage	Students can store their work in a virtual university system.

The results of this brief study of the three universities are consistent with the account of virtualisation given by Burd (2011) as a technique that divides a single mainframe's capacity among virtual servers: one for web services, and others for database management, background applications and email services. Burd (2011) further explains that virtualisation works well because it offers flexibility in server configuration and deployment, enables the resizing of machinery to match changing requirements and allows easy movement of virtual machines from one physical computer to another by simply copying files across a network. Furthermore, "with this technique, an organisation can also clone virtual servers on multiple physical servers to increase capacity or provide service redundancy" (Burd, 2011:37). To achieve the above functions in a secure and reliable way requires service oriented architecture to be present as a framework.

This section has presented a critical study of three UK universities which provide virtual learning environments. It has identified certain types of virtual learning environment, Moodle and Blackboard, and the benefits and challenges associated with virtualising university education. The benefits which relate to the aims of the present research are: availability and timely delivery of educational resources and the equitable status of all students regardless of their gender, race or geographical location. The results also indicate that virtualising university education can provide cost-effective mass education.

#### **4.6 Summary**

This chapter has shown that virtual universities in the UK have many advantages, especially for non-resident, part-time, financially disadvantaged or physically disabled students. The new technology makes the idea of virtuality applicable and widespread through the Web, using different learning methods and techniques, regardless of the place or time. Moreover, the outcomes of these universities are very similar to those of real ones. This chapter has also considered the use of VLEs such as Blackboard and Moodle by the great majority of universities providing virtual higher education. The results also indicate that ICT network topologies were being used, the most common being bus topology. Finally, it has identified certain challenges, both technical and operational. The latter include isolation and resistance to change, while the technical challenges identified are standardisation, scalability and distributed architecture.

The following chapter gives an account of application-to-application technologies.



## **Chapter 5 Application-to-Application Technologies**

### **5.1 Introduction**

According to Bih (2006), software development has passed through various stages, including the object-oriented paradigm, culminating in the development of several object-oriented programming languages, such as Java. With the advent of internetworking and the evolution of web technologies, the needs of business for individualised services have placed new demands on software architecture, resulting in the concept of Web services.

In industry and commerce, there is a need for an architecture embracing a collection of services, among which data are communicated and where two or more services combine to perform coordinated activities. In the context of education and training, with which this thesis is concerned, the present researcher also perceives the need for an architecture that is well defined, self-contained and does not depend on the context or state of other services to provide a robust interactivity. The best available architecture to meet the above demands is SOA.

### **5.2 Web Services**

Papazoglou (2008:5) describes a Web service as “a self-contained software module available via a network such as the Internet, for completing tasks, solving problems or conducting transactions on behalf of a user or an application”. He adds that “WSs constitute a distributed computer infrastructure made up of many different interacting application modules, communicating over private or public networks to form a virtual single legal system”.

Papazoglou (2008) goes on to delineate four fundamental WS functions, which this research seeks to apply to the context of a virtual university. First, a WS can be a self-contained business task, such as a fund deposit service (relevant to the payment of student fees). It can also be a fully-fledged business process such as the automation of the purchasing of office supplies, an application such as stock replenishment or finally a service-enabled resource such as access to a back-end database, containing student records, for example.

Web services can also vary in complexity, from simple requests like checking credits and pricing enquiries to complete business applications that access and combine information from multiple sources (Papazoglou, 2008). As they are further said to address problems related to the rigid implementation of predefined relationships and isolated services, this technology would appear to be ideal for virtual universities, since it dovetails with the long-term goals of enabling distributed applications so that they can be dynamically assembled according to changing business needs and customisation, based on access to devices and users, while enabling wide utilisation of any given piece of business logic wherever it is needed.

### **5.3 Service Integration**

The concept of service integration (SI) is covered widely in the literature, but this researcher was surprised to find only elementary explanations of the software design and implementation aspects. Little advanced and detailed writing on the topic appears to be available. Therefore, this subsection is dedicated to defining SI and identifying its benefits.

Before defining SI, however, it seems appropriate to explain the problem that it is intended to address. According to Capgemini (2013), “businesses have long recognized the value of IT outsourcing and have found that transferring the operational responsibility for IT provision to specialist organizations has offered significant cost savings. However, as enterprises seek more value from their outsourced services, they face the challenge of managing sophisticated IT supplier frameworks”. Capgemini (2013) adds that SI represents a first step towards re-empowering the information officer with the ability to support the business and add value, as cloud service adoption accelerates.

Capgemini (2013:5) then defines SI as “the management of separately supplied IT services to ensure they consistently work together to deliver business benefits ... the provider of SI services is the interface between the client and its service suppliers and is accountable for their performance.” As to its benefits, the researcher states that these include enabling the streamlining of IT service governance and procurement practices, while simultaneously bringing tangible business advantages from reduced operating

costs, decreased risk, enhanced governance and compliance, and improved service quality.

Capgemini (2013) also identifies three stages of SI: service integration, business process integration and value management. SI refers to the bringing together of different IT service elements into a coherent set of end-to-end services bounded by operating-level and service-level agreements. Business process integration here refers to the management of the relationship between key business processes and their supporting and enabling IT services, while value management means managing the relationship between business outcomes and their associated IT services. The above can be achieved by following certain protocols.

#### **5.4 Remote Procedure Call (RPC)**

According to Peterson and Davie (2007:411), “one common pattern of communication used by application programs is the request-reply paradigm, also called message transaction”. With this paradigm, the client computer sends a request message to a server and the server responds with a specific reply message. Meanwhile, the client computer will suspend execution while waiting for the reply. A transport protocol that supports the request-reply paradigm deals with correctly identifying processes on remote hosts and correlating requests with responses (Peterson and Davie, 2007).

As to the remote procedure call “it is fundamentally more than just a protocol, being a mechanism for structuring distributed systems based on the semantics of a local procedure call. This means that the application makes a call into a procedure without regard for whether the call is local or remote and blocks until the call returns”. This apparently perfect protocol is nevertheless complicated by two main problems (Peterson and Davie, 2007). First, Peterson and Davie (2007:412) explain that “the network between calling process and the called process has much more complex properties than the backplane of a computer”. The authors offer the example of writing, where message sizes are likely to be limited and the procedure has a tendency to lose and reorder messages. The second problem with RPCs which they identify is that the computers on which the calling and called processes run may have significantly different architectures and data representation formats.

Therefore, the VUKSA RPC mechanism actually involves two major components, the first being a protocol which manages the messages sent between the client computer and the server processes, and which deals with the potentially undesirable properties of the underlying network. The second is the mechanism that the programming language and compiler support to package the arguments into request messages on the client computer, then to translate the same messages back into arguments on the server machine and likewise with the return value (stub compiler) (Peterson and Davie, 2007).

Treese and Stewart (2003) explain that in an RPC the calling program, rather than invoking a local subroutine, invokes a client stub, which communicates in turn with a remote server, where a server snub makes the actual call to the subroutine. Mitra et al (2007) also comment on the writing of RPCs, stating that “one of the design goals of SOAP Version 1.2 was to encapsulate RPC functionality using the extensibility and flexibility of XML”. They identify six pieces of information needed to invoke a SOAP RPC. Mitra et al (2007:13) explain that “such information may be expressed by a variety of means, including formal Interface Definition Languages (IDL). Note that SOAP does not provide any IDL, formal or informal. It should also be noted that the information listed above differs in subtle ways from that generally needed to invoke non-SOAP RPCs”.

The literature identifies three limitations of RPCs: lack of resilience, lack of scalability and locking up services for prolonged periods. Little et al (2004:186) point out that “because RPC-style middlewares are tightly coupled, they are not resilient to change ... if a method on a remote interface needs to change, all clients have to be updated; until each client is updated, it will not be able to interact with the system.” The second limitation is that of scalability. Little et al (2004) explain that for each client to interact with RPC services, it has to maintain an open connection to the system for the duration of the request-response process; moreover, requests have to be handled as they arrive. “This tends to scale poorly; it is even less appropriate for extremely high-volume event-driven applications” (Little et al, 2004:186). Thirdly, they argue that RPC-style interactions are not practical for long-running operations, as clients are forced to block for the duration of the request. They explain that locking up the service for prolonged

periods further degrades the performance and functionality of the application and potentially causes deadlocks in critical back-office resources.

Regardless of the above limitations, like other systems which utilise RPCs, VUKSA will bind its interface to the appropriate server by using a network directory service. Rather than using a specialised binary wire protocol, VUKSA is built on standard Web servers and http, which have the effect of permitting nearly frictionless use of the existing Internet infrastructure for communication between programs (Treese and Stewart, 2003). This leads to the simple object access protocol discussed below.

### **5.5 Transport Protocol**

This subsection deals with the transport protocol (TP). Stallings (2011) explains that regardless of the nature of the applications that are exchanging data, there is always a need that data be exchanged reliably, meaning that there should be assurances that all of the data sent leave the sending machine and arrive at the receiving machine safe and secure, in the same order in which they were sent. Therefore, the mechanism for providing this reliability should be independent of the nature of the applications. According to Stallings (2011), a TP provides an end-to-end data transfer service that shields upper-layer protocols from the details of the intervening network(s).

If the TP is connection oriented, it takes the form of transmission control protocol (TCP). Regardless of whether it is connection oriented or connectionless, the transport protocol provides services to transport service (TS) users such as FTP, SMTP and TELNET. The connection-oriented service provides for the establishment, maintenance and termination of a logical connection between TS users. It should be noted that there are two different mechanisms, one dealing with a reliable network, called a reliable sequencing network service, and the other with an unreliable network, called an unreliable network service (Stallings, 2011; Tanenbaum and Wetherall, 2011).

### **5.6 SOAP**

SOAP, as explained by Mitra et al (2007:5), is “fundamentally a stateless, one-way message exchange paradigm, but applications can create more complex interaction patterns: request/response and request and multiple responses.’ This is achievable by

combining one-way exchanges with features provided by an underlying protocol and/or application-specific information”.

Treese and Stewart (2003) describe SOAP as essentially the specification of how RPCs are implemented over the Web in three key steps: calling conversions for RPCs, encoding rules for parameters and return values and the envelope. The relationship between SOAP and RPCs is confirmed by Bass et al (2013:109): “SOAP is quite general and has its roots in remote procedure call model of interacting applications ... relies on HTTP and RPC for message transmission ... it is an information exchange standard ... the interacting applications need to agree on how to interpret the payload”.

According to Myerson (2002), SOAP was born in 1998 out of an idea by Dave Winer for an XML-based RPC mechanism. The contributions of a number of important players in the development of SOAP, including W3C, Microsoft and IBM, resulted in different versions being released periodically. IBM released SOAP version 1.1 in 2000, then W3C released a public draft designed to define messaging formats between different architectures in 2001. The coming of SOAP removed ambiguity as to how messages are processed, provided more feedback in error messaging and updated the XML schema and name spacing.

Weerawarana et al (2008:64) add that ‘SOAP started off as the Simple Object Access Protocol, developed by Microsoft, Developmentor and Userland. Subsequently, IBM and Lotus contributed to a revised specification that resulted in SOAP version 1.1, published in April 2000.’ They also state that from that date, SOAP specifications were widely accepted throughout the industry and formed the basis of several open-source interoperable implementations. From there on, SOAP grew in dimensions, capabilities and interoperability, evidenced by the fact that now, “SOAP clients can invoke CORBA servers and CORBA clients and servers to interoperate using SOAP” (Myerson, 2002:70).

Weerawarana et al (2008) report that there was much confusion about what the acronym SOAP represented, with several interpretations becoming popular. Acknowledging that at some point in its development, calling it ‘simple’ or ‘object oriented’ could no longer be justified, the World Wide Web Consortium (W3C) working group decided towards

the end of 2000 that SOAP should no longer be considered an acronym, but simply the name of the protocol specification (Moller and Schwartzbach, 2006). In 2003, the W3C working group produced the SOAP 1.2 recommendations, which consisted of a primer, messaging framework and adjuncts.

This chapter has so far addressed issues of both hardware and software. The hardware helps with connectivity, the software with security and communications. The following section turns to combining SOA and SOAP in the form of web services.

### 5.6.1 Bringing SOA and SOAP together

In order to provide WSs, three players (a service provider, a service consumer and a directory) use WSDL to communicate, as shown in Figures 5.1 and 5.2 (Barry, 2003).

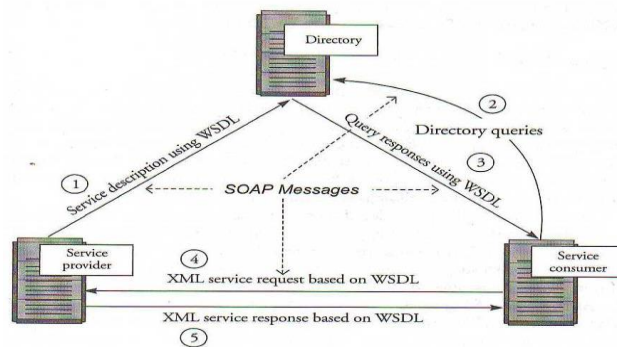


Figure 5-1: Basics of Web Services (Barry, 2003)

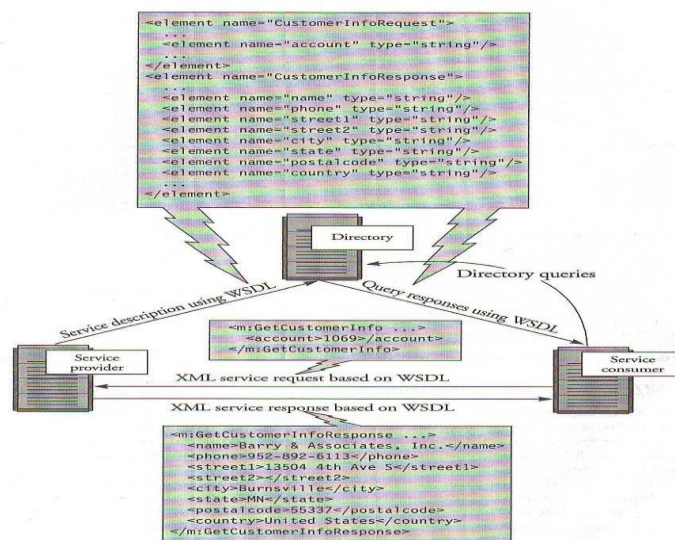


Figure 5-2: Web Service Messages (Barry, 2003)

In this sense, “a service is a function that is well-defined, self-contained and does not depend on the context or state of other services” (Barry, 2003:19). The same researcher identifies five steps which are involved in providing and consuming a service. First, a service provider describes its services using WSDL, publishing the definition to a directory of services which uses the UDDI specification. (Barry, 2003:19) noted that “In the second step, the service consumer issues one or more queries to the directory to locate a service and determine how to communicate with that service. Next, part of the WSDL provided by the service provider is passed to the service consumer, telling the consumer what the requests and responses are for the provider. The fourth step is when the consumer uses the WSDL to send a request to the provider”, then finally, the service provider gives the expected response to the service consumer. All the messages illustrated in Figure 5-2 are sent using SOAP, which essentially provides envelopes for sending WS messages using http or any other means of connection.

### **5.6.2 SOAP architectural concepts**

This subsection introduces a set of architectural concepts that describe the protocol, together with the transmission and receiving of encapsulated data. Given that SOAP is a set of conventions that specify a message format, together with a set of rules that govern the processing of the message as it passes along a message path, it is useful to be clear on how a message is assembled and what interactions can occur among SOAP nodes processing SOAP messages along the message path (Weerawarana et al, 2005).

Peterson and Davie (2007:672) state that “SOAP provides a simple messaging framework whose core functionality is concerned with providing extensibility, ... using message formats defined using XML Schema, bindings to underlying protocols, MEPs, and reusable specification elements identified using XML namespaces”. Similarly, Bass et al (2013:108) note that “SOAP is a protocol specification for XML-based information that distributed applications can use to exchange information and hence interoperate.” They further explain that SOAP is often accompanied by a set of SOA middleware interoperability standards and compliant implementations. The above definitions of SOAP make it clear that XML technology plays an important role. Therefore, Section 5.9 of this chapter is dedicated to a critical discussion of XML technology.



Treese and Stewart (2003) state that the SOAP RPC conventions explain how to represent calls to remote procedures and their responses. Peterson and Davie (2007) add that SOAP's approach to problems associated with application-to-application interactions is to make them feasible, to generate protocols that are customised to each network application, leading to a mass customisation.

Peterson and Davie (2007:670) also explain that the “architecture informally referred to as SOAP is based on Web Services Description Language (WSDL) ... SOAP is a framework for specifying and implementing application and transport protocols”. They add that SOAP is used to define transport protocols with exactly the features needed to support a particular application protocol, by aiming to make it feasible to define many such protocols by using reusable components. Thus, each component, as depicted in Figure 5-3, captures the header information and logic that go into implementing a particular feature. Therefore, a SOAP feature must specifically include a “URI that identifies the feature ... the state information and processing, abstractly described, that is required at each SOAP node to implement the feature ... the information to be relayed to the next node ... and the life cycle and temporal relationships of the message exchanged” (ibid).

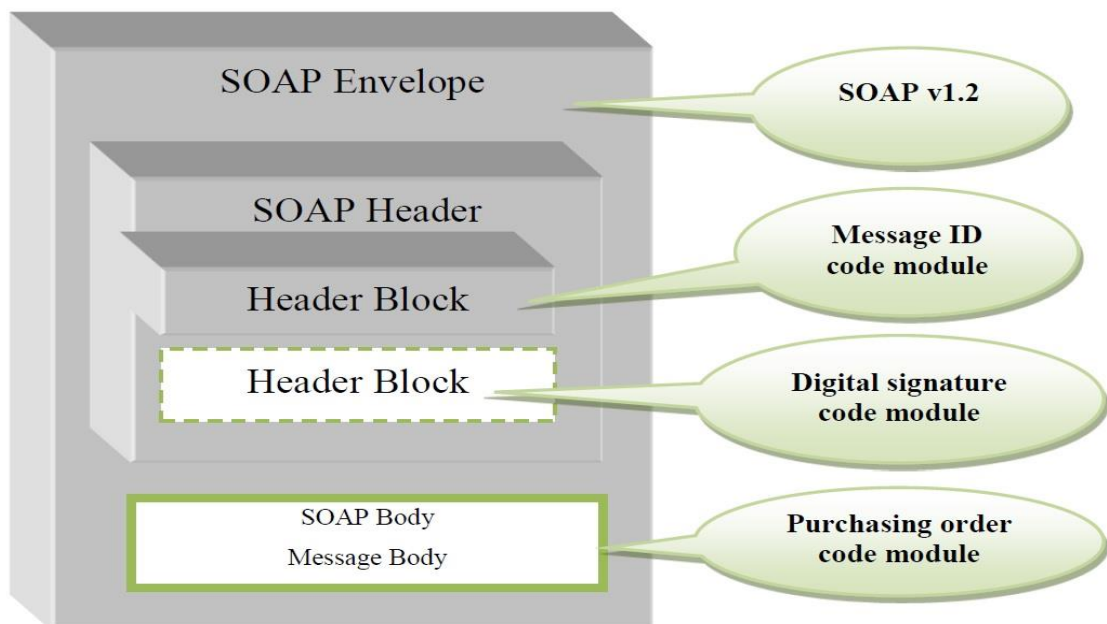


Figure 5-3: SOAP Message Structure (adapted from Peterson and Davie, 2007)

For VUKSA, the way to implement these features involves header blocks. Thus, a SOAP message consists of an envelope containing a header that contains header blocks, and a body that contains the payload destined for the ultimate receiver (Peterson and Davie 2007), forming the messaging structure shown in Figure 5-3.

Mitra et al (2007) describe a SOAP header as

an extension mechanism which provides a way to pass information in SOAP messages that is not application led. However, a SOAP message can be extended in an application-specific manner. The immediate child elements of the env:Header elements are called header blocks. These represent a logical grouping of data which can be individually targeted at the SOAP nodes that might be encountered in the path of a message from a sender to an ultimate receiver.

Papazoglou (2008) concurs with Mitra et al (2007), adding that SOAP divides any message into two parts contained in a SOAP <envelope>: <header> and <body>. The header contains all processing hints that are relevant for the endpoints or intermediate transport points. Papazoglou (2008) also states that the header may contain information about where the document shall be sent and where it originated, and may even carry digital signatures. The SOAP body is the mandatory element within the SOAP env:Envelope, which implies that end-to-end information conveyed in a SOAP message must be carried in the body (Mitra et al, 2007).

The second part of the SOAP envelope is the body, which according to Papazoglou (2008:133) is “the area of the SOAP message where the application-specific XML data, payload, being exchanged in the message is placed.” The body element must be present and be an immediate child of the envelope. Papazoglou explains that it may contain an arbitrary number of child elements, called body entries. “Body elements can also be empty, but all body entries that are immediate children of the <body> element must be namespace qualified” (ibid). By default, the body content may be an arbitrary XML and not subjected to any special encoding rules. In more detail, Papazoglou (2008:134) states that “the body element contains either the application-specific data or fault message”. In this case, application-specific data is the information that is exchanged with a Web service, which can be arbitrary XML data or parameters to a method call. Papazoglou adds that “the SOAP body is where the method call information and its

related arguments are encoded, where the response to a method call is placed and where error information can be stored”.

According to Papazoglou and Van den Heuvel (2007), “SOAP messages are conveyed using any protocol, as long as a binding is defined. Therefore, when the request is received by a runtime service (listener) that accepts the SOAP message, it extracts the XML message body, transforms it into a native protocol and delegates the request to the actual business process within an enterprise”.

Weerawarana et al (2005) describe a SOAP message as the basic unit of communication between SOAP nodes and explain that “a SOAP node is an implementation of the processing rules described within the SOAP specification that can transmit, receive, process, or relay a SOAP message”. While acknowledging that SOAP is widely accepted as the core transport protocol for Web services, Ng et al (2004) query its performance and question whether it really meets the performance needs of business. The results of their study “suggest that the majority of current SOAP implementations are able to deliver reasonably good performance when handling short messages, with the best implementations coming close to binary/TCP performance. However, as the size and complexity of the messages increases, the performance of SOAP implementations worsens accordingly”. The researchers also found that although both the Document and Literal implementations performed better than any of the RPC/Encoded implementations, there was still a sizable gap between the performances of the Document and Literal implementations. Finally, they report the finding that the processes of serialisation and deserialisation were the primary bottlenecks when processing large SOAP messages and that the overhead of deserialisation was higher than that of serialisation (Ng et al, 2004).

On the value of SOAP to Web services, Curbera et al (2002) begin by stating that application-to-application interaction built on top of existing Web protocols and based on open XML standards provides a systematic and extensible framework. Web services simplify the process of polling multiple companies which may be using incompatible applications, by defining a standard mechanism to describe, locate and communicate with online applications. Essentially, each application becomes an accessible WS component that is described using open standards.

Of most interest to the present study in the work of Curbera et al (2002) is their tripartite division of the WS framework into communication protocols, service descriptions and service discovery, each with its own but harmonious specifications. Of the three commonly discussed frameworks, SOAP enables communication among Web services, WSDL provides a formal, computer-readable description of WSs and UDDI is a registry of WS descriptions. Curbera et al (2002) add that because the Web is intrinsically heterogeneous, communication mechanisms must be platform-independent, international, secure and as lightweight as possible. XML is firmly established as the lingua franca of information and data encoding for platform independence and internationalisation. Therefore, SOAP is valuable in working with existing TPs such as HTTP, SMTP and MQSeries.

At its core a SOAP message has a very simple structure: an XML element with two child elements, one of which contains the header and the other the body. ...the SOAP specification defines a model that dictates how recipients should process SOAP messages. The message model also includes actors, which indicate who should process the message. A message can identify actors that indicate a series of intermediaries that process the message parts meant for them and pass on the rest (Curbera et al, 2002:87).

At this point it may be appropriate to discuss the contention that SOAP, like any other protocol, is seen to have both advantages and disadvantages. Papazoglou (2008) lists six advantages; simplicity, portability, firewall-friendliness, use of open standards, interoperability, universal acceptance and resilience to change. In more detail, “SOAP is simple as it is based on XML, which is highly structured and easy to parse [and it] is portable without any dependencies on the underlying platform like byte-ordering” (Papazoglou, 2008:143). Furthermore, SOAP is firewall-friendly in that it is able to get past firewalls that pose problems for other methods, because it uses the open standard of XML to format data which makes it easily extendable and well supported. On the aspect of interoperability, Papazoglou (2008) explains that SOAP is built on open, rather than vendor-specific, technologies and thus facilitates true distributed interoperability and loosely coupled applications. As a result, SOAP is universally accepted in the message communication domain, as well as being resilient to change, as modifications to it will not affect applications using the protocol. Moller and Schwartzbach (2008:472) concur

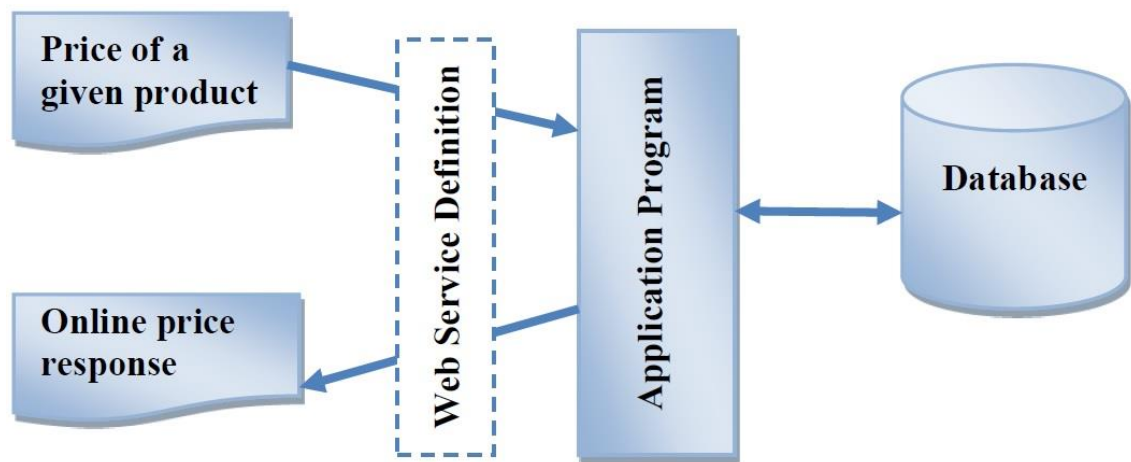
with Papazoglou on these advantages, noting that “the main strengths of SOAP are support for intermediaries, fault management and RPC interactions.”

Papazoglou (2008) also identifies three disadvantages of SOAP, however. First, it was initially tied to HTTP and this mandated a request/response architecture that was not appropriate in all situations. SOAP is also stateless, which entails that the requesting application must reintroduce itself to other applications when more connections are required, as if it had never been connected before. However, “statelessness does not mean that services cannot contain and manage state... the existence of state is the reason for the existence of most web services” (Webber and Parastatidis, 2009:66). This issue of statelessness is revisited in section 5.6.7. Its third disadvantage, according to Papazoglou (2008:144), is that “SOAP serialises by value and does not support serialisation by reference. Serialisation by value requires that multiple copies of an object will, over time, contain state information that is not synchronised with other dislocated copies of the same object.”

While recognising the above disadvantages of SOAP, this researcher is persuaded that the lightweightness of the protocol for exchanging information in a decentralised, distributed environment like VUKSA is sufficiently advantageous to outweigh these limitations. Its fault management mechanism also makes SOAP a protocol of choice. Meanwhile, the next two subsections address in turn the SOAP communication model and messaging using SOAP.

### **5.6.3 SOAP Communication Model**

According to Papazoglou (2008:56), “a WS communication model describes how to invoke Web services and relies on SOAP. The SOAP communication model is therefore defined by its communication style and its encoding style, as it supports two possible communication styles, RPC and document, conveying information about how the contents of a particular element in the header block or body element of a SOAP message are encoded” .



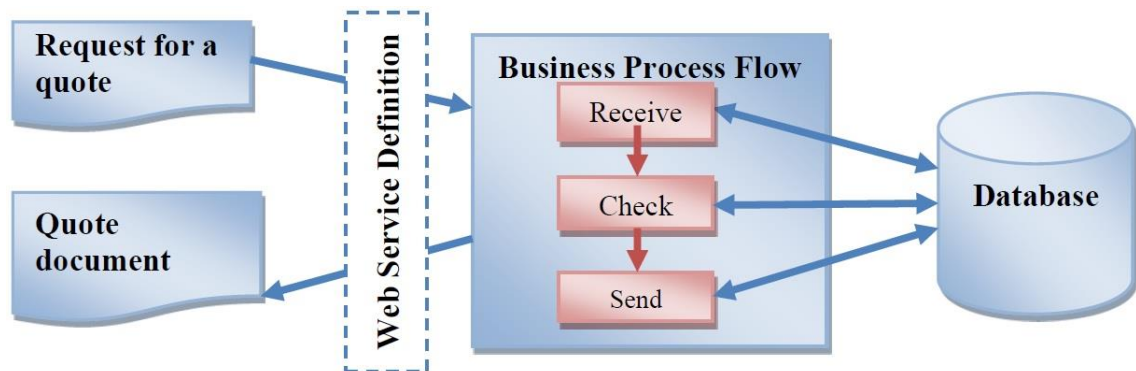
**Figure 5-4: SOAP Communication Model (adapted from Papazoglou, 2008)**

Figure 5-4 shows an RPC-style Web service appearing as a remote object to a client application. The interaction between a client and an RPC-style WS centres on a service-specific interface. In Figure 5-4 the client expresses its request as a method call with a set of arguments, which returns a response containing a return value, represented as sets of XML elements embedded within a SOAP message. The RPC style supports the automatic serialization/deserialisation of messages, which permits developers to express a request as a method call with a set of parameters, returning a response containing a return value. Because of bilateral communication between the client and Web server, RPC-style WSs require a tightly coupled or synchronous model of communication between the client and service provider (Papazoglou, 2008).

The other communication model is the document (message) style of Web service. With this model, SOAP can also be used for exchanging documents containing any kind of XML data. Papazoglou (2008) explains that this enables complete reuse of code, from systems of any type, both within an enterprise and between business partners, by fostering transparent integration to heterogeneous systems and infrastructure. However, Papazoglou (2008) warns that SOAP does not provide a means of encoding source and destination information into the envelope; rather, is up to the individual SOAP client to decide where and how the information is to be transmitted.

Papazoglou (2008) makes it clear that document-style Web services are message driven, meaning that the client invokes a message-style WS, typically sending it an entire

document such as a purchase order, as shown in Figure 5-5, rather than a discrete set of parameters.



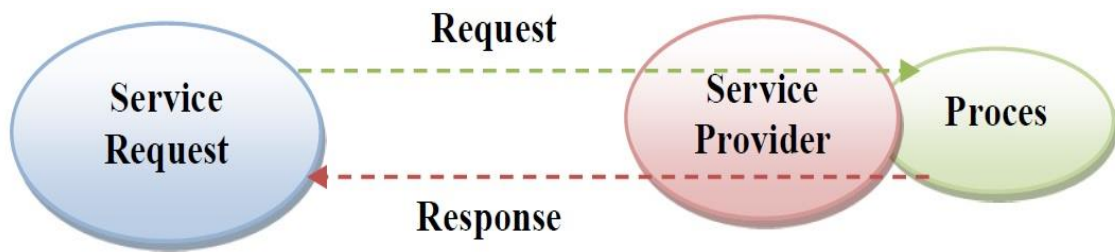
**Figure 5-5: Document-style web service (adapted from Papazoglou, 2008)**

Figure 5-5 shows that the Web service is sent an entire document, which it processes. However, it may or may not return a response message, making the style asynchronous in that the client invoking the web service can continue with its computation without waiting for a response. It should be noted that a client invoking a WS does not need to wait for a response before it continues with the remainder of its application. Unlike the RPC style, “the document style does not support automatic serialisation/deserialisation of messages, rather it assumes that the contents of the SOAP message are well-formed XML documents” (Papazoglou, 2008:138).

#### **5.6.4 Messaging using SOAP**

To understand messaging using SOAP, let us take the example of a VUKSA-registered student who wants to purchase an examination package using online facilities. First, the student uses the system to register for the examination, then checks to see whether the registration was successful. He/she expects the system to respond by providing the venue, subject and time of the exam. To explain the SOAP message exchange pattern, Weerawarana et al (2008) describe a one-way messaging model for transferring information between an initial SOAP sender and an ultimate SOAP receiver. This information is expressed in terms of a “SOAP Infoset that is created by initial SOAP sender and re-created by the ultimate SOAP receiver ... this simple one-way model can be extended to provide more useful interaction between web services” (Weerawarana et

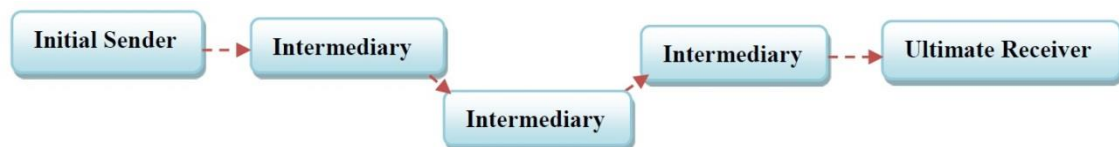
al, 2005:75). These interactions, called message exchange patterns (MEPs), are illustrated in Figure 5-6.



**Figure 5-6: Request/Response MEP (Weerawarana et al, 2005:75)**

Like other Web-based systems, VUKSA operates using the request/response MEP, whereby the requesting service sends a message to a provider, which processes the message then responds to the requester. The communication is not straightforward, however, being complicated by the stateless nature of the WS, because no session state is preserved. Therefore, the requesting services correlate the response to the request by means of either application-based or middleware-based correlation (Weerawarana et al, 2008).

According to Curbera et al (2002:87), “a SOAP message has a very simple structure: an XML element with two child elements, one of which contains the header and the other the body. The header contents and body elements are themselves arbitrary XML”. Curbera et al (2002) state that in addition to “the basic message structure, the SOAP specification defines a model that dictates how recipients should process SOAP messages and indicates which actors should process them.” Moller and Schwartzbach (2008:472) further explain that “the path of a SOAP message involves three intermediaries”, as shown in Figure 5-7.



**Figure 5-7: SOAP message involving 3 intermediaries (Moller and Schwartzbach, 2008:472)**

Moller and Schwartzbach (2008) explain that intermediaries are found between the initial message sender and ultimate receiver. Each of them inspects the message,



especially the header, then perhaps modifies it and finally passes it on to the next node on the path. Papazoglou (2008:131) adds that “the route taken by a SOAP message, including all intermediaries it passes through, is called the SOAP message path”.

Mitra et al (2007:38) distinguish forwarding from active intermediaries: “a forwarding intermediary is a SOAP node which, based on the semantics of a header block in a received SOAP message or based on the message exchange pattern in use, forwards the SOAP message to another SOAP node”. They offer the example of “processing a ‘routing’ header block describing a message path feature in an incoming SOAP message, which may dictate that the SOAP message be forwarded to another SOAP node identified by data in that header block”.

To use SOAP for RPCs, Curbera et al (2002) advise that “one must define an RPC protocol, including how typed values can be transported back and forth between the SOAP representation (XML) and the application’s representation, such as java class, and where the various RPC parts (object identity, operation name and parameters) are carried”. It is important to note here that:

W3C’s XML Schema specification provides a standard language for defining the document structure and data types of XML structures. That is, given a type like integer or a complex type such as a record with two fields, e.g. an integer and a string, XML Schema offers a standard way to write the type in XML. Furthermore, to enable transmission of the typed values, SOAP assumes a type system based on the one in XML Schema and defines its canonical encoding in XML. Using this encoding style, one can produce an XML encoding for any type of structured data. RPC arguments and responses are also represented using this code. (Curbera et al 2002)

For a student to find out if the online registration was successful, the system may utilise a SOAP RPC call. To find out if the examination is to be held on time, the student enquires through the system, which sends a string containing the subject name and an integer with the examination time. The SOAP message is carried by HTTP.

The HTTP headers are above the SOAP: Envelopment element and the POST header shows that the message uses the HTTP post, which browsers also use to submit forms. Following the post header is an optional SOAP Action header, which indicates the message’s intended purpose. If there were a response, the HTTP response would be of type text/xml, as declared in the Content-Type

header, and could contain a SOAP message with the response data. Alternatively, the recipient could deliver the response message later, asynchronously. (Curbera et al, 2002)

In the SOAP envelope above, the call to GetExaminationInfo is an XML element with attributes that include information about the encoding and the children of elements which are the arguments of method calls: subjectName and subjectNumber.

Data types are defined in the type attributes, where xsd refers to the XML schema definitions. When the SOAP implementation receives the message, it converts the XML text for Computer Science and 1111 into the appropriate string and integer, based on the implementation of the service. It then calls the GetExaminationInfo method with those arguments. (Curbera et al 2002)

Therefore, a complete WSDL service description, as critically discussed by Curbera et al (2002), “provides two pieces of information: an application-level service description, or abstract interface, and the specific protocol-dependent details that users must follow to access the service at concrete service end points”. The authors explain that this separation accounts for the fact that similar application-level service functionality is often deployed at different end points with slightly different access protocol details. They conclude that separating the description of these two aspects helps WSDL to represent common functionality between seemingly different end points.

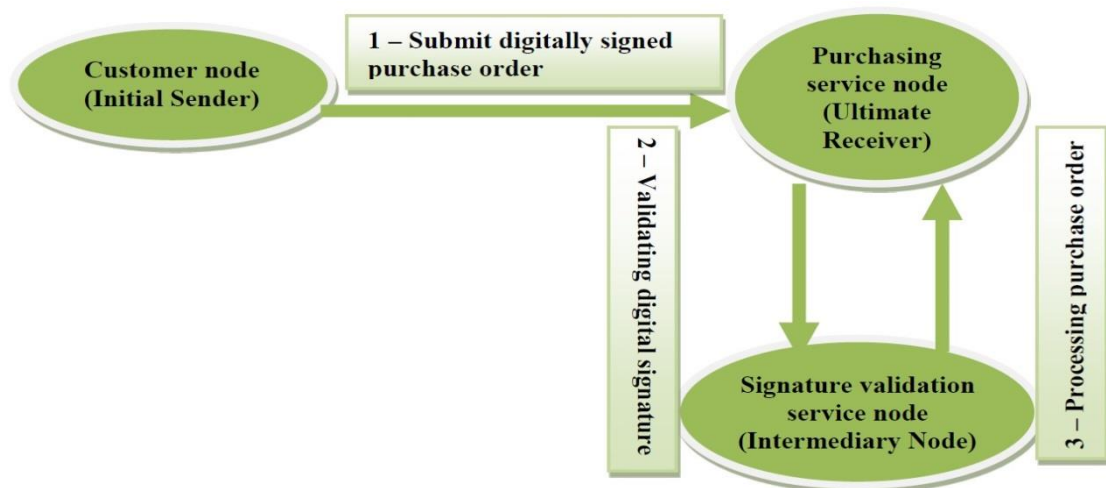
It would be useful here to outline the working of WSDL. Curbera et al (2002:88) explain that “WSDL defines a service’s abstract description in terms of messages exchanged in a service interaction”. There are three main components of the abstract interface. First is the vocabulary. Agreement on a vocabulary is the foundation of any type of communication. WSDL uses external type systems to provide data type definitions for the information exchange. Although WSDL can support any type of system, Curbera et al (2002) state that most services use XML Schema Definition (XSD). Two data types (string and int) are defined in XSD and two others (examination info type and e-registration) in the external schema. WSDL can import such external XSD definitions using an ‘import’ element specifying their location.

From the example above it is also clear, according to (Curbera et al, 2002), that

WSDL defines message elements as aggregations of parts, each of which is described by XSD types or elements from a predefined vocabulary. Messages provide an abstract, typed data definition sent to and from the services. The example shows the three messages that might appear during a Web services interaction. The message, GetExaminationInfoInput, has two parts: studentName, which is an XSD string, and subjectNumber, which is an XSD integer.

On the same aspect of intermediaries, Papazoglou (2008) affirms that they can both accept and forward SOAP messages. They receive a SOAP message, process one or more of the header blocks, then send it on to another SOAP application along the message path, i.e. a SOAP node. Three key use cases define the need for SOAP intermediaries: crossing trust domains, ensuring scalability and providing value-added services along the message path.

Figure 5-8 illustrates the message path that a VU can use to validate a purchase order SOAP message generated by a student or any other customer.



**Figure 5-8: SOAP message for validating a purchase order (Papazoglou, 2008)**

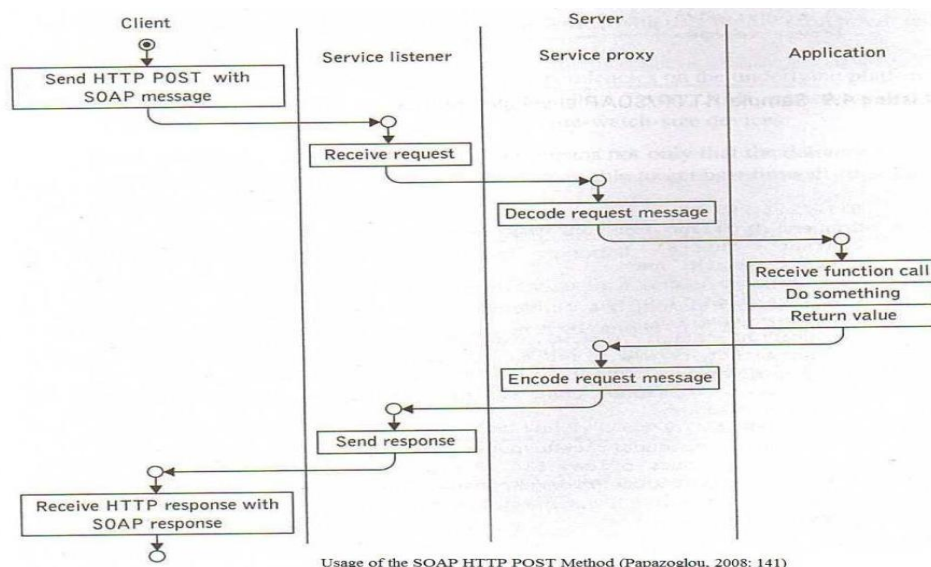
The purchasing service node validates that the purchase order was indeed sent to it by a particular customer. The intermediary service verifies that the digital signature header block embedded in the SOAP message is actually valid. The SOAP message is automatically routed to the intermediary node for the purpose of providing signature verification services. The intermediary node “extracts the digital signature from the

SOAP message, validates it, and adds a new header block telling the purchasing service whether the digital signature is valid” (Papazoglou, 2008:131).

### 5.6.5 SOAP vs HTTP

This subsection considers the advantages of SOAP over HTTP. Papazoglou (2008: 140) explains that “SOAP codifies the use of XML as an encoding scheme for request and response parameters typically using HTTP as a transport protocol to reach destinations on the Internet without needing any additional wrapping or encoding.” It is also made clear that a SOAP method is simply an HTTP request and response that complies with the SOAP encoding rules, while a SOAP endpoint is simply an HTTP-based URL that identifies a target for method invocation, as can be seen in Figure 5.9. Therefore, SOAP does not need a specific object to be tied to a given endpoint; it is up to the implementer to decide how to map the object endpoint identifier onto a provider-side object.

Figure 5-9 is sequential diagram showing the concept of HTTP binding with a SOAP request-response message exchange pattern, using the HTTP post method. It can be seen that SOAP requests can be transported in the body of an HTTP post, which transmits the request content in the body of the HTTP request message. “With post, the SOAP envelope becomes the data part of an HTTP request message and the SOAP response is returned in the HTTP response” (Papazoglou, 2008:141).



**Figure 5-9: HTTP/SOAP Sequential Diagram, Papazoglou (2008:141)**

The message is posted to some service provider, a procedure is invoked and results are generated, then returned in a SOAP response message. This message is carried in the data part of the HTTP response, as shown in Figure 5-9.

### **5.7 Simple Mail Transfer Protocol**

As a web-based system, VUKSA will also rely heavily on the use of email, thus on writing, sending, receiving and reading. According to Tanenbaum and Wetherall (2011), email services are made possible within the Internet by having the sending computer establish a TCP connection on port 25 of the receiving computer. Listening to this port is a mail server that understands SMTP (Tanenbaum and Wetherall, 2011).

Stallings (2011:77) adds that SMTP provides a basic email transport facility in the form of a “mechanism for transferring messages among separate hosts. Features of SMTP include mailing lists, return receipts and forwarding”. Explaining how the protocol works, Stallings states that once a message is created, SMTP accepts it and makes use of TCP to send it to the SMTP module of another host. The targeted SMTP module uses the local email package to store the incoming message in the user’s mailbox.

Tanenbaum and Wetherall (2011) explain that the elements of the communication follow a specified order: the server accepts the incoming connection, subject to some security checks, then accepts the message for delivery. If a message cannot be delivered, an error report containing the first part of the undeliverable message is returned to the sender. Peterson and Davie (2012) observe that SMTP has a companion protocol, Multipurpose Internet Mail Extension (MIME), which specifies the format of the data that can be exchanged.

### **5.8 Message Format**

According to Peterson and Davie (2012:700), “RFC 822 defines messages to have two parts: a header and a body ... both parts are represented in ASCII text ... the message header is a series of <CRLF> terminated lines.” For the sake of clarity, they explain that CRLF stands for ‘carriage return plus line feed’, denoting a pair of ASCII control characters. The header is separated from the body by means of a blank line, and each header line contains a type and value separated by a colon. For example the To: header

identifies the message recipient, while the Subject: header identifies the purpose of the message (Peterson and Davie, 2012). Since its inception in the early 1990s, RFC 822 has gone through several updates and now allows email messages to carry many different types of data such as audio, video, images and documents in many other forms.

Peterson and Davie (2012) describe MIME as consisting of three basic elements, the first of which is a collection of header lines that augments the original set defined by RFC 822. These header lines describe the data being carried in the message body in various ways, including the MIME version, content description, content type and content transfer encoding. The second element consists of definitions of a set of content types, such as image/gif, text/plain or text/richtext. MIME also defines a multipart type that explains how a message carrying more than one data type is structured. The third element is a way to encode the various data types so that they can be shipped in an ASCII email message.

## **5.9 XML**

### **5.9.1 XML Concepts**

One of the challenges facing VUKSA is ensuring that a Web server correctly describes Web pages, regardless of the Web browser used. The solution lies with XML, defined by Peterson and Davie (2007:554) as “a framework, a syntactic foundation, for defining different markup languages for different kinds of data”. They further explain that XML defines a basic syntax for mixing markup with data text.

Weerawarana et al (2008:23) clarify that XML “is actually not a language, but a meta-language for defining new languages ... XML is platform independent and is defined using Unicode, which helps it to represent content from many natural languages.” They add that XML provides a set of core concepts for defining languages: elements, attributes, comments, literal text and documents. The XML syntax rules are that XML documents must have a root element, elements must have a closing tag, all tags are case sensitive, all elements must be properly nested and all attribute values must be quoted.

An XML element is a named construct that has a set of attributes and some children. Attributes are name-value pairs that are associated with an element, and an element can

have any number of attributes. Comments are enclosed within the “<!-- comments -->” character sequence and are meant for the processor to ignore. Literal text is when elements contain character sequences consisting of Unicode characters, and XML documents are units of XML packaging that consist of exactly one element and may contain comments and a few other items (Weerawarana et al, 2008).

In the case of VUKSA, one of the key classes is student. A student record in an XML-based language will be stored in a file named student.xml. The student attributes will be student id, title, first name, surname, date of birth, home address, course, date enrolled and finishing date.

Peterson and Davie (2007) explain that the “definition of a specific XML-based language is given by a schema, which is a database term for a specification of how to interpret a collection of data”. An individual schema defined using XML Schema is then called an XML Schema Definition (XSD). The XSD for student.xml, defining the language to which the student document conforms, is stored in a file called student.xsd.

XML schemas will be ideal for VUKSA, because they provide datatypes such as strings, integers, decimal and Boolean (Peterson and Davie, 2007). They also allow datatypes to be combined in sequences or nested, as in student.xsd, to create compound datatypes. An XSD file defines more than a syntax; it defines its own abstract data model. It is appropriate at this stage to acknowledge that a document that conforms to the XSD represents a collection of data that conforms to the data model (Peterson and Davie, 2007).

### **5.9.2 XML Security Standards**

According to Papazoglou (2008), because XML and WS-based SOA facilitate business integration within and across organisational boundaries, security systems must also integrate without compromising data integrity, confidentiality or privacy. In this researcher’s opinion there should be methods of configuring, monitoring, analysing and controlling integration. The implementation, management and monitoring of security policies across enterprise boundaries are vital to the success of integrated enterprises like virtual universities. Therefore, this subsection concentrates on XML security solutions for integrating enterprises within XML Trust Services.

Papazoglou (2008:467) describes XML Trust Services as “a suite of open XML specifications for application developers developed in partnership with industry to make it easier to integrate a broad range of XML security services into integrated business applications over the web”. The main technologies for XML Trust Services encompass VeriSign, XML signatures for cryptographically authenticating data, XML, XML data encryption and XML Key Management Specification (XKMS) for managing key registration and key authentication. The other aspects of XML Trust Services are Security Assertion Markup Language, for specifying entitlement and identity, and XML Access Control Markup Language, for specifying fine-grained data access rights (Papazoglou, 2008).

### **5.9.3 XML signature**

The XML Signature specification forms the basis for securely exchanging an XML document and conducting business transactions with the objective of ensuring data integrity, message authentication and non-repudiation of services. Papazoglou (2008) explains that an XML signature is applied to arbitrary digital content via an indirection. The process of generating a XML signature starts with data objects being digested and the resulting value placed in an element with other information, which is then digested and cryptographically signed.

There are three types of XML signature: an enveloping signature, where according to Papazoglou (2008), the signature envelops the entire document to be signed, an enveloped signature, where the XML signature is instead embedded within the document, and finally the detached signature, where the XML document and signature reside independently and the document is usually referenced by an external URI.

Signature validation requires that the signed data object be accessible and the XML signature itself will then indicate the location of the original signed object by referencing to enveloping, enveloped and detached signed objects (Papazoglou, 2008).

### **5.9.4 XML Encryption**

The XML encryption functionality is provided by the XML encryption specification, which is a W3C initiative to support encryption of all or part of XML documents. There



are four simple steps for XML encryption, detailed by Papazoglou (2008, quoting Eastlake, 2002b): selecting the XML document to be encrypted in whole or in part, converting the XML document to be encrypted to a canonical form, encrypting the resulting canonical form using public-key encryption and sending the encrypted XML document to the intended recipient.

### 5.9.5 XML Key Management Specification

Quoting W3C and Galbraith (2002), Papazoglou (2008) explains that XKMS is an initiative used to simplify the integration of a public key infrastructure (PKI) and the management of digital certificates with XML applications, the main object being to enable the development of XML-based trusted Web services for the processing and management of PKI-based cryptographic keys. XKMS also “strives to remove the complexity of working with PKI, making it easier for XML-based applications to incorporate security mechanism into their context” (Papazoglou, 2008:473).

As a result, Papazoglou (2008) claims that XKMS facilitates the integration into applications of authentication, digital signature and encryption services such as certificate processing and revocation status checking, without the constraints and complications associated with proprietary PKI software toolkits. Figure 5-10 shows how XML signature and encryption are related to XKMS.

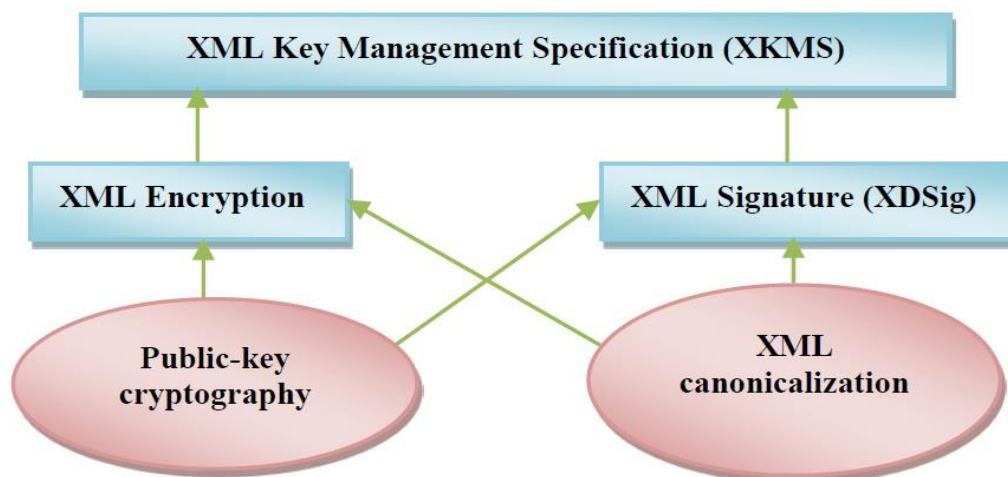


Figure 5-100: Basic building blocks of the XML Trust framework (adapted from Papazoglou, 2008)

Figure 5-10 illustrates the statement of Papazoglou (2008) that XKMS supports three major services, i.e. register, locate and validate services, which link well to service

brokering, as described in Chapter 2, section 2.9.2. The register service is used for registering key pairs for escrow services and once the keys are registered, the XKMS service manages the revocation, reissue and recovery of registered keys. As to the locate service, this is used to retrieve a public key registered with the XKMS service, while the validation service provides all the functionality offered by the locate service, in addition to supporting key validation (Papazoglou, 2008).

## **5.10 Messaging Technology**

The most important part of the VUKSA project for virtualising university education is distributed communication. This raises the challenge of understanding messaging technologies and how they work, as well as their transactional capabilities in achieving reliable communication. According to Little et al (2004:185), “if the application is distributed and meant to interoperate across different operating systems, the most familiar programming construct is the stream-based TCP/IP socket abstraction”. They add that socket-level programming can often be replaced with higher-level middleware like remote procedure calls, CORBA or SOAP facilities. Bearing in mind that messaging consists of sending, queuing and receiving, this section explores these actions.

According to Peterson and Davie (2012:46), “it is important to provide some measure of security in a data communication system.” Therefore, in a reliable and efficient manner, the sender of data must be assured that only the intended receiver actually received the data, while the receiver must also be assured that the data have not been altered in transit and that they actually came from the purported sender. Peterson and Davie further state that “an abstract web service interface consists of a set of named operations, each representing a simple interaction between a client and the web server”. They add that each operation specifies a message exchange pattern that gives the sequence in which the messages are to be transmitted, including the fault messages to be sent when an error disrupts the message flow.

## **5.11 JMS and Transactions**

To address the needs of VUKSA, this researcher is of the opinion that JMS is the most appropriate message service. The JMS specification, according to Little et al (2004),

defines an API that is used to access message-oriented middleware systems. This section therefore provides a critical discussion of the key concepts of messaging technologies, the capabilities they provide and the reasons why transactional capabilities fit well with message bus and queue architecture.

Little et al (2004:188) assert that JMS “defines a set of interfaces and the associated semantics that facilitates communication between Java applications and message implementation”. Thus the applications concerned can create, send, receive and read messages in both the point-to-point and broadcast paradigms. In a fashion that is closely related to SOA, JMS enables communication that is loosely coupled, asynchronous and reliable. Little et al provide detailed descriptions of the workings of JMS which are summarised in the following paragraphs, bearing in mind that it provides a fairly straightforward programming model for accessing topics and queues.

According to Little et al (2004), the standard mechanism for looking up a JMS administered object in J2EE is via the Java Naming and Directory Interface (JNDI) and to support it, application servers have to allow users to map the client view of JMS into their managed naming environment. They explain that to communicate with a Queue or Topic requires that two objects be looked up: the QueueConnectionFactory and the Queue itself. The QueueConnectionFactory interface contains these methods:

```
Public QueueConnection createQueueConnection () throws JMSEException;
```

```
Public QueueConnection createQueueConnection (String username, String password);
```

Little et al (2004:190) further explain that “JMS supports several alternatives for message delivery and receipt semantics based on acknowledgement modes”. They state that the acknowledgement modes determine the degree to which the client and server interact to guarantee delivery and receipt of a message and set during the creation of a JMS session. Working on a queue session leveraging the auto-acknowledgement mode can be achieved by the use of this piece of code:

```
Session queueSession = QueueConnection.createQueueSession (false,  
Session.AUTO_ACKNOWLEDGE);
```

Using `AUTO_ACKNOWLEDGE` mode makes the JMS provider explicitly responsible for guaranteeing delivery; the client is not in direct control of message acknowledgement. Other modes which can be used are `DUPS_OK_ACKNOWLEDGE` and `CLIENT_ACKNOWLEDGE` (Little et al, 2004).

The above code is an example of part of VUKSA that uses JMS sessions, sending messages and making modifications to a relational database within a transaction. The code implements an employee transfer. The employee insert operation is implemented by sending a message to a queue, then an employee is deleted from a table maintained in the database. Little et al (2004) explain that the use of transactions guarantees that the transfer as a whole respects the ACID properties (atomicity, consistency, isolation and durability).

## **5.12 Message-Passing System**

This subsection considers the message-passing system, so it is important first to define 'message'. According to Farley (1998:138), "a message is a structured piece of information sent from one agent to another over a communication channel". Some are requests made by one agent to another, while others deliver data or notifications to another agent. It is also important to recall that in the application of a virtual university, a message consists of message identifier and set of arguments. A message identifier usually consists of simple, unique tokens such as integer values and tells the receiver the purpose of the message, as well as differentiating one type of message from another. On the other hand, a set of arguments contains additional information that is interpreted according to the type of message (Farley, 1998). Arguments can be read and written directly using the Java `DataInputStream` and `DataOutputStream` classes.

However, for VUKSA to send and receive messages over a connection to a remote agent, the application has to utilise `BasicMessageHandler`. The basic message handler class handles messages in term of string tokens. In the handler class below is the `readMsg()` method, which reads the message identifier of the incoming message first, then calls `buildMessage()` to construct the message object corresponding to the message type (Farley, 1998). These two classes define a framework for simple message-passing protocols.

### 5.13 WS-Reliable Messaging

Web-service reliable messaging (WS-RM) was developed to provide a framework for interoperability between different reliable transport infrastructures (Papazoglou, 2008, quoting Bilorusets, 2005). Fremantle (2006) adds that WS-RM is a specification that allows two systems to send messages between them reliably, with the aim of ensuring that messages are transferred properly from the sender to the receiver. Quoting the same source, Papazoglou explains that the WS-RM protocol determines invariants maintained by the reliable messaging endpoints and the directives used to track and manage the delivery of a sequence of messages.

The protocol ensures that unreceived and duplicated SOAP messages can be detected and received messages can be processed in the order in which they were sent. In addition, messages can be exchanged with varying levels of delivery assurance, although WS-RM depends on other WS specifications for the identification of service endpoint addresses and policies. However, the use of WS-RM in conjunction with WS-addressing enables transport-neutral, bidirectional, synchronous, asynchronous and stateful service interactions across networks that include the likes of endpoint managers, firewalls and gateways (Papazoglou, 2008).

Figure. 5-11 illustrates the implementation of the whole WS-RM model, from initial sender to ultimate receiver.

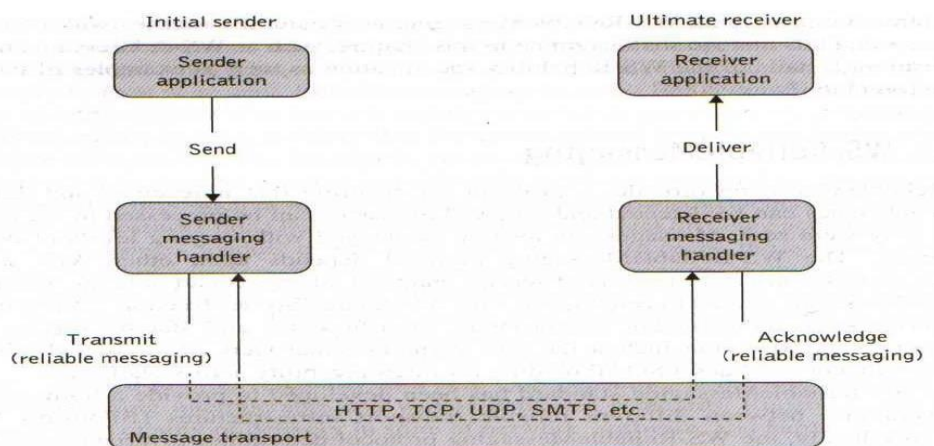


Figure 5-11: WS-Reliable Messaging Model (Papazoglou, 2008)

The diagram indicates that multiple receivers may be interposed between the initial message sender and ultimate receiver. It can also be seen that the message is transmitted using a reliable messaging protocol, in that both interaction endpoints establish preconditions for message exchange and subsequently the sender formats the message to the transport protocol agreed. WS-RM distinguishes two important traits, the first being the reliability protocol between message handlers, implemented by using the same notions of sequence of messages within which each message is identified by sequence numbers. The second trait is the reliability of QoS contract, which provides a delivery assurance and a QoS to the communicating parties (Papazoglou, 2008).

There are four basic delivery assurances that end points provide and which are supported by WS-RM: at-least-once delivery, at-most-once delivery, exactly-once delivery and in-order delivery. The first, according to Papazoglou (2008, citing Barry 2005), is a feature which guarantees that every message sent will be delivered or an error will be raised on at least one endpoint, while the second guarantees that every message will be delivered at most once without duplication or an error will be raised on at least once endpoint. Exactly-once delivery guarantees that every message sent will be delivered without duplication or an error message will be raised on at least one endpoint. Finally, in-order delivery enforces the delivery of a sequence of messages at the destination in the same order as the submission order by the sending application.

In this researcher's opinion, it is important at this stage to understand the structure of WS-RM, which was developed around three core elements: sequences, message numbers and acknowledgements. First, the WS-RM specification always models a message exchange between endpoints as a sequence, irrespective of whether only one or an entire sequence of messages transmitted as a group are exchanged. The protocol uses the <sequence> element to identify and track a group of messages, which are given a unique global sequence identifier. Secondly, individual messages in a sequence are identified by an ascending sequence number, which makes it simple to detect missing or duplicated messages. Finally, an acknowledgement is an indication that a message has been successfully transferred to its destination (Papazoglou, 2008).

Papazoglou (2008) refers to messages containing the <Sequence> element. The message in the example is the third in a sequence and is identified by a URI, in addition to the

mandatory <Identifier> and <MessageNumber> elements. The <Sequence> header here includes a <LastMessage> element, which indicates that this particular message is the last in the exchange. Papazoglou (2008) states that WS-RM proposes the use of a <SequenceAcknowledgement> header element for the purpose of returning a receipt acknowledgement for one or more messages in a given sequence. This element uses a number of <AcknowledgementRange> elements to indicate that the range of messages in the sequence being acknowledged is not contiguous.

Papazoglou (2008) also notes that reliable message delivery does not require an explicit coordinator, but advises that when using WS-RM, the participants must recognise the protocol based on the information sent in SOAP message headers. He adds that a message sequence can be established either by the initiator/sender or the WS, often by both when establishing a duplex association.

#### 5.14 Peer-to-peer Multicasting Model

This subsection presents a Java-based peer-to-peer multicasting model to address the problems and challenges identified above. In developing this model, much thought was given to accommodating changes in the higher education environment and technical developments in software and hardware. The key functions of the model which address the operational challenges are cloud computing, Internet-based coordinated teaching, discussions, chat rooms, messaging, entertainment and translation. The translation function, which is essential in a multi-language system, is discussed in the implementation section.

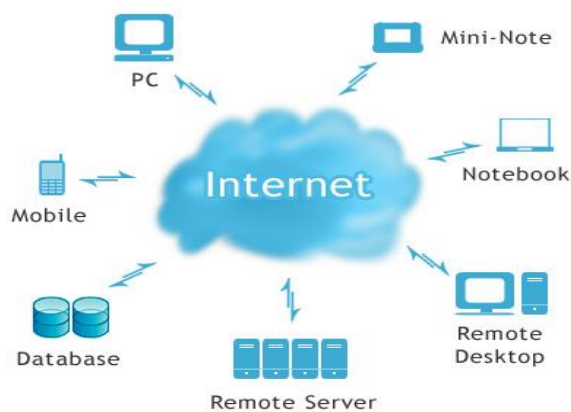


Figure 5-12 : Cloud Computing (Carmen, 2012)

Cloud computing, as illustrated in figure, 5-12, addresses the problem of numerous hardware and software updates arriving at different times. Dhakar et al (2013:1) state that “cloud computing is internet-based computing whereby shared resources, software and information are provided to computers and other devices on demand”. According to Morris (2011), work is done on local computers, with the data being stored on a server at another location, resulting in certain advantages and disadvantages.

The first advantage is convenient connectivity, meaning that data can be accessed from anywhere as long as there is an Internet connection and the appropriate devices, such as those shown in Figure . 5-12. the second is security, which is assured because the specialist companies that provide and facilitate cloud computing use industrial-level security software and practices which make it difficult for hackers to access data. Since all data are stored remotely and backed up off site, another advantage is that they will remain available even if the local computer crashes. The fourth advantage is collaboration, whereby document owners can permit other users to access, view and modify centralised documents. Finally, cloud computing is environmentally friendly, in that it saves energy and other resources.

Dhakar (2013) agrees with Morris (2011) that cloud computing requires very little upfront infrastructure investment, featuring just-in-time infrastructure and more efficient resource utilisation. System administrators can manage resources more efficiently and effectively by handling application requests on demand and relinquishing resources when not needed. In this researcher’s opinion, this characteristic makes cloud computing ideal for VUs, which act as service providers.

The disadvantages of cloud computing include the risk of outages, especially when the provider breaks down, and the fact that a remote server may apply storage limits. Another is that the uploading and downloading of large documents may take a long time. Notwithstanding these disadvantages of cloud computing, the benefits of peer-to-peer multicasting to the VUKSA project include the collaborative network environment, enabling coordinated teaching, whereby teaching staff could highlight the interactive nature of Internet-based learning. Specific learning requirements would be networked to meet the demands of high quality constructivist education. Therefore, this function



makes group learning and collaborative learning among remote students possible and enjoyable.

For discussions, the system will provide forums for teachers and students to provide structured online communication capabilities. The other function will be the chat-room, a tool that allows system users to simultaneously log on to the system in real time and engage in spontaneous dialogue. Of the functions identified above, entertainment is particularly innovative, in that it will be designed to merge educational goals in an entertaining content.

The key function to address technical challenges is building an application that does not rely on any particular operating system, but can work with existing operating systems without much modification. To achieve this, the proposed model uses concurrent and distributed programming. The advantages of concurrent programming for the model include the ability of system users to interact with applications while other tasks are running and the capacity to transfer large files over the Internet. Another is the availability of computing services such that long-running tasks need not delay short-running ones; for example, a Web server can serve an entry page while at the same time processing a complex query.

Parallelism means that complex programs can make better use of multiple resources in new multi-core processor architectures, SMPs, LANs or WANs. Finally, controllability means that tasks requiring certain preconditions can suspend and wait until the preconditions hold, then resume execution transparently. However, this researcher is aware of four disadvantages of concurrent programming, as presented by Little et al (2004, concurring with Lea, 1999). These concern safety, whereby concurrent tasks should not corrupt the consistent state of a program; aliveness, meaning that tasks should not suspend and wait for each other indefinitely, causing deadlock; non-determinism, which means mastering an exponential amount of interleaving due to different schedules; and resource consumption, whereby threads can be expensive. Any of these possible problems can result in overheads of scheduling, context-switching and synchronization, making concurrent programs run more slowly.

Distributed programming in the model presented also has its advantages and disadvantages. The advantages include performance (in terms of both economics and speed), inherent distribution, reliability and incremental growth. A collection of processors can very often provide higher performance. As to distribution, many applications, by their nature, involve spatially separated machines. Reliability is high because of fault tolerance; that is, even if some of the machines crash, the system can survive. Finally, incremental growth is facilitated in that new machines can be added incrementally as requirements for processing power grow. As to disadvantages, this researcher is aware of three, affecting software, networks and security. There are difficulties in developing distributed software, especially after considering the form that operating systems, programming languages and applications should take. Several problems are created by the network infrastructure, which has to deal with loss of messages and overloading. Finally, sharing generates the problem of data security.

### **5.15 Summary**

This chapter on application-to-application technologies has established that web services comprise a self-contained software module available via a network for completing tasks, solving problems, or conducting transactions on behalf of a user or an application. It was also shown that web services constitute a distributed computer infrastructure made up of many different interacting application modules communicating over private or public networks to virtually form a single legal system. Therefore, web services are an essential part of virtualising universities in the sense that they open up access to educational resources and students can access the resources at any time from anywhere in the world.

On the subject of service oriented architecture, it was established that it is a logical approach to design a virtual university for the purpose of providing services to end-user applications and to other services distributed in a network via published and discovered interfaces. The second point here was that SOA exist to enable general-purpose interoperability among existing technologies and extensibility to future purposes and architectures. Thirdly, it was demonstrated that SOA allows easy cooperation of a large number of computers that are connected over a network, where every computer can run an arbitrary number of services that are built in a way that they can exchange

information with any other service within the reach of the network, without human interaction and without the need to make changes to the underlying program itself. As with WSs, understanding and implementing SOA is the most practical and viable way of virtualising universities.

The three points made above, regarding the provision of services, enabling general-purpose interoperability and allowing easy cooperation of computers, is closely related to the concept of virtualising university education. The same points contribute in explaining the benefits of a virtual university as well as how a VU can be a service provider on an SOA framework.

This chapter has also critically explained service integration and established that the benefits of SI include enabling the streamlining of IT service governance and procurement practices, while simultaneously bringing tangible business benefits realised through reduced operating costs, decreased risk, enhanced governance and compliance, and improved service quality. Therefore, SI is also an important part of virtualising universities, in that it helps to address the challenges relating to operating costs, computer infrastructure governance and compliance issues, and the quality of the services provided.

The concept of remote procedure calls was also researched, and based on available knowledge it was established that RPC is a mechanism for structuring distributed systems based on the semantics of a local procedure call, which means that the application makes a call into a procedure without regard for whether the call is local or remote and blocks until the call returns. The transport protocol discussion established that there is always a need for data to be exchanged reliably, meaning that there should be assurances that all of the data sent leave the sending machine and arrive at the receiving machine safe and secure, in the same order as sent. The reliable exchange of data helps to establish how available technologies can be utilised to improve the virtualising of university education. The following section considered the registering and discovering of web services. Three aspects of messaging technology were then addressed: JMS and transaction, message-passing and WS-RM. In regard to JMS and transaction messaging, it was established that JMS supports several alternatives for message delivery and receipt semantics based on acknowledgement modes and that the

acknowledgement modes determine the degree to which the client and server interact to guarantee delivery and receipt of a message and set during the creation of a JMS session.

The next chapter describes the proposed architecture for VUKSA.

## **Chapter 6: The Proposed Architecture**

### **6.1 Introduction**

This chapter proposes an architectural approach for a virtual university. It is divided into three parts, the first showing how the existing WS facilities of registering and discovering will fit with the delivering of a virtual university. The second part focuses on the integration of WSs with V U systems such as PayPal, email, an online library service and a social media service. The final part is concerned with securing web services, which are key components of online communication.

### **6.2 Registering and Discovering Services**

Service registration and discovery are two core functions of the service-oriented architecture approach. In WS applications, a virtual university has a service registry, which is necessary to keep track of what services it has to cover, as well as their characteristics. As recommended by Papazoglou (2008), the UDDI specification for their creation will address the challenges of service registration and discovery. UDDI is a cross-industry initiative to create a registry standard for WS description and discovery, together with a registry facility that supports the publishing and discovery processes. This section offers a description and critical discussion of the role of service registries and service discovery for Web services, focusing on the concept and structure of UDDI and its relationship with WSDL documents as they are utilised to support virtualism.

Just like any other business providing online services, a virtual university must be able, in order to exploit the full potential of e-business, to discover services, make its needs and capabilities known, and compose WSs from diverse organisations into new services and business processes (Papazoglou, 2008). Therefore, VUs will be exposed to the challenges of enabling themselves to discover and reach each other, to learn what kinds of capabilities their potential trading partners have and to continuously discover new potential trading partners. Indeed, the challenges go beyond the continuous discovery of potential partners to understanding service provider's capabilities and seamlessly

conducting e-business with others. With this approach, according to Papazoglou (2008), virtual universities will then require the creation of a service registry architecture that enables enterprises to introduce a global, platform-independent, open framework for different departments to discover each other, to define how they would interact over the Internet and share information in a global registry, thus accelerating the global adoption of e-business and e-learning.

Service registration, Papazoglou (2008) explains, requires visibility and control; a service registry must keep track of the services operated by an organisation and their characteristics. Papazoglou distinguishes two types of e-business registry: document-based and metadata-based registries. These differ largely in the ways that they handle descriptive service information: the former “enables its client to publish information by storing XML-based service documents in the registry”, whereas the latter uses “a different approach” (Papazoglou, 2008:175) related to the structure of the information. Therefore, in a virtual university submitting descriptive documents to a document-based service registry, service providers must give descriptive information about each document in the form of metadata, which is “one of the key elements of any integration solution because it is used to describe the structure of information held in the disparate systems and processes” (Papazoglou, 2008:175).

Furthermore, in this model of a virtual university, as explained by Papazoglou (2008:549), “most semantic interoperability issues are handled by using a common vocabulary of terms that each party must adhere to when communicating to a group of trading partners.” Typical semantic interoperability solutions at the data level exhibit three characteristics: semantic intermediation, semantic mapping and context sensitivity.

In this model, semantic interoperability solutions will use a common ontology as a mediation layer in order to abstract data terms, vocabulary and information into a shareable distribution model. “In semantic interoperability solutions, mapping accounts for much more than simple many-to-many data formatting rules or data syntax arbitration” (Papazoglou, 2008:550). Semantic mapping to ontology preserves the native semantics of the data and eliminates the need for custom-developed code. Context sensitivity in this instance refers to the meaning of any data item bounded to a specific context. Consequently, any semantic interoperability solution must

accommodate the possibility that the same data item may mean different things from different semantic viewpoints.

The virtual university as recommended by Papazoglou (2008), being an advanced registry, has five appealing characteristics. First, it maximises WS reuse and encourages broad usage by all potential users in an SOA solution. It also creates a management and governance structure to grow and sustain a successful SOA implementation. The third appealing characteristic is that it contains all the metadata about WSs and their associated objects, service providers, consumers and their relationships. The fourth is that it provides general and special-purpose interfaces which address the needs of providers, consumers, administrators and operators. Finally, it ensures that the evolving SOA can handle the growing number of services and consumers and that it can adapt rapidly to changing business requirements.

### **6.2.1 Service Discovery**

Papazoglou (2008:176) defines service discovery as “the process of locating web service providers and retrieving web service descriptions that would have been previously published”, adding that WS discovery entails locating and interrogating Web service definitions. It is through this process that virtual university clients will learn of the existence of a particular service, its capabilities and how to interact with it. There are two basic types of service discovery: static and dynamic. Static service discovery occurs at design time, whereas dynamic discovery occurs at run time. With static discovery, the service implementation details are bound at design time and service retrieval is performed on a service registry. With dynamic discovery, the service implementation details are left unbounded at design time so that they can be determined at run time (Papazoglou, 2008, citing Graham, 2004a).

### **6.2.2 UDDI**

A UDDI registry contains relatively lightweight data with the prime purpose of providing network addresses to the resources it describes, according to Papazoglou (2008), who offers an example which is ideal for a virtual university. He explains and exemplifies schemas, interface definitions and endpoints in locations across the

network, adding that the core concept of the UDDI initiative is the UDDI business registration, an XML document used to describe a business entity and its Web services.

Working with WS providers and with clients who want to find and use them, the UDDI service in a virtual university will provide methods of querying a WS registry to determine the availability of specific services. In this setting, a requester queries a registry with a WSDL query, to which the registry responds with the protocol of how the requester may interact with the requested services (Sebesta, 2008). Papazoglou (2008:177) concurs and adds that UDDI “is a cross-industry initiative to create a registry standard for web service description and discovery together with a registry facility that supports the publishing and discovery of services”. UDDI uses W3C and Internet Engineering Task Force standards such as XML, http and domain name protocol. It provides a global, platform-independent, open framework making it easier to publish an enterprise’s preferred means of conducting business, find trading partners and interoperate with them over the Internet (Papazoglou, 2008; Sebesta, 2008; Webber and Parastatidis, 2009). UDDI also enables service providers to describe their services and business processes in a global, open environment on the Internet, which means extending their reach, enabling potential clients to discover information about WS providers, to find descriptions of their services and to acquire technical information about WS interfaces and definitions of how the enterprises may interact over the Internet (Papazoglou, 2008).

Papazoglou (2008) states that the information provided in a UDDI business registration consists of three interrelated components which will be utilised by a virtual university: white pages, yellow pages and green pages. The white pages include address, contact and other key points of contacts, the yellow pages contain information arranged according to industrial classifications, based on standard industry taxonomies, and the green pages describe the technical capabilities of services offered, including references to WS specifications.

Two observations relevant to the proposed VUKSA may be made here. First, the above information strongly suggests that like any other enterprise, a VU can use a UDDI registry to discover the existence of potential trading partners and obtain basic information about them through the white pages, to find companies in specific industry



classifications through the yellow pages, and to uncover the kind of WSs offered and to interact with the enterprises through the green pages.

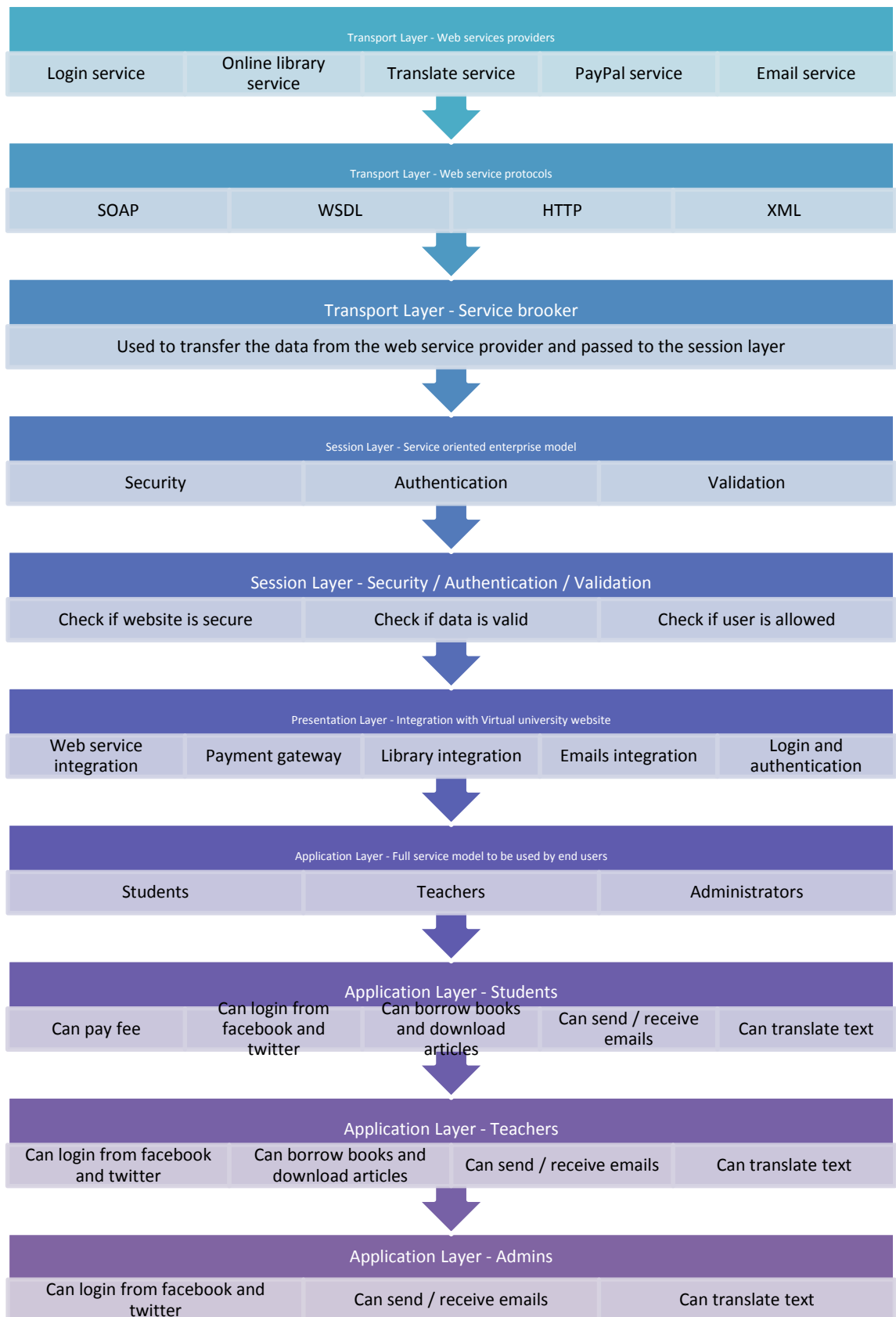
The second observation is that the information that would be stored in the UDDI registry can be used by applications and developers to determine who the business entity represents, what the business does, where the services that it provides can be found and finally how other businesses can avail themselves of the available services in order to avoid ‘reinventing the wheel’. This researcher concludes that a UDDI registry has a role in virtualising university education, a role related to information about Web services similar to that of a phone book for telephone numbers.

### **6.3 Integrating Web Services with Virtual University Systems**

We have seen above how WSs can be found, how the data are transferred between them and how these services are consumed by the websites or other applications. In the case of integrating a few web services, we will see how they can be linked together with the VU website and what procedures we will have to take to configure them to work properly.

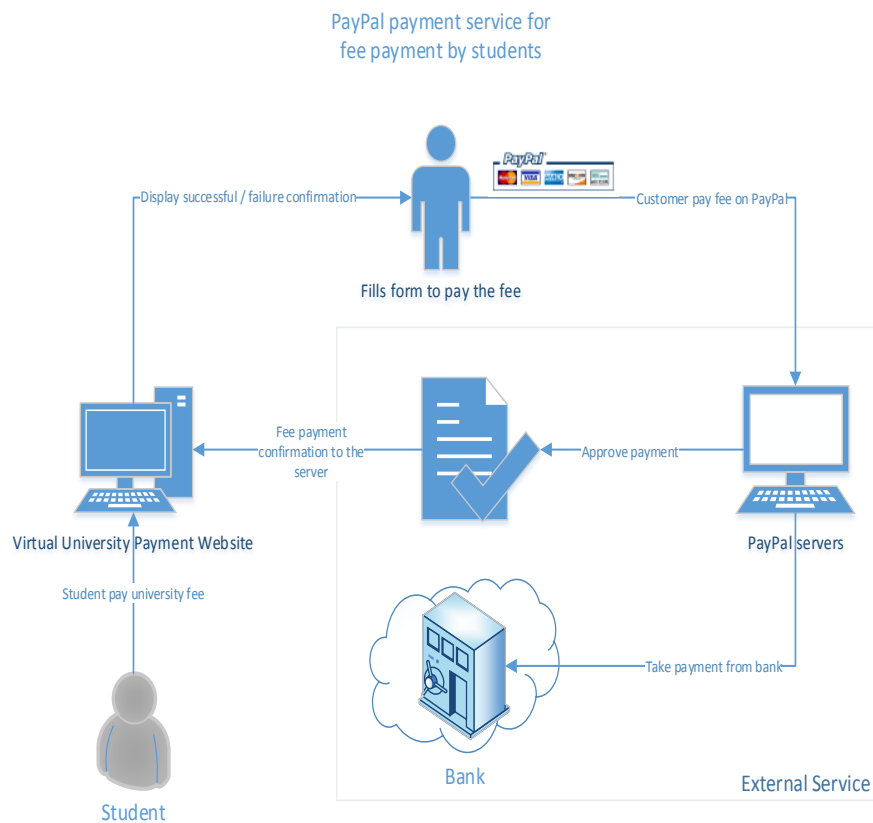
The first step is to identify the web services and discover how they can be integrated. This step is covered in the section on UDDI, which explains what the service does and how it can be accessed. The services to be used will then be integrated into the virtual university website. There is a step of proper validation and authentication to consume the services, because some services are password protected and require authentication before they can be accessed. It has been explained that a SOAP message can contain header information and that the authentication key or username/password combination can be passed to the service. The model illustrated in Figure 6-1 details how all of this can be achieved.

First, the services are discovered and in our case we have login, email, translate, online library and the PayPal payment service. These services are communicated in different ways with different protocols: some of them use only HTTP calls and some use the WSDL method, which also contains XML, as discussed earlier. After being used with their respective protocols, these services are passed from the enterprise model where they are checked for authentication and to confirm that they are from valid sources.



**Figure 6-1: Web Service Model for Virtual University**

After this they are integrated with the various parts of the virtual university website; for example the PayPal service (Figure 6-2) is integrated with the payment page and online library with the library page. Login services are required for students to access the student panel where they can see their courses, etc. Therefore, after integration these services are ready for end users to consume them for their specific needs. For example, students and teachers can access the library, email and translation services, while administrators can keep a check on how these are used.

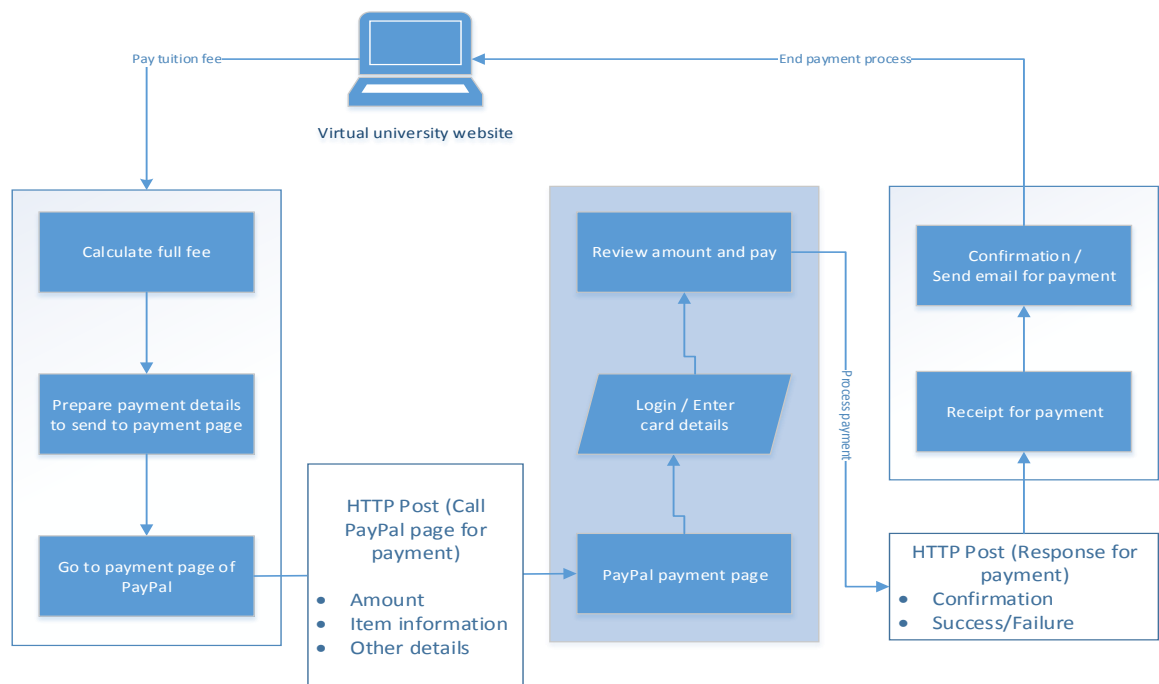


**Figure 6-2: PayPal Payment Service**

The PayPal service will be used by the system so that students can pay course fees by using their credit cards. PayPal provides a way of integrating its service into a university website, so that students can then pay the fee and the money will be transferred from their bank accounts to the PayPal account. When users pay the fee, the PayPal service

checks whether the payment was successful; if so, PayPal sends confirmation to the university website.

The PayPal service is integrated into the website for the payment of student fees. It is integrated with HTTP post methods, which send payment information to the PayPal website from the payment page, as shown in Figure 6-3. The HTTP post method is used to send a form of values to a specific page given by PayPal with the list of predefined name-value pairs of text such as currency, amount, basket items, etc. After the user is directed to the PayPal page he or she will pay either by credit or debit card or will login to a personal PayPal account and perform the payment process. Then, when the payment has been processed successfully, the user will be redirected to the virtual university website. The HTTP post method on the website will get that data and show the confirmation accordingly.

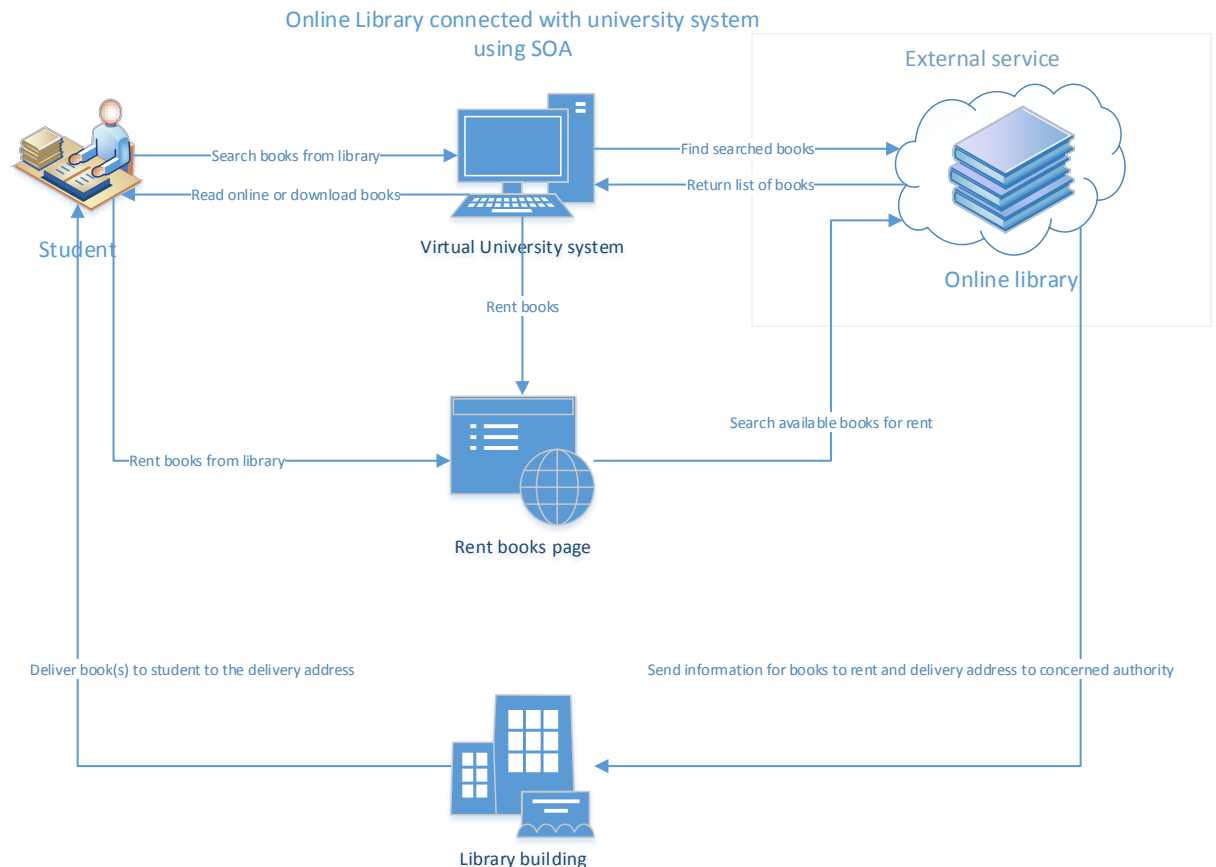


**Figure 6-3: PayPal and HTTP**

### 6.3.1 Online Library Service

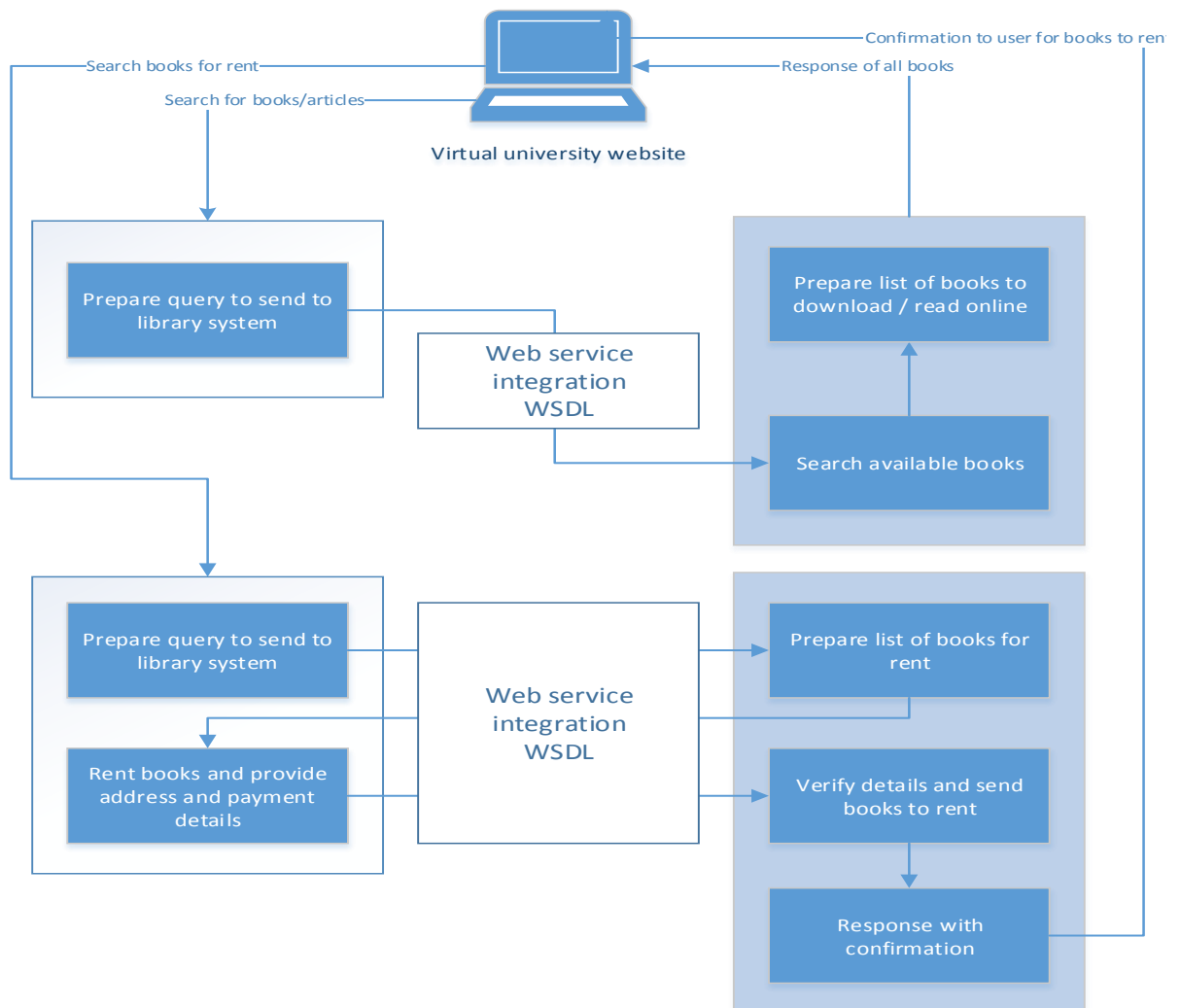
It is a major task to integrate the online library service into the university system. Everyone needs books, articles and other resources to do their research and homework. The VUKSA library will provide easy access to materials that students and others can

either read online or download. This library can be accessed from anywhere, e.g. at home or university. Another benefit of this service is that students can rent hard paper copies of books from the library, which will be delivered to their addresses following the order confirmation (Figure 6-4).



**Figure 6-4: Online Library**

The best way to integrate the online library service (Figure 6-5) is to use WSs, due to their ease of use and wide range of functionality. The web service will be integrated with the virtual university website and process its details over service calls. The WSDL contains the methods to bring books into the library and for searches to be carried out. As discussed earlier, the WSDL file is a form of xml data communication between the client and web service.

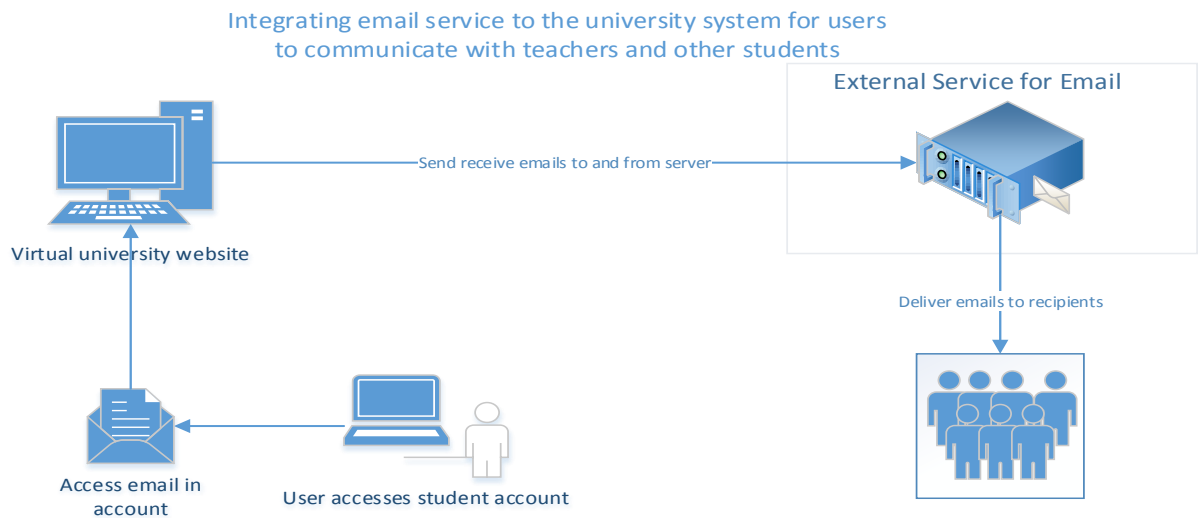


**Figure 6-5: Online Library Integration**

### 6.3.2 Email Service

The email service is used for ease of access and communication between teachers and students, so that messages can be sent and received easily between them. Email providers like Hotmail and Gmail provide a way to integrate their email services into the website's systems. The users will be able to login with their own accounts and send emails as normal from their student accounts. Figure 6-6 show how the email service works and integrates with the VU system, illustrating all the protocols and technologies used. Email services provided by Gmail or Hotmail can be integrated easily, but they

cannot be merged with the website. Custom emails can be set up on the owning domain, but as we are using service-oriented architecture, these have to be external services.

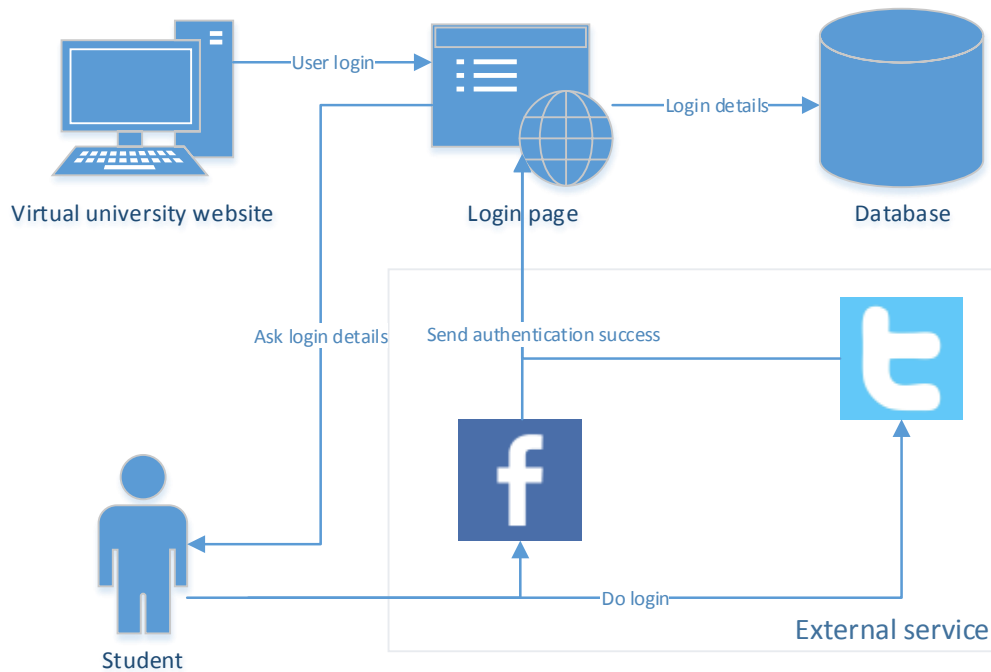


**Figure 6-6: Email Integration**

### 6.3.3 Social Media

Many people nowadays use social networking sites such as Facebook and Twitter to socialize with others. These services also provide an easy way to log in to the systems by integrating a login button to login-protected web pages. Users can create accounts and link them to their Facebook or Twitter accounts so that they do not need to provide their login credentials every time they access the website (Figure 6-7). These logins provide an access token which will be saved to the website for automatic login.

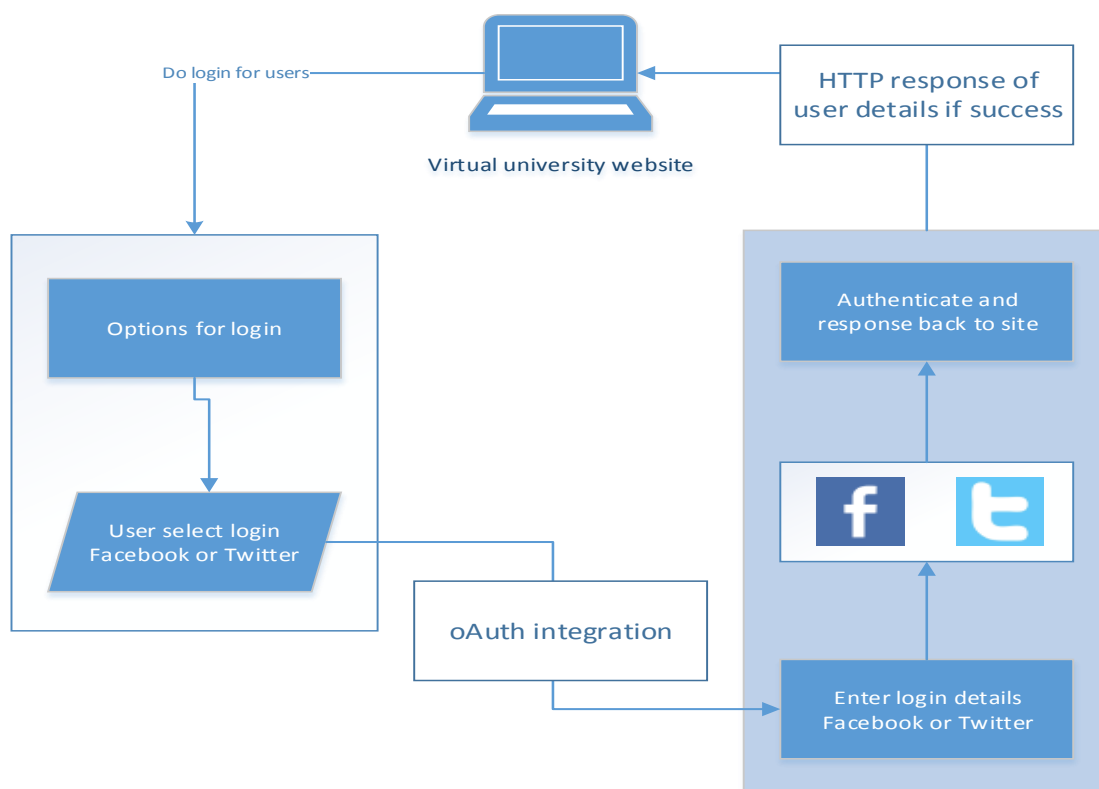
### Login to university system using Facebook and Twitter and storing the details of user



**Figure 6-7: Social Media Login**

The social login process can be integrated by using popular social sites such as Facebook and Twitter with their API (Figure 6-8). The API uses the oAuth technique to integrate the login process and get the user's details. This is all done through HTTP methods which reside side by side with the oAuth functionality.





**Figure 6-8: Integrating Social Media Login**

## 6.4 Securing Web Services

Among the challenges of virtualising university education is that since SOAP consists primarily of a protocol specification language based on XML in a world of many custom protocols, support for the automation of implementation is crucial to avoid the effort of manually implementing each protocol (Peterson and Davie, 2007).

The second challenge is that with improvements in technology, accessibility and portability, there is a great demand for mobile technologies, especially to facilitate the downloading and uploading of the large files which are inevitable components of a virtual university. It is also clear that Web services use the Internet for mission-critical transactions, with the possibility of establishing dynamic, short-term relationships, and that the Internet is well known to be insecure (Papazoglou, 2008). It is also clear that the flexibility and other benefits of WSs creates potential security gaps. Therefore there a strong need to secure WSs against a wide range of security attacks and to ensure their integrity and confidentiality, through the application of a comprehensive security

model. The following paragraphs therefore critically discuss two concepts as they relate to the implementation of a virtual university: security and session control.

#### **6.4.1 Security**

By its nature as a virtual system, VUKSA will possess valuable information, which could be technical, commercial, financial or legal, among many other possibilities, and which will need to be guarded closely. The most basic and normally the first steps in securing and protecting information are to control and monitor access and usage. This can be achieved both by controlling access to the building and the computer hardware containing the information and by passwording access to files and documents. There is thus a great need for a serious consideration of information security and protection.

For VUKSA, there are three main challenges, the first being to secure and protect all kinds of data, information and communications so that no university official or student will be able to gain authorised access to another person's file, directory or communication. The second challenge is that of the law of conservation of threat (Tanenbaum, 2009), referring to attacks from outside by viruses, worms and other digital pests which could enter the computer system over the Internet. The third is what this researcher will call Java application security, because most of the protocols discussed in this thesis and the implementation examples are biased towards Java. Therefore, in this context, Java application security will be critically discussed in terms of authentication, encryption and auditing. The present researcher is particularly interested in Java application because according to Oaks (2001:2), "the new distribution model for Java programs ... has the ability to download programs over a network and run those programs on another machine... on an as-needed, just-in-time basis".

#### **6.4.2 Securing and Protecting System Contents**

From a security perspective, like any other computer system VUKSA will have four goals: data confidentiality, data integrity, system availability and privacy. Data confidentiality is "concerned with having secret data remain secret ... if the owner of some data has decided that these data are only to be made available to certain people and no others, the system should guarantee that release of the data to authorised people never occurs" (Tanenbaum, 2009:611). Hunter and Crawford (2001:230) describe

confidentiality more succinctly as “ensuring that only the parties involved can understand the communication”. Therefore, as an absolute minimum, VUKSA system users should be able to specify who can see what and the system should enforce security specifications ensuring that only the parties involved, such as tutors or students, can understand the communications intended for them.

The second goal of VUKSA is data integrity, which Hunter and Crawford (2001:230) define as “being able to verify that the content of the communication is not changed during transmission”. This means that an authorised system user should not be able to modify—i.e. change, remove or add—any data, without the owner’s permission (Tanenbaum, 2009). The implementation of VUKSA’s security features must ensure this level of integrity.

The third goal is system availability, which Tanenbaum (2009:612) explains as meaning that “nobody can disturb the system to make it unusable”. Examples of such so-called denial of service against which VUKSA must be protected include sending a flood of requests to the servers, which could cripple the system by utilising all of its CPU time in examining and discarding incoming requests. Other threats to availability may be even more serious. Although most people are law abiding, there are a few who may seek to cause trouble, either for their own commercial gain or simply because they bear a grudge against a particular organisation, group or country. Some are simply angry people who attempt to destroy as much infrastructure as they can without regard to the nature of the damage or who the specific victims are (Tanenbaum, 2009). Like any other system, VUKSA will be exposed to such intruders and measures must be taken to ensure that it is well protected from them. The fourth goal is privacy, which is concerned with the legal and moral issue of protecting individuals from the misuse of information about them (Tanenbaum, 2009).

### **6.4.3 Cryptography**

Following the recommendations of Tanenbaum (2009), one of the measures which VUKSA will implement to address security threats is cryptography. Knudsen (1998) agrees that cryptography, the science of secret writing, will make VUKSA more secure. In order to protect against the threats outlined above, VUKSA has to assure system

users who they claim to be; therefore there is a need for authentication, which means ensuring that a client computer is talking to a legitimate server. The system must also operate with confidentiality, i.e. be sure that any information it transmits is not subjected to eavesdropping. (Hunter and Crawford, 2001:243) state that “cryptography provides strong methods of authentication by means of digital signatures and certificates. Digital signatures allow web servers and clients to use advanced cryptographic techniques to handle identification and encryption in a secure manner”.

The paragraphs below focus on three aspects of security that are commonly supported by JMS providers: authentication, authorisation and secure communications (Monson-Haefel and Chappell, 2001).

#### **6.4.3.1 Authentication**

Monson-Haefel and Chappell (2001:136) state that “authentication verifies the identity of the user to the messaging system; it may also verify the identity of the server to the JMS client . They explain that the most common kind of authentication is a login screen that requires a username and a password, which is supported explicitly in the JMS API when a Connection is created and in the JNDI API when an InitialContext is created”.

There are two different authentication methods: http authentication and form-based authentication. For the reasons explained below, VUKSA is to implement form-based authentication. According to Hunter and Crawford (2001:49), “the http protocol provides a built-in authentication support called basic authentication, based on a simple challenge/response, username/password model”. The researchers explain that with this technique the Web server maintains a database of usernames and passwords, and identifies certain resources as protected.

However, Hunter and Crawford (2001:231) also point out that “the basic authentication alone is very weak ... it provides no confidentiality, no integrity and only the most basic authentication”. It is weak because the passwords would be transmitted over the network, thinly disguised by a well-known and easily reversed Base64 encoding. Given these advantages and drawbacks of http authentication, the present researcher has opted for form-based authentication. This utilises html forms, allowing users to enter VUKSA through a well-designed, descriptive and friendly login page. Implementing form-based

authentication “is relatively straightforward with servlets because form-based authentication is built into Servlet API 2.2” (Hunter and Crawford, 2001:238).

#### **6.4.3.2 Authorisation**

Monson-Haefel and Chappell (2001) describe authorisation or access control as an important step in the security process, where intelligent decisions have to be made about what a specific user is allowed to do. Authorisation is important because it is the process that applies the security policies which regulate what a system user can and cannot do within a specified system.

VUKSA will require access control, because there will be different types of users: students, tutors and administration staff. This will be achieved by having different user groups within the larger group of users.

#### **6.4.4 Secure Communication**

Communication channels between a client and a server are frequently the focus of security concerns; therefore VUKSA channels of communication will have to be secured by encrypting the communication between the client and the server. Using encryption would mean that “messages passed are encoded so that they cannot be read or manipulated while in transit ... this normally involves the exchange of cryptographic keys between the client and the server” (Monson-Haefel and Chappell, 2001:138). The exchanged keys would be used by the message receiver to decode and read the message.

According to Monson-Haefel and Chappell (2001), there are two basic ways that messages are encrypted by JMS providers: Secure Sockets Layer (SSL) and payload encryption. They recommend SSL because it is an industry standard specification, a claim supported by Oaks (2001). With SSL, Monson-Haefel and Chappell (2001) explain that the JMS provider’s protocol is encrypted, protecting every aspect of the JMS client’s exchanges with the message service, while payload encryption allows messages to be encrypted on a per-topic, per-queue basis.

### 6.4.5 Web Service Security

In addition to Java security measures, the explanation given by Weerawarana et al (2008) of the roles of security in Web services has persuaded this researcher that a discussion of WS-Security would add value to this thesis. This subsection considers how to use WS-Security specifications to secure some aspects of WS interactions. However, it should be noted that WS-Security is not meant to replace any existing security technologies, but to augment and federate existing security infrastructures and to provide a unified model for application programmers and system administrators, by providing message-layer security (Weerawarana et al, 2008).

Given that SOAP is architected to allow messages to go through one or more intermediary nodes, some information in the travel flow may be corrupted and hence need to be protected to ensure integrity and confidentiality. Weerawarana et al (2008) state that the establishment of such end-to-end security requires a mechanism above the transport layer system, which in this case would be the message layer system. Under a message-layer security system, the original message should be secure end to end, independent of the point-to-point protocols. According to Weerawarana et al (2008:271), “WS-Security: SOAP Message Security provides support for end-to-end message security in the form of three key concepts: security token, signature elements and encryption element”, as illustrated in Figure 6-



Figure 6-9: End-to-end Configuration (adapted from Weerawarana et al, 2008:271)

SOAP messages contain security tokens with authentication information, which can flow with the message through intermediaries to vouch for message claims to downstream systems. In terms of signature elements, SOAP messages can contain digital signature information for all or part of the message. As to the encryption element, SOAP messages can be encrypted either wholly or in part.

The VUKSA application will operate with WS-Security defined in the SOAP security header format, containing sub-elements for security, signature and encryption elements. WS-Security defines elements in a SOAP message whose body is protected by XML signature for integrity and XML encryption for confidentiality (Weerawarana et al, 2008). Weerawarana et al (2008) also explain that in addition to security tokens, the WS-Security header block <wsse : Security> contains encryption directives in the <xenc : ReferenceList> element and a signature directive in the <ds : Signature> element. In this case, the security token carries an X.509 certificate that is used in conjunction with the signature.

The system works in such a way that the receiving node will process sub-elements in the order they appear and in this case it will process the binary security token and extract the X.509 certificate within. The system is next expected to decrypt the message body, referenced by the <xenc : ReferenceList> sub-element, then finally verify the signature contained in the <ds : Signature> element. Weerawarana et al (2008) note that the sender node is thus responsible for prepending sub-elements as they are processed during the composition of the message.

#### **6.4.6 Session Control**

Bates (2006) lists four steps in communicating across the Web: make the connection, request a document, and respond to a request and close the connection. As a Web-based system, VUKSA will follow these four steps by connecting computers, requesting documents, responding to requests and closing the connections, which raises the topic of session lifecycle.

According to Hunter and Crawford (2001) and Bates (2006), a session either expires automatically after a set time of inactivity or is ended manually, when it is explicitly invalidated by a servlet. However, Hunter and Crawford (2001) warn that as a stateless protocol, HTTP provides no built-in way for a server to recognise that a sequence of requests has originated from a single user. VUKSA will need to be robust in interacting with system users, remembering information about each user between requests.

To make a connection, Bates (2006:589) states that a “browser opens a standard TCP connection to the server ... port 80 is used by default but any port which is not required

by another application can be used". Once the TCP connection is established, the browser requests a given document using its URL and this can be in the format: GET /index.html HTTP/1.1.

## **6.5 Summary**

This chapter first focused on service registry, service discovery and UDDI. It was established that for any virtual university to exploit the full potential of e-learning, they must be able to discover each other, make their needs and capabilities known, and compose web services from diverse organisations into new services and business processes by means of service registry.

After service registry there should also be service discovery; a process of locating web service providers and retrieving web services descriptions that would have been previously published. It was established that web service discovery entails locating and interrogating web service definitions; it is through this discovery process that the WS clients would learn of the existence and capabilities of a particular service and how to interact with it. To address the challenges of service registration and discovery, the UDDI specification was created as a cross-industry initiative to create a registry standard for web service description and discovery, together with a registry facility that supports the publishing and discovery processes.

With service registry, service discovery and UDDI in place, this researcher is of the opinion that the technology can be utilised in virtualising e-learning. Bearing in mind that messaging consists of sending, queuing and receiving the following section explored messaging technology and the next discussed issues pertaining to security, securing and protecting system contents, threats, authentication, authorisation, secure communication and web service security. In regard to security, it was established that there are challenges to securing and protecting all kinds of data, information and communication so that no university official or student should be able to gain access to any other person's file, directory and or communication without following the correct procedures.

It was also established that most of the protocols discussed in this thesis and the implementation examples are biased towards Java. In this context, Java application



security was critically discussed in terms of authentication, encryption and auditing. Finally, it was shown that digital signatures could be used to allow web servers and clients to use advanced cryptographic techniques to handle identification and encryption in a secure manner, thus securing and protecting system contents, avoiding threats and ensuring authentication, authorisation, secure communication and WS security.

The next chapter presents a blueprint of the proposed VUKSA system, with appropriate illustrations.

# Chapter 7: VUKSA Blueprint with Diagrams

## 7.1 Introduction

The main aim of this chapter is to present the VUKSA model as it will be applied in Saudi Arabia, bearing in mind that the history of distance learning in the Kingdom indicates that the field is in a constant state of evolution, influenced by the stream of new ideas associated with technological developments. Therefore, the VU concept has become very important in the Kingdom.

In the proposed model, the Virtual University of the Kingdom of Saudi Arabia is an improved version of a third-generation virtual university, which has no physical buildings except small offices housing computers and a very small, highly skilled staff. Supported by the power of internet technology, cloud computing and SOA, this is a model of a real university in the virtual space which offers all of its services to its learners in an integrated and entirely paperless way, through the Internet. Its services include online learning materials of different types, specialized virtual centres for the development of educational courses, library and administrative functions, an interactive environment for synchronous and asynchronous communications and online collaboration.

Saudi society is in need of a virtual university and the success of e-learning is quite realistic. As a private university, VUKSA will start by granting undergraduate degrees in specific specialties, before broadening its scope. Therefore its initial organizational structure will be simple. However, it will involve the selection of narrow criteria to establish a new private virtual university of reasonable size and high reputation, which will be convenient and cheap, but of high quality, to encourage lifelong learning.

## 7.2 Proposed Model

The necessary basic structure of VUKSA requires the implementation of structures and procedures appropriate to a university of the relevant size, due to the virtual nature of

the university. The setting up of an ideal VU in Saudi Arabia can be divided into three main areas, involving administrators, lecturers and students.

The admin area will have tools and utilities to help VUKSA's employees to carry out their main duties, as in a real-world university, but in this case they will do it online and will deal with students without seeing them. The needs and actions of employees in this virtual environment will differ from one employee to another, depending on their duties, tasks, job descriptions and interactions with students.

The lecturers' area will contain all the tools which academic staff members require to teach courses online and to interact with students using chat, email or interactive boards, to construct and correct online exams, and to put their lecture notes and reading lists on the Web for students to browse. It will also contain a library. Course outlines are commonly published on departmental websites, while libraries have Web interfaces for searching, checking availability and reserving books. Lecturers must also provide meaningful intrinsic feedback on the actions that relate to the nature of the task or goal. There are now many more opportunities for higher education, and several fellowships and scholarships have come into being. It is also possible to contract lecturers or researchers from various parts of the country who would like to work part-time for a VU for a specified number of hours each week.

The students' area would be the main virtual space for students enrolled in the University. It would provide an environment or interactive area where they could access their courses, assignments, email, the virtual blackboard tools and facilities, such as Blackboard and Web-Learn, online tutorials and the library, as well as tools to interact with teachers and with student welfare and administration staff.

Figure 7.1 depicts the proposed model of how the Virtual University system is connected with other components and other data services and how the different modules communicate with other components and services to fetch the data and respond to user requests. The preconditions for a virtual university model are that providers and requestors of services would have to be connected for them to exchange information using a common language and a common protocol, that all services be described in a

machine readable form and that all clients—users and businesses—would have to utilise UDDI to find the services they need.

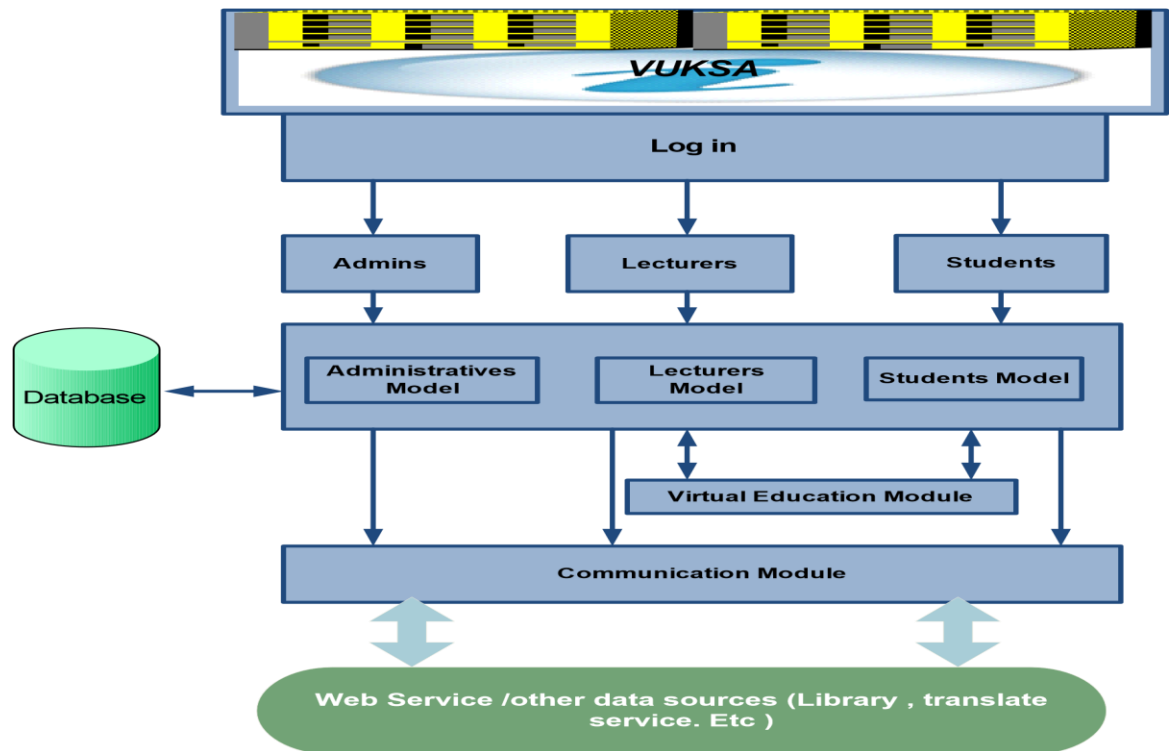


Figure 7-1: Virtual University Model

This thesis presents a virtual university model using SOAP, WSDL, WS-Addressing, WS-Policy, WS-Security, WS-Reliable Messaging and WS-Atomic Transaction, because they are the existing and tested technologies to support web-based systems and to address business-to-business integration. Although the illustration does not include a critical discussion of what implementation platform or technology any of the parties would use, it does show how the WSs work and provides a clean architecture for building integrated business-to-business applications. Therefore, this researcher concludes and recommends that the implementation of virtual universities can be improved by utilising the existing architecture: SOA, SOAP and cloud computing.

### 7.3 Design and Implementation

Unified Modelling Language (UML) is a standard language for constructing, visualizing, specifying and documenting the artefacts of software systems, including a set of graphic notation techniques to create visual models of object-oriented software-

intensive systems. It is a very important part of developing object-oriented software and this software development process has proven successful in the modelling of large and complex systems. UML has been preferred because it is an object-oriented modelling language that defines structural diagrams, which describe the static relationships between components (Fowler, 2004).

### 7.3.1 Component Diagram

The VUKSA system consists of four top level components: a student's panel, a lecturer's panel, an admin panel and the data access components, which consist of server and cloud database and other web services, as shown in Figure 7-2.

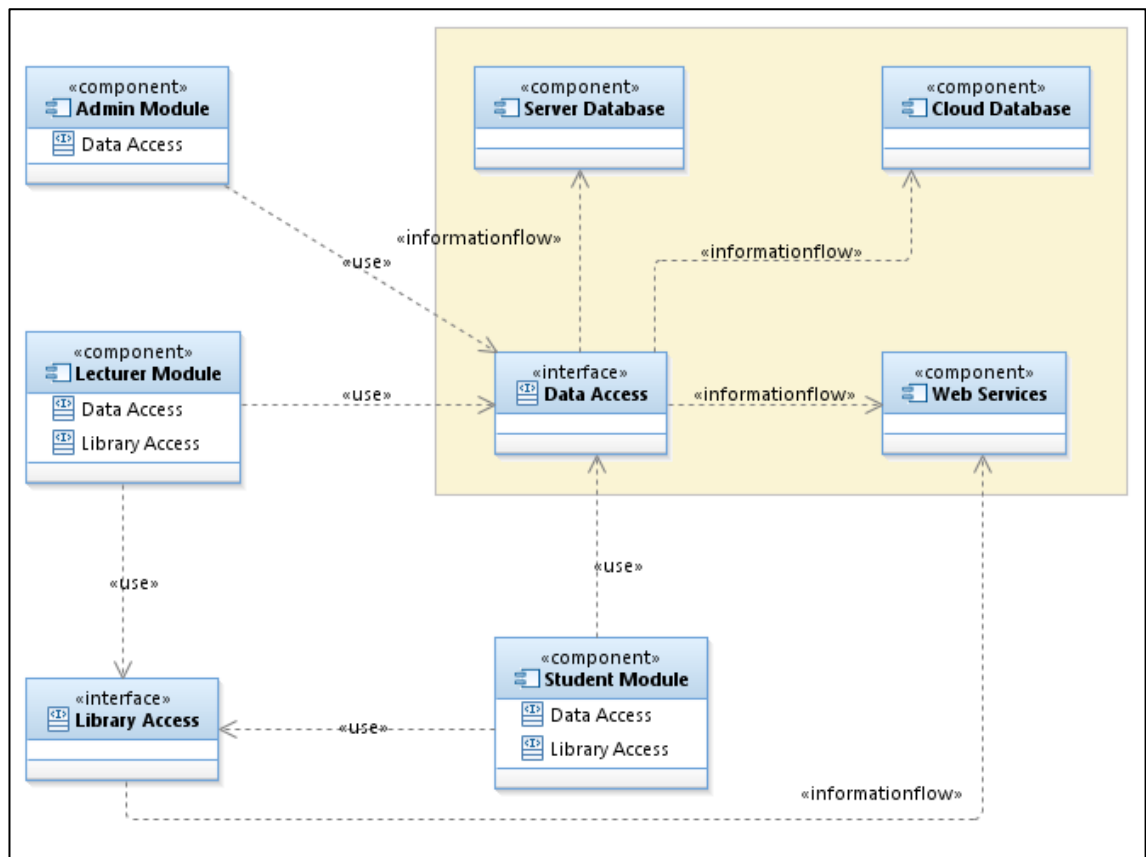


Figure 7-2 : Component Diagram

The data access component is responsible for storing and managing user data across the board. It saves and provides data on request by the interface. The data are stored in different data sources, and different data are fetched from their respective data sources. It can be the main server database, a cloud database or other web services which fetch

and display the data. The interface is more than a middle-man, allowing the components connected to the database interface to interact with the database.

The administrators can access the admin panel to manage the system. The panel helps them to perform administrative tasks including management of users i.e. students, lecturers and other administrators. The admin panel interacts with the interface for database access, which responds to the request or interacts with database components on the server to fulfil admin requests.

The lecturers can also interact with the system using the lecturer panel. A lecturer can add new assignments, upload documents for course material, review assignments and submit results. The lecturer panel works the same as the admin panel to access the database.

Each student interacts directly with the student panel, which provides the facility to perform student-related tasks, such as assignment submission, viewing feedback from lecturers on work done, and accessing course materials. The student panel works in the same way as the admin panel to access the database.

Students and lecturers can also benefit from the library through a web service which will also be built with this system. This WS can be also used by other university systems which can be added to their systems; thus our system will become service-oriented, as we are adding a web service to it. It will provide books, articles, journals, etc to the library and users can search for anything in the system and view or download the books to their systems. If they want to borrow a book they can reserve it and visit the library to collect it.

The component diagram in Figure 7-2 elaborates the model shown in Figure 7-1 by showing how the components of the system are related. The components are parts of the system which are interconnected to make the other parts of the system function with each other. This component diagram is a high-level diagram which gives an overview of the main parts of the system and how they are connected with each other in order to consume each other's services.

### 7.3.2 Flow Charts

A flow chart illustrates the flow of actions or data when a user interacts with the system and what actions are performed with each other. It describes a single action at one time and how the decisions are taken to perform each action. Figure 7.3 is a flow chart for the admin function. The main tasks of an admin user are seen to cover the management of the system. An admin user can manage the whole website and system by adding, modifying and deleting records, and can also assign modules to students and to lecturers.

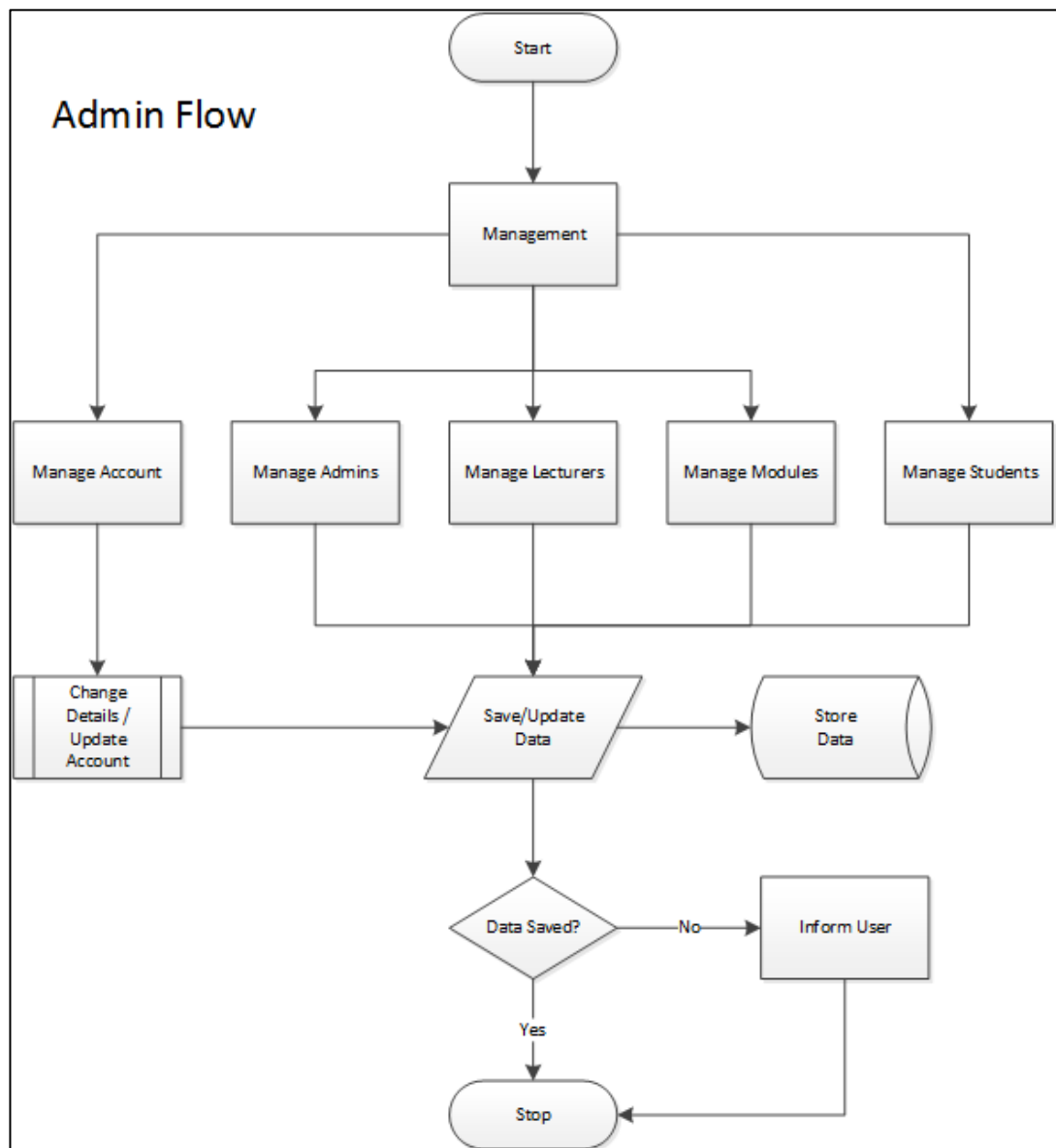
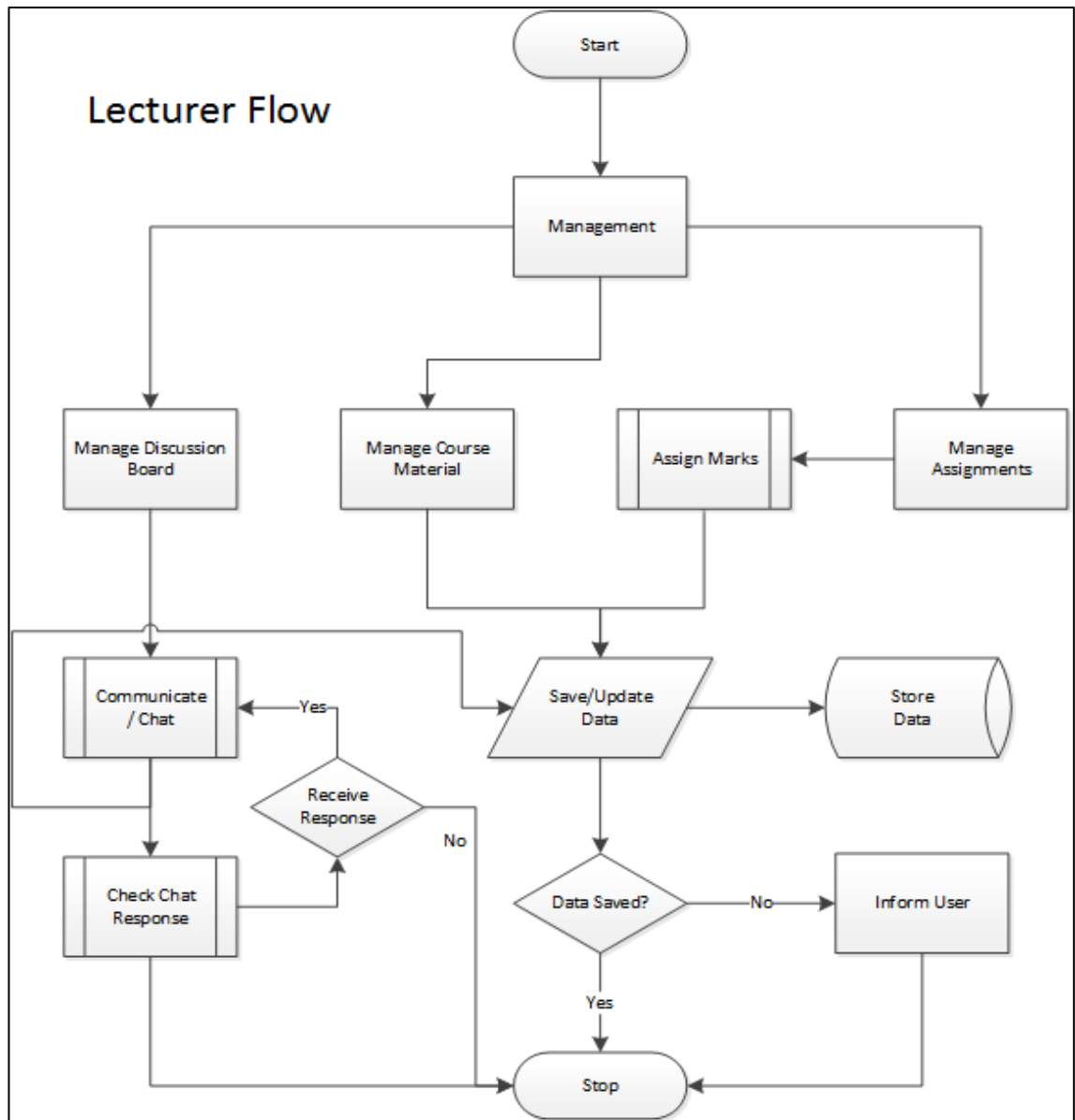


Figure 7-3: Admin Flowchart

Figure 7-4 is the equivalent chart for the lecturer function. The main tasks of the lecturer include the management of modules and uploading course material to the website. The students can then download course material. Lecturers can also create assignments and give marks to them. They can chat with other lecturers and students through discussion boards.



**Figure 7-4 : Lecturer Flowchart**

The final flow chart, in Figure 7-5, show the activities of students. VUKSA students can view their modules and enrol in different modules. Within these modules, students can submit assignments and view their marks. They can also chat to other students and



lecturers to discuss their work or ask questions. Students can attend conferences and view videos made by the lecturers for different modules. In this way they can learn more about the module.

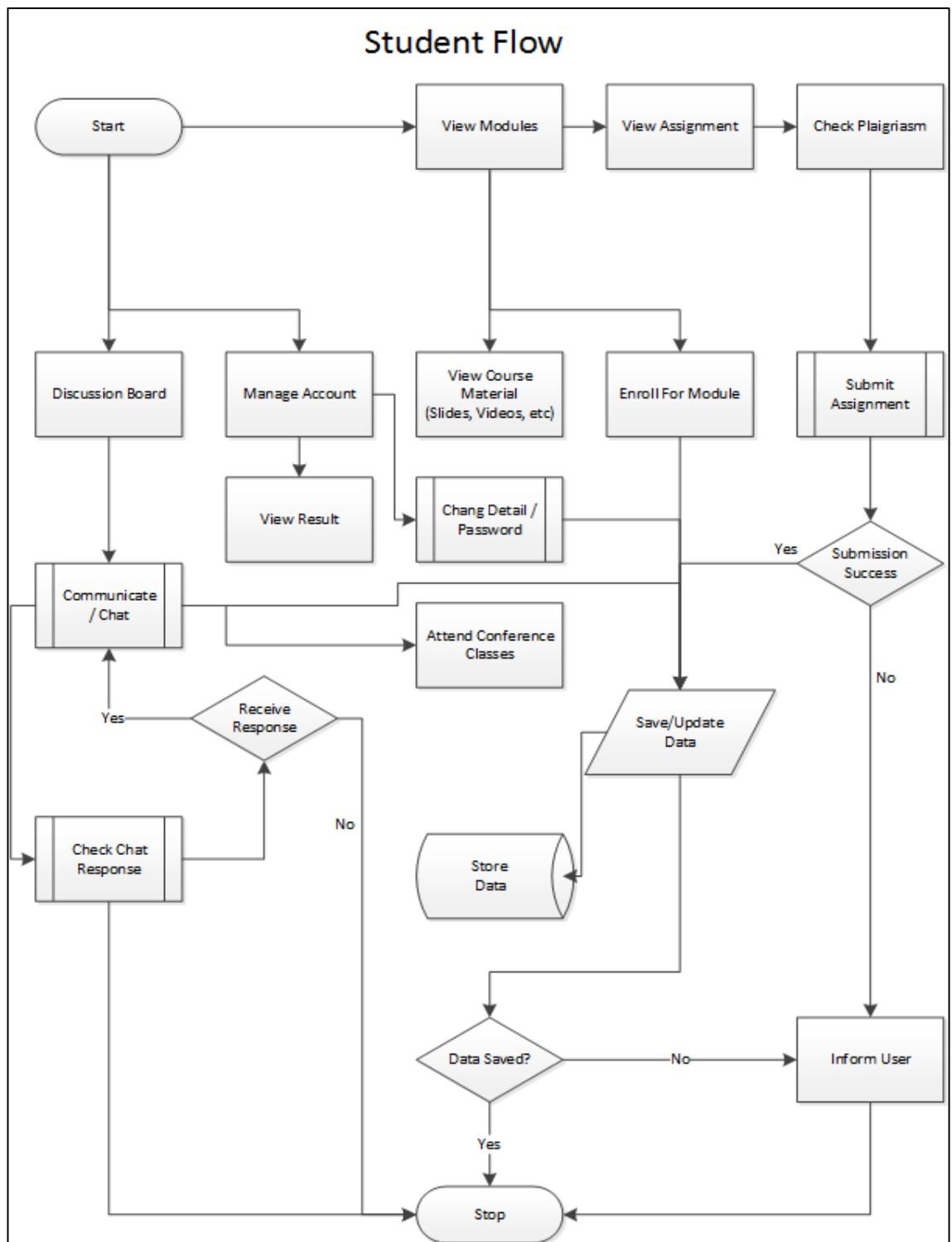


Figure 7-5 : Student Flowchart

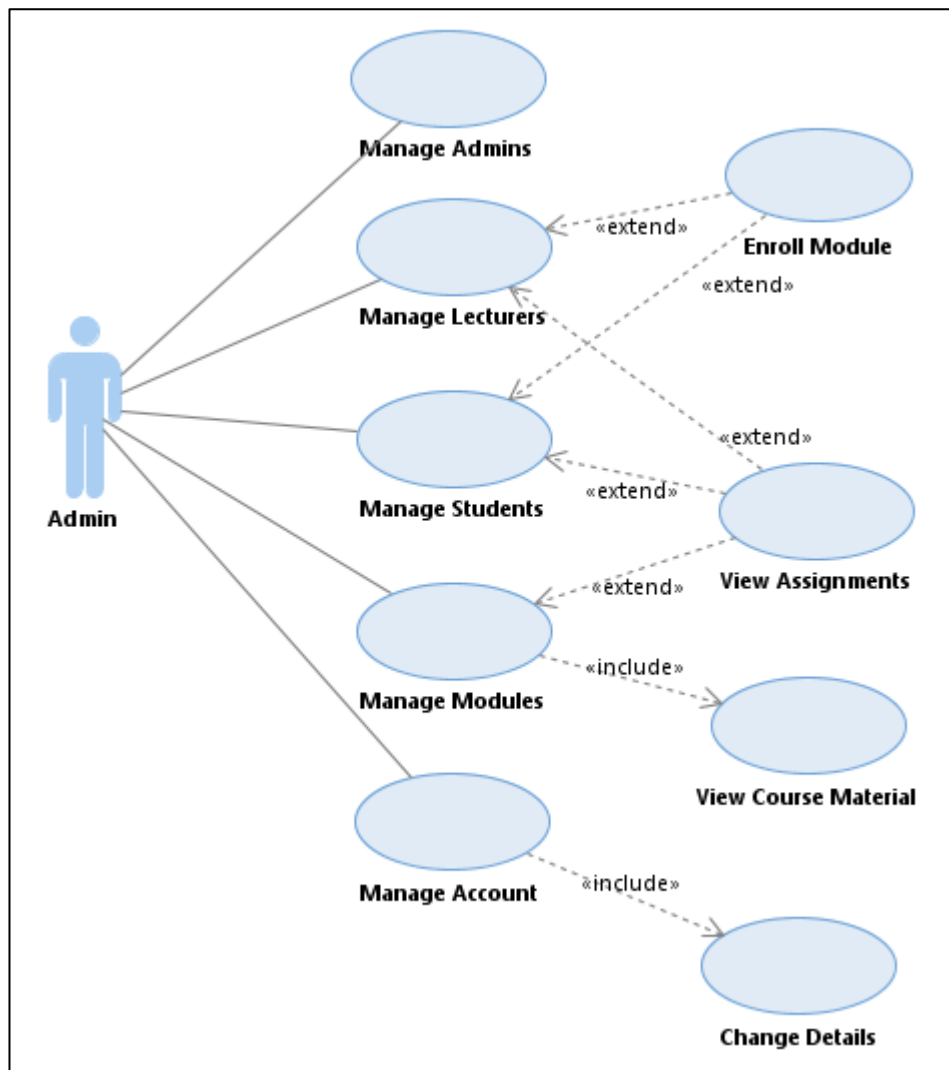
### 7.3.3 Use Case Diagrams

Cockburn (2000:1) describes use cases by stating that they “capture a contract between the stakeholders of a system about its behaviour”, adding that they describe the system’s behaviour under various conditions as it responds to a request from a stakeholder. Welling and Thomson (2005) agree with Fowler (2004) in describing the use case as a technique for capturing a system’s functional requirements. Cockburn (2000), Fowler (2004) and Welling and Thomson (2005) agree that there is no one way of writing use cases; different formats work well in different cases. The most important aspect of use case modelling is that users of the system and the tasks they undertake within the system should be identified (Stevens and Pooley, 2000). Fowler (2004:99) added that “use cases work by describing the typical interaction between the users of the system and the system itself, providing a narrative of how a system is used ... a set of scenarios tied by a common user goal”. This subsection thus illustrates the set of scenarios linked by the common goal of running a virtual university, representing respectively use case diagrams for administrators, lecturers, students and the library.

Fowler (2004) explains that in use cases, users are referred to as actors, each playing a particular role with respect to the system. The actors in VUKSA are students, assessors and administrators. The use case diagram is used to display the actions of the system and which users interact with those actions; it is the overview of system functionality.

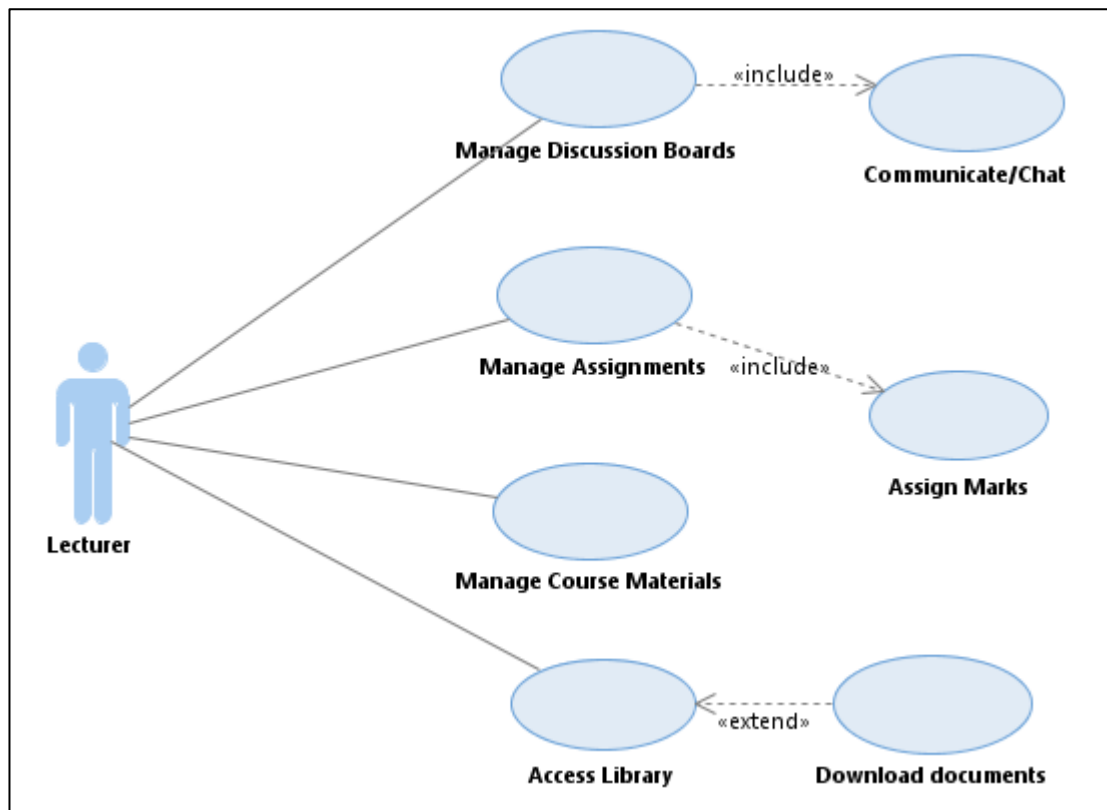
In order to understand the use case diagrams below, it is necessary to explain the purpose of the <extend> and <include> use cases. <Extend> is used to spread out or attach another functionality of the base use case; when a use case is extended, the base use case can function without the extended use case. For example, the administrator can manage modules in the system, but he is not required to manage lecturers at that instant when he is logged in. The extended use cases are optional during that instance.

<Include> is used where a functionality is part of the base use case and is also used in another use case. So to reduce the duplication, and to extract a functionality common in more than one use case, <include> is used. For example, for an administrator to access modules, he has to first enter his login details to be authenticated by the system, which is the <include> use case.



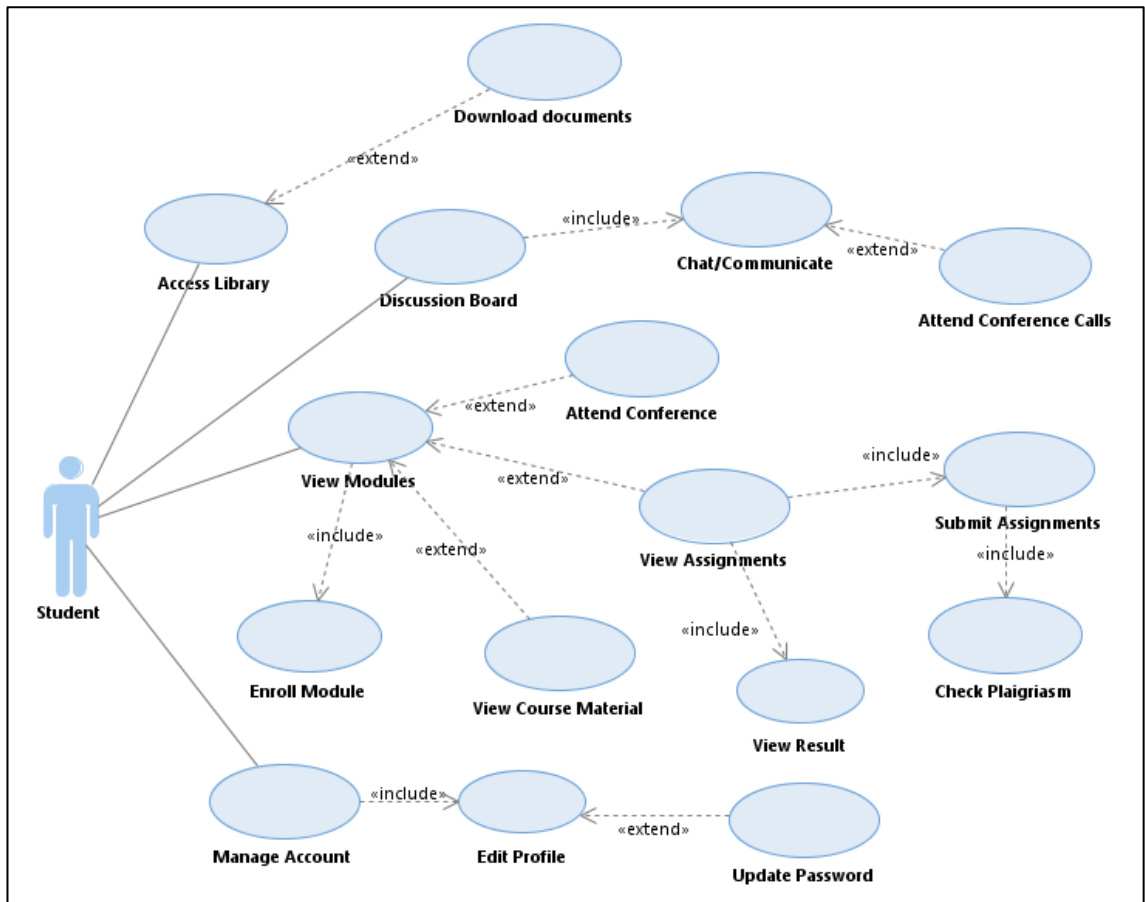
**Figure 7-6: Admin Use Case Diagram**

Figure . 7-6, illustrates the two main functionalities of administrators. The first is administration of the full site, involving these functions: manage administrators (add, update, delete), manage lecturers (add, update, delete), manage modules (add, update, delete), manage students (add, update, delete) and assign modules to lecturers/students (add, update, delete). The second functionality is managing user accounts and updating details such as changed passwords.



**Figure 7-7 : Lecturer Use Case Diagram**

Figure 7-7. Shows the functionalities of lecturers, limited to management of parts of the site: manage discussion boards, chat with lecturers and students through discussion boards, manage assignments, assign marks to students' assignments and manage course material. Lecturers can upload course files, presentation slides, etc. and access the library to view or download books and other documents from the library system.



**Figure 7-8 : Student Use Case**

Figure 7-8. shows that students are the main users of the system, who interact with it via many functionalities: they can manage their accounts to update profiles and change passwords, view the results of assignments they have submitted, view modules, enrol on modules, view, download and read course materials, view assignments, submit assignments after completion, check for plagiarism, attend conferences, view videos of the classes in modules on which they are enrolled, view discussion boards, chat and communicate with other students and lecturers, and access the library to view or download books, journal articles and other documents.

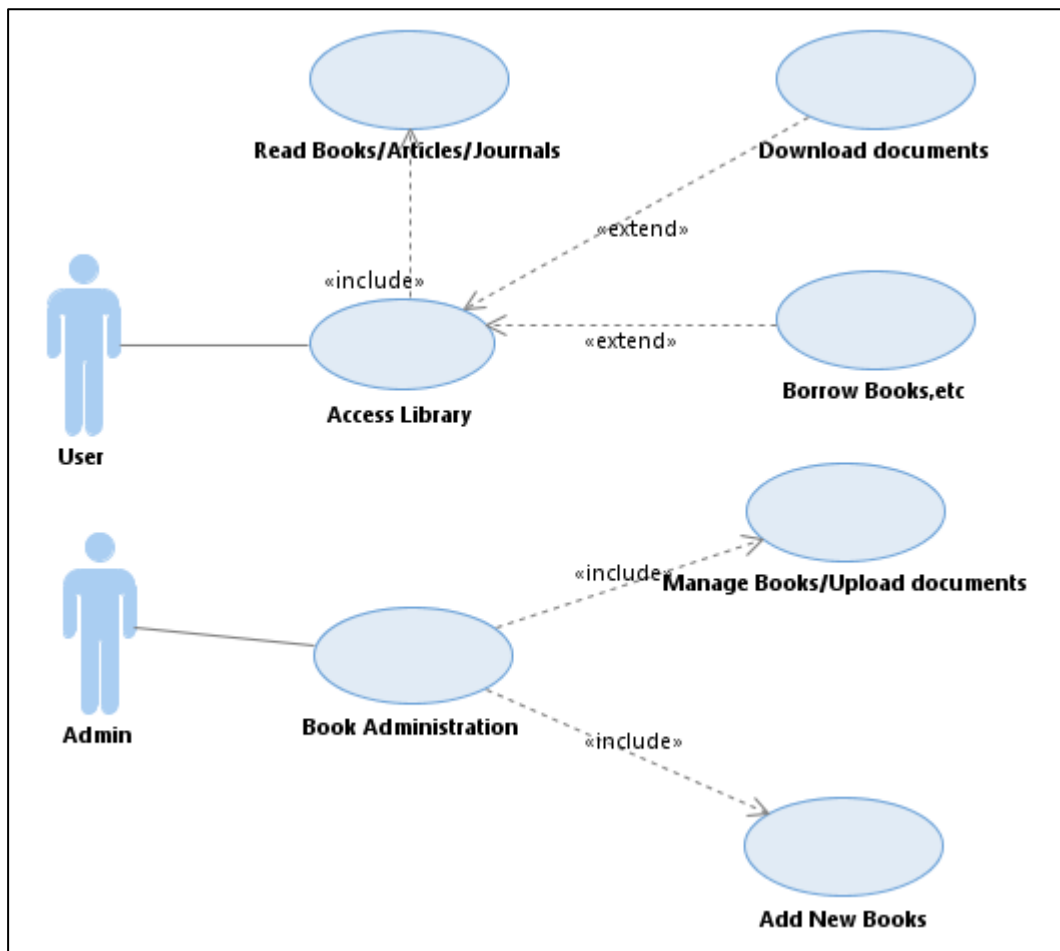


Figure 7-9 : Library Use Case

The library system can be accessed by various users including lecturers and students. This system will provide books and other materials which will be easily available for viewing and downloading within the system. Admins can upload new documents and books, and manage and update existing ones. The library will be a web service which will be added to the system for managing it. A small website will also be created to enter data into the library and upload files. Whoever will be using the library can access the books and borrow them by placing them on hold, then collecting them from the library physically. This system will become service oriented, which is also good for other universities, because they can add this library to their systems. Thus, everyone will benefit from it. Only selected admins can upload books to the library, as they will have their own usernames and passwords.

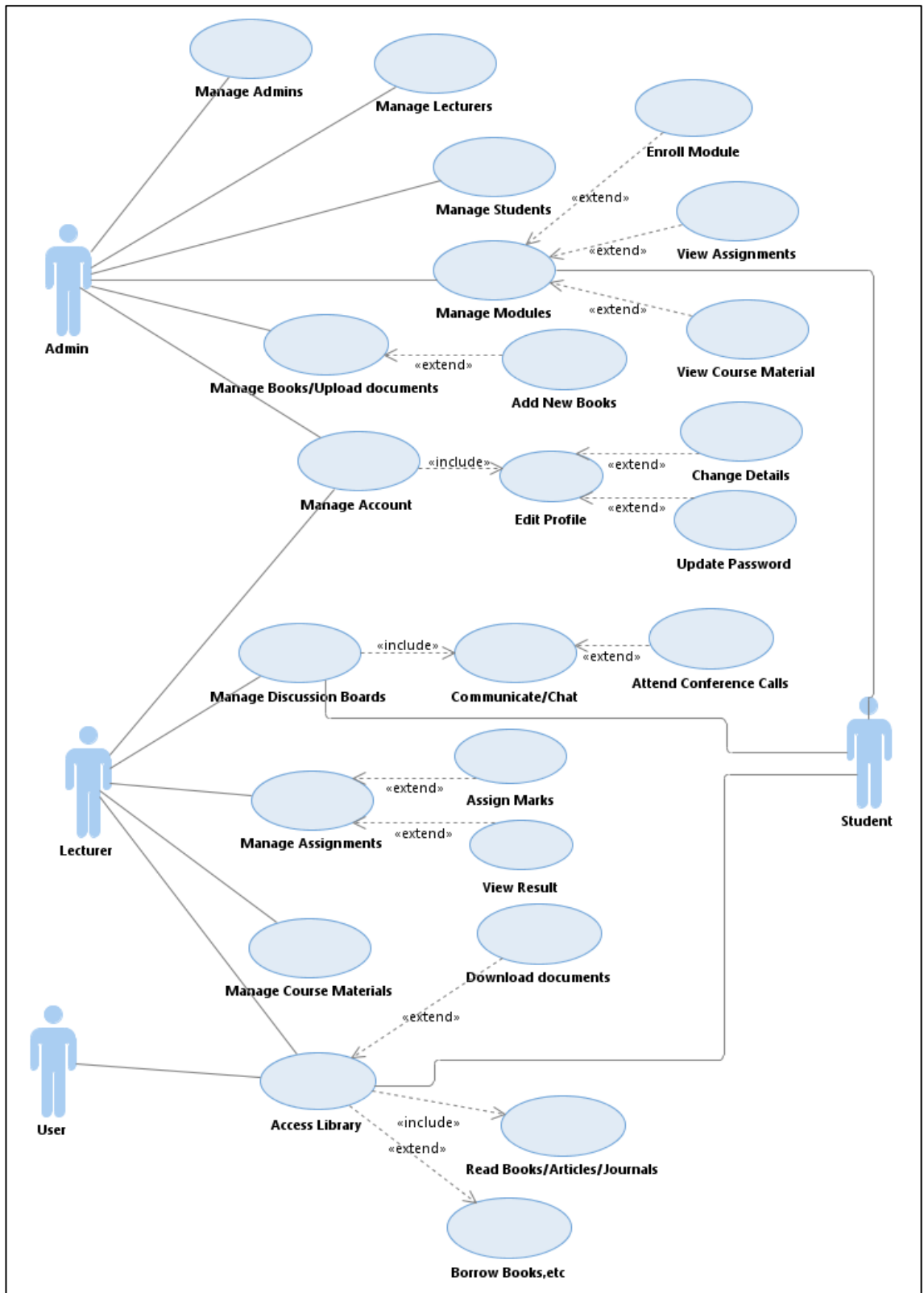


Figure 7-10: Complete System Use Case

Figure 7-10 is a cumulative diagram of all the actors and use cases that can be actioned by different users of the system. It provides an overview of all the functionalities performed by the system at different stages. This combined diagram shows how the use cases are connected with each other at different levels and how they are accessed. The admins, lecturers and students access the system via their login details and are authenticated before accessing each page. A normal user can access the library and view the books, borrow them from the library and read the material online from the system.

#### **7.3.4 Class Diagrams**

The class diagram of VUKSA presented here as Figure 7-11 was designed and developed following the definition and recommendations of Fowler (2004), who asserts that a class diagram should describe the types of objects in the system and the various kinds of static relationships that exist among them. Fowler (2004:35) adds that it should “show the properties and operations of a class and the constraints that apply to the way the objects are connected”. UML presents class diagrams in the form of boxes divided into three compartments: the class name in bold, its attributes and its operations. Properties represent structural features of the class which correspond to fields. In addition to specific components of the class, class diagrams also show associations, in the form of a solid line between two classes directed from the source class to the target class. Associations correspond to verbs expressing the relationship between classes. In interpreting class relationships, the name of the property goes at the target end of the association, together with its multiplicity (Fowler, 2004; Stevens and Pooley, 2000).



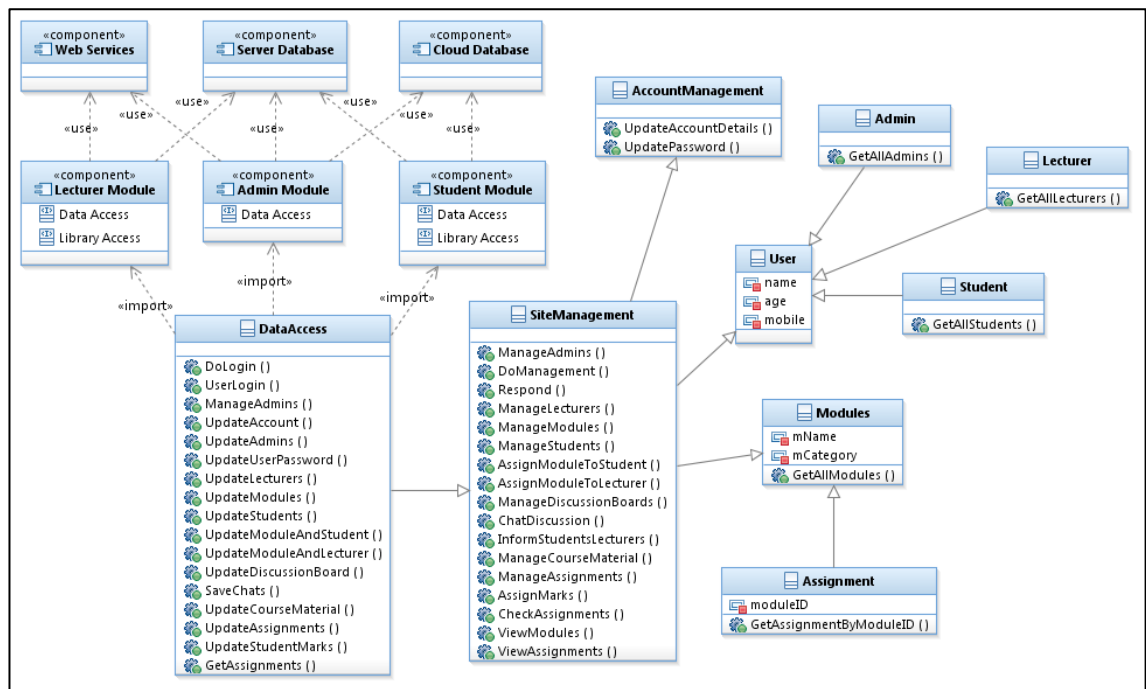


Figure 7-11: Class Diagrams

Figure 7-11 shows the relationships among the nine basic classes: DataAccess, SiteManagement, AccountManagement, User, Admin, Lecturer, Student, Modules and Assignment. Each class, its attributes, operations and relationships are elaborated in the following paragraphs and in the class diagram.

It can be said that VUKSA has four components: the Server database, the Lecturer panel, the Admin panel and the Student panel. The class diagrams illustrated in Figure 7-11 show the main classes and functionalities of the system. All users will have a main class (admin, lecturer or student) and other classes inherited from it. All of these classes will have separate functions to perform according to their needs. The main class which will interact with the database is DataAccess, which will perform tasks such as adding to, updating and deleting from the database. There is also a class called SiteManagement, between the database access class and the other classes, which can perform interactions between users and the DataAccess class.

A student can register for one only course, but may study up to four different modules per semester. An assessor can assess only one course and two modules, with a minimum of one student and a maximum of twenty. An administrator can administer multiple assessors, multiple students, multiple courses and multiple modules. A department can

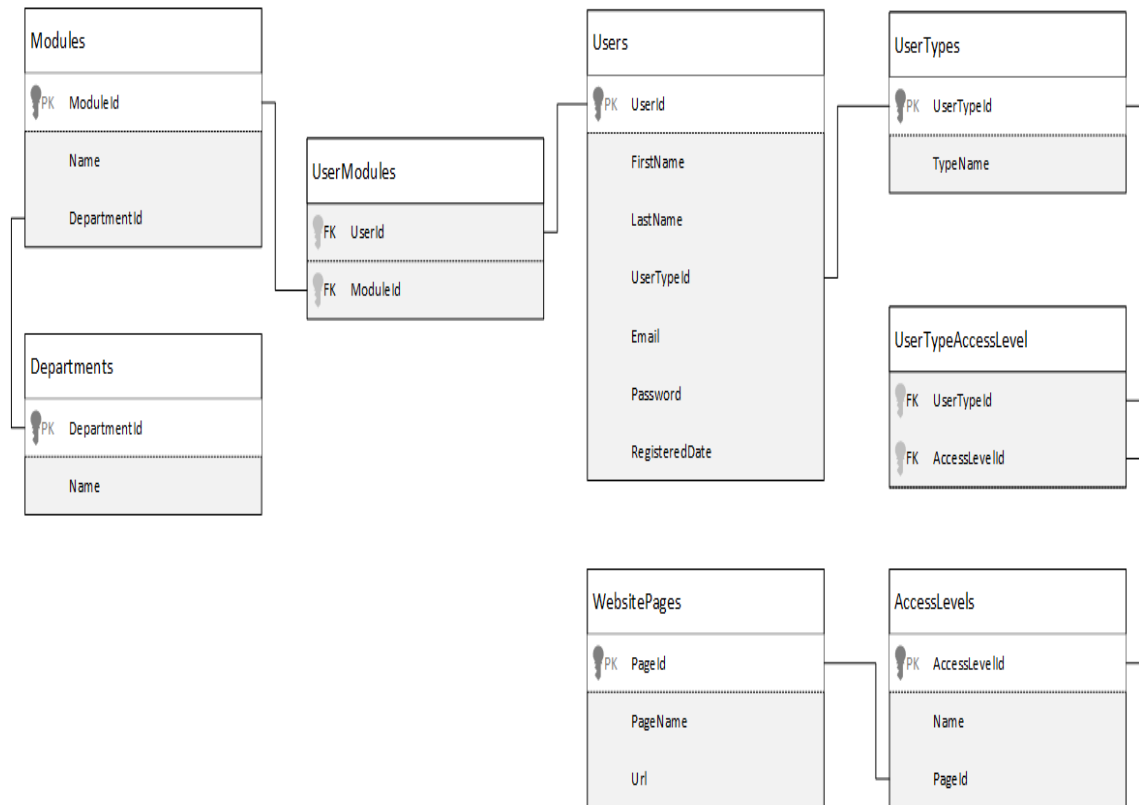
run more than one course, consisting of a maximum of 24 modules, studied by multiple students and assessed by different assessors. A module can be studied under two different courses by different students, but assessed by only one assessor.

To make the model easy to understand, the first step is to identify the services which are provided by the university, the services consumed by the university and how those services can be registered, so that other trading partners can access them.

#### **7.4 Database Design: Entity Relationship Diagram**

The database design shown in Figure 7-12 is different from the class diagram because it shows the relations between different tables and the entities in the database. Each relationship can have a different cardinality; for example, one-to-one, one-to-many or many-to-many. In the case of Users and Modules, this cardinality would be many-to-many. An entity relationship diagram of the system database can be used as the foundation for a relational database. Alternatively, the class diagram shows how the hierarchy is displayed between the structures of classes, their types, what fields they have and what functions are contained in the class.

The database design includes details of many users such as their names, addresses, emails and encrypted passwords. Users can access different areas of the system. In addition, they all have different roles or user types. Each type of user (Admin, Teacher and Student) has a different role in the system and can access different parts of the system. Each user can be of only one user type, but one user type can have many different users, so this is a one-to-many relationship.



**Figure 7-12: Database Design**

The user types in the system have different access levels and permissions. Some users cannot access some parts of the system; for example, students cannot access those pages which only teachers are allowed to see and teachers cannot access the pages which only admins are allowed to see. One access level can have one page in it, so this is another one-to-many relationship.

The UserTypeAccessLevel table contains two foreign keys, which are IDs of both user type and access level tables. These will keep a record of which user type is associated with which access level. The foreign keys are UserTypeId and AccessLevelId. For example, one user type can have different access levels and one access level can be on different user types, so this is a many-to-many relationship.

The WebsitePages table contains a list of all the pages in a website which a user type can access. The pages contain their names and only specific pages are accessed by different access levels or user types.

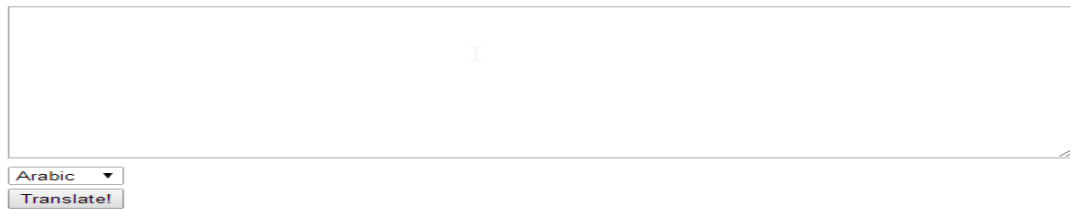
The Modules table contains all the records of modules taught in the university which are associated with the teachers and students. Students can be enrolled into various modules and various modules can be taught by teachers. The modules are under different departments. UserModules contains foreign keys which list the IDs of the Modules and Users tables. Different users can be associated with different modules. For example, a student can reside under one module or many and one teacher can teach one module or many. This is a many-to-many relationship. The Departments table includes records of all the departments in the university. Modules can come under different departments, so it contains the name of the department in question.

### **7.5 Implementation Example: SOAP Translation**

This section presents an example of a working element within the system: the translator. This will be an important aspect of VUKSA, because it will be used for translating text between different languages, supported by three methods: AJAX, HTTP and SOAP. The method adopted here uses SOAP, which basically means using it through a Web service. First, a reference is added to the service through the WSDL web address of Microsoft Translator (W3, 2012). After adding the service reference, a connection is made to the WS and the project automatically generates a structure of the service and its XML. This is automatically generated by the project when a service is added. The second step is designing the website with a text box for entering text, a list to show the languages for translation and a button. To use the service, one needs to register an account to access the translator through a client ID and secret key. This is a type of login which Microsoft Translator requires. After all of the above steps have been completed, the system creates a token to be sent to the translation service with the text to be translated, specifying the source and target languages.

After the token is generated, the Translate () method is called to translate the text and pass the parameters with it: Translate (token, text-to-translate, from-language, to-language). This will return the translated text, which will be displayed to the user on the webpage.

## Microsoft Translate Text by SOAP



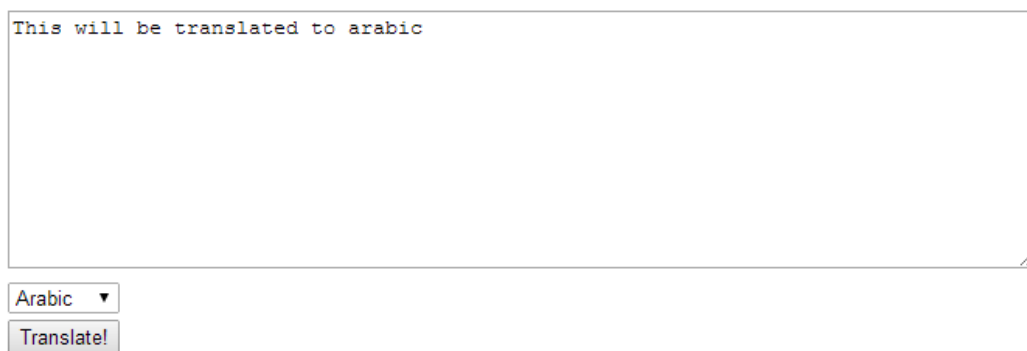
The screenshot shows a web interface for Microsoft Translate. At the top, there is a large, empty text input box. Below the input box, there is a dropdown menu with 'Arabic' selected, and a 'Translate!' button.

Figure 7-12: Translator

Figure 7-12 illustrates the initial page displayed to the user for inputting the text; then the user can select a language to be translated to. The text is entered in the textbox, a language is selected from the dropdown menu, and when the translate button is clicked, the text is sent to the SOAP service, a translation is performed and the translated text is returned to be displayed.

The following is an example of the translation of a text from English to Arabic:

## Microsoft Translate Text by SOAP

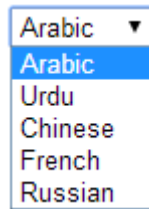


The screenshot shows the Microsoft Translate web interface with the text 'This will be translated to arabic' entered in the input box. The dropdown menu is set to 'Arabic' and the 'Translate!' button is visible.

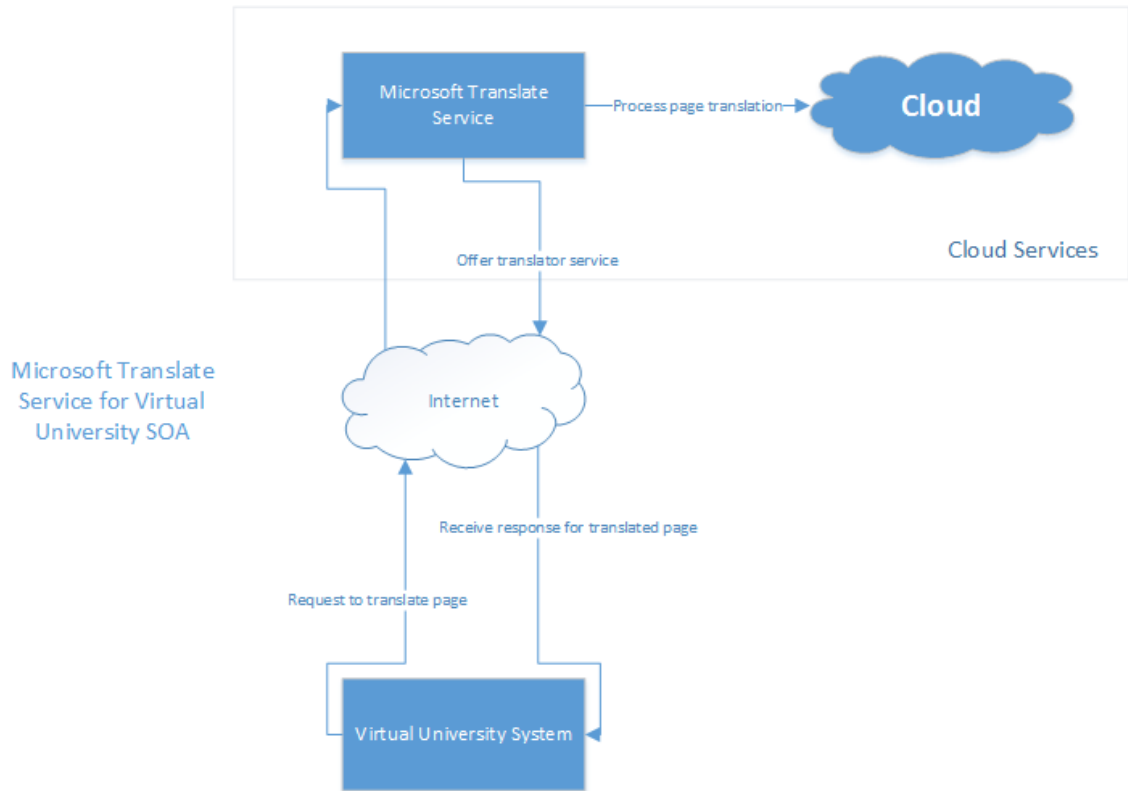
هذا وسوف تترجم إلى اللغة العربية

Figure 7-13 : MS Translation from English into Arabic

Figure 7-13 shows the text to be translated, while Figure 7-15 shows that the user can select any one of several different target languages.



**Figure 7-14: Translating English into Different Languages**



**Figure 7-16: Translate Service**

As shown in Figure , the translate service will be used as a tool to translate content from one language to another. This will be an external service from Microsoft Translate. When a page is viewed by a student the service will be called and a page will be sent to translate. The service will send the page to its cloud-based servers, where the content will be translated before being sent back to the system, where it will be viewable by others. This service will be attached via the Internet to minimise the use of VUKSA computer resources.

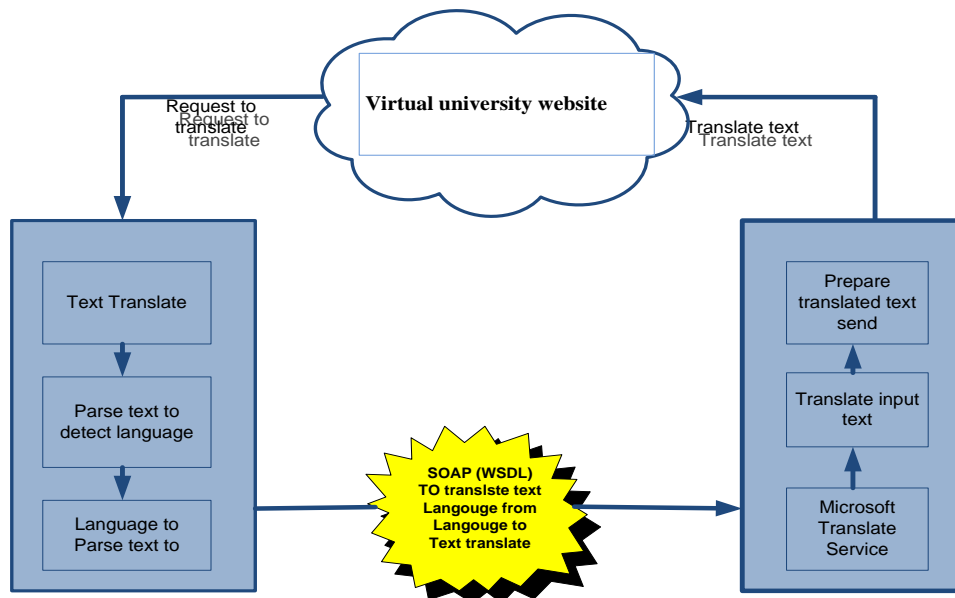


Figure 7-17: Translate process

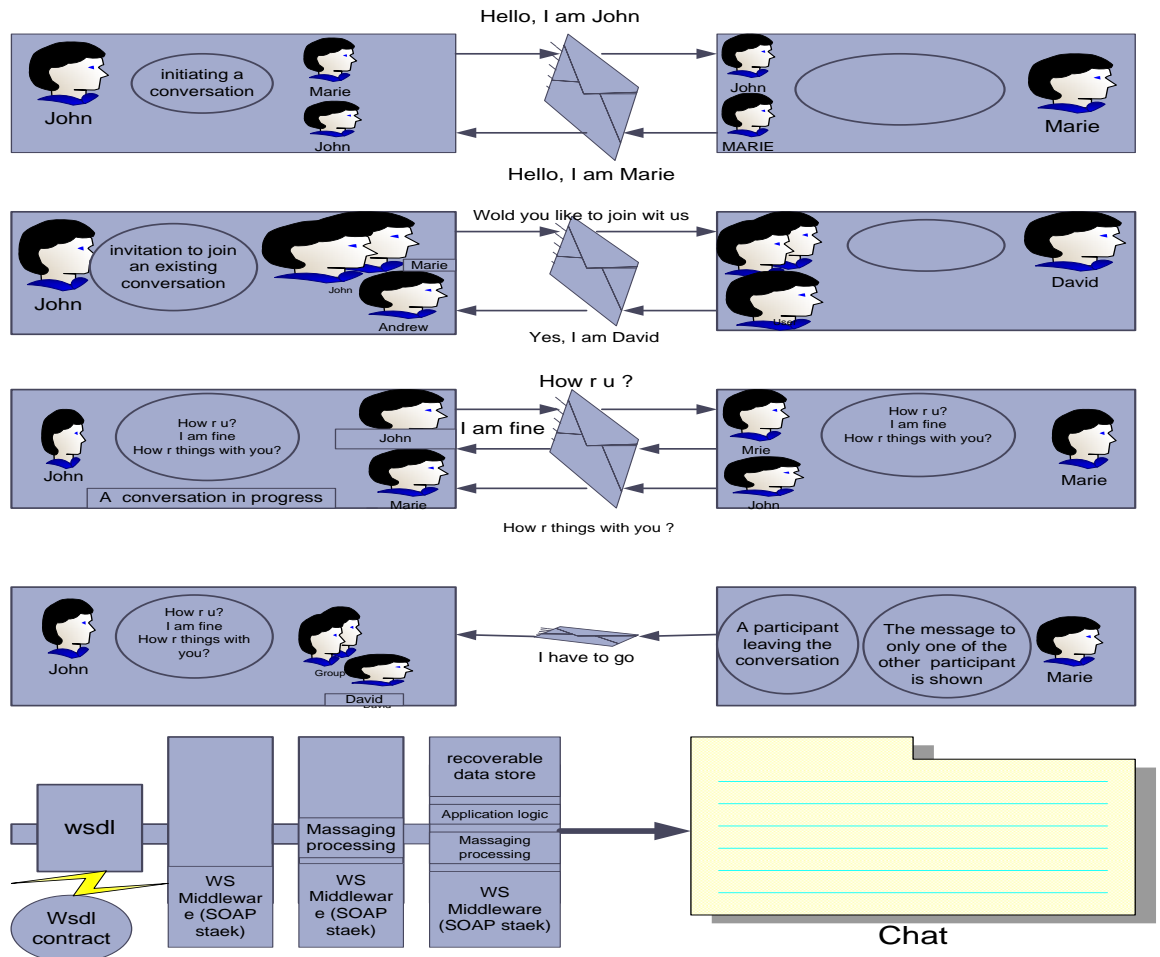
Figure illustrates the translation process in more detail. The service used here is Microsoft Translate, which can be accessed through various interfaces, from AJAX, HTTP and SOAP. AJAX is a JavaScript call from the web pages to call the service from the client browser. The HTTP request is the GET and POST requests from the page to translate text and return the translated text from the service. The SOAP method uses WSDL to call the translate service API and converts the message to the XML format of WSDL to send to the server and receive output from it (W3, 2012).

## 7.6 Case Study: Instant Messaging

This case study scenario represents the implementation level, illustrating the process of two or more participants exchanging messages in an asynchronous manner. It then gives a snapshot to show how different elements of SOA and SOAP can be brought together. A typical WS is designed, implemented and hosted in a runtime environment to provide scalability and loose coupling while promoting ease of development and robustness to change.

The protocol for chatting across the Internet using instant messaging (IM) consists of three stages. In the initial stage, one participant sends an invitation message to another, inviting him/her to join a conversation, to which the remote user responds with a message of acceptance, with a message of declination or not at all. The second stage is

that of message exchange, where text is exchanged between the participants in a conversation. At this stage, a message is sent to all participants in the conversation. This stage continues until the participants decide to end the conversation. Additional participants may be added to an existing conversation through an invitation. The third and final stage of message exchanges is when one participant informs the other that he or she is leaving the conversation. Figure illustrates this process.



**Figure 7-18: Instant Messaging (adapted from Webber and Parastatidis, 2009)**

When it comes to building applications which use WSs, developers have to rely on the WS contracts and policies to determine the manner in which to develop these applications. The final element of Figure illustrates how the IM application should be developed, first by distilling the message exchange into a WSDL contract, then selecting the hosting environment and the required protocol specification. The third phase is constructing the application logic.



Message security issues have to be taken into account to ensure that any state maintained would be recoverable in case of failure. This assurance is achieved “by factoring state management code into a separate module in order to keep the application logic stateless and thus easy to deploy and scale”, according to Webber and Parastatidis (2009:70), who add that the approach to building other WS applications is very similar to the one above, regardless of whether they involve sophisticated enterprise-to-enterprise integration or something as trivial as an IM application. To achieve the above scenarios, three pieces of XML Schema code were adapted from Webber and Parastatidis (2009). These show respectively the elements of chat-invitation and chat-invitation-acceptance messages, the declaration element for the chat message and the elements of the chat termination message. The body of the chat-invitation message supports the invitation for a conversation and includes the code names of the initiating user and of the chat-invitation-acceptance message. The schema captures the identity of the conversation and the details of the participants, which can also be used for inviting two or more participants to the conversation, facilitated by the unbounded number of participants.

The structure of the message to convey the text of the conversation is defined through the chat complex type. Since chat participants do not have to chat non-stop, anyone wishing to exit a conversation has to utilise the chat-exit XML Schema reproduced. On receipt of the chat termination message, the exiting participant is removed from the list of active participants in the conversation (Webber and Parastatidis, 2009). Given that the IM hosting environment might host multiple simultaneous conversations, it should be noted that the messages described above include a chat-ID element carrying a unique identifier, which is used to contextualise the message (Webber and Parastatidis 2009). The chat-ID is used by the WS to scope message exchanges to specific IM conversations and to establish an execution context for its associated message exchanges.

## **7.7 Summary**

This chapter has made a practical attempt to present the VU model as it will be applied in Saudi Arabia. Its main purpose was to explain the components of VUKSA illustrated by UML diagrams (use-case diagrams, data flow diagrams, flowcharts and activity

diagrams) and to examine Blueprint diagrams using UML. This helped to explore potential designs and to validate the architectural design of the software and supporting tools for the project and design process by proposing a VU model with components that would work in harmony. The implementation section gave an example of a working element of the whole system: the translator. This will be an important aspect of VUKSA, because it will be used for translating text between different languages, supported by three methods: AJAX, HTTP and SOAP. The method adopted here uses SOAP, which basically means using it through a Web service. Finally, a case study of instant messaging presented a scenario at the implementation level to illustrate the process whereby two or more participants would exchange messages in an asynchronous manner.

The next chapter offers an experimental evaluation and discusses the findings.

# Chapter 8: Experimental Evaluation and Findings

## 8.1 Introduction

The main objective of this research was to design a virtual university system that could be implemented in the Kingdom of Saudi Arabia. Similar systems have not been implemented in this country before, so the only way to assess qualitatively the benefits of introducing such a system there was by eliciting the views of professionals currently responsible for providing traditional education. These findings are presented and discussed in the second part of this chapter, which begins with a simple comparison of the proposed VUKSA system with the existing facilities offered by two British VUs: the Open University and the International Virtual University.

## 8.2 VUKSA Compared with the OU and the IVU

The present research investigates the design of a virtual university supporting distance learning (VUKSA) to meet the KSA's regional needs, which could be implemented on a wider international scale, and which takes account of the characteristics of similar universities operating in the UK. In particular, the methods, facilities and operation of VUKSA are compared here with those of the Open University and the International Virtual University UK. The VUKSA, OU, and IVU systems all offer their students the chance to pursue their studies from the comfort of their own homes. Indeed, students are free to choose the time and place to study. All three also follow the principle of 'lifelong learning', which means that their students can be of any age, embodying the concept that it is never too late to learn something new or to do what one really enjoys in life. Different aspects characterize each of these universities and provide an indication of the quality of learning provided.

### 8.2.1 Teaching Methods

Table 8-1 shows that the methods by which students learn vary from one university to another and within the same university, depending on the topic of study and on the aims

of particular modules. At the OU and the IVU, teaching is provided through audiovisual materials including documentaries, interviews and case studies, in the form of printed documents, PowerPoint presentations and reference books. For certain modules, home experiment kits are sent out to students to complete an experimental activity which gives them hands-on experience. Further assistance is then provided through the virtual interface via forums and emails.

Students of the OU have the option to communicate with their tutors by telephone, and tutors can arrange group seminars in convenient locations to elaborate on the module topics. This face-to-face interaction can help students to develop their communication skills and receive the tutoring required to complete the modules.

VUKSA provides recorded lectures presented by tutors, live-streamed lectures and other audiovisual material, PowerPoint presentations, printed module material and reference books. The further assistance offered by VUKSA is far more convenient for distance learners than it is in the cases of the OU and IVU. VUKSA provides students with the ability to arrange video conferences with their tutors at a convenient time, where they can go over module materials and participate in question and answer sessions. These can be arranged for groups of students, thus allowing them to benefit from each other's knowledge as well as from the presence of the tutor. Emails, forums and chat facilities are standard for all modules, allowing students to interact and contribute to discussions in their own time.

**Table 8-1: Teaching Methods**

Teaching Methods								
Features	Audio Visual Material	Documentaries	Printed Documents	PowerPoint Presentation	Virtual Classroom	Telephone	Group Seminars	e-Conferences
OU	✓	✓	✓	✓	✓	✓	✓	✓
IVU	✓	✓	✓	✓	✓	×	×	×
VUKSA	✓	✓	✓	✓	✓	✓	✓	×

### **8.2.2 Student-Tutor Interaction**

Table 8-2 depicts student-tutor interactions, which play a crucial role in shaping students' performance in any given module, and later in the workplace. The OU, IVU and VUKSA all offer their students the ability to contact their tutors via email and forums, which are the minimum that can be offered, to maintain contact between tutors and students. Additionally, OU students and tutors can communicate by telephone to discuss any academic issue or to arrange face-to-face meetings. The OU also offers its students access to advisers and study facilities in their own regional centres, where they can obtain additional face-to-face support when needed. It offers contact with other students too, at tutorials, day schools, informal study groups and events, as well as online conferencing and online social networks. This is in line with the OU philosophy of 'supported open learning'.

VUKSA students would enjoy a more comfortable tutoring experience through video calls and group video conferencing, offering the equivalent of the face-to-face meetings provided by the OU but in a more relaxed environment and independent of the student's location. Thus, if a student is travelling or has registered from outside the KSA, they will still benefit from the face-to-face tutoring facility and obtain the highest quality of education available. Telephone contact is also possible in case students have problems with their internet connections. The fact that VUKSA is a totally virtual university allows the staff to work from anywhere in the world, hence endowing the university with more expertise, diversity and educational value.

**Table 8-2: Student-Tutor Interactions**

Student Tutor Interactions							
Features	Emails	Forums	Own Regional Centre	Informal Study Groups	Social Media		
					Facebook	Twitter	LinkedIn
OU	✓	✓	✓	✓	✓	✓	✗
IVU	✓	✓	✗	✓	✗	✗	✗
VUKSA	✓	✓	✗	✓	✓	✓	✓

### 8.2.3 Assessment Methods

Both the OU and IVU use tutor-marked assignments (TMAs) as an assessment method. Each TMA covers material from the module being studied, and its completion helps students to consolidate and use what they have learnt. Some modules include other types of written assessment such as computer-marked assignments, project work or dissertations. Examinations at both universities are usually taken in person at a local centre. Students can book to attend an examination when they complete a module and they can then register for further modules.

In the proposed VUKSA, additional assessment methods would be offered to allow distant learners to be fairly assessed. Online assessment, where the student uses a webcam to record himself, is one way to ensure that the student is himself undertaking the exam from his room. Another method is telephone-based assessment, where candidates simply telephone in for few minutes throughout the duration of the module and undertake small assessments each time, until they have completed their tasks. Video conference presentations can also be used, whereby the student presents work to multiple tutors through a video conference, is assessed and receives feedback from the tutors during his allocated slot. These methods are listed in Table 8-3.

**Table 8-3: Assessment Methods**

Assessment Methods						
Features	TMA	Computer-Marked	Local Centre	Online Assessment	Telephone Based Assessment	Conference Presentation
OU	✓	✓	✓	✓	×	×
IVU	✓	✓	✓	✓	✓	×
VUKSA	✓	✓	×	✓	✓	✓

### 8.2.4 Social Aspects

Conventional universities play an important role in social integration, moulding students with diverse backgrounds into a cohesive unit. Social interaction, networking and people skills obtained in conventional universities prepare the student to enter the job market and integrate easily into society.

The OU has a student union that offers an active student environment comprising clubs, societies and social events so that students can become involved beyond the virtual world. Such facilities, together with group seminars organized by personal tutors, will compensate to some extent for the lack of classroom interaction provided by a conventional university. These facilities are not offered at the IVU, which instead concentrates on offering all its resources and support via the internet on its online interface, in line with its philosophy of ‘supported virtual learning’.

VUKSA values the social aspects of university life, so its online interface includes a social networking platform for students to communicate professionally with other students. Students are able to customize their profiles, adding as much information about their skills and experiences as they wish, allowing them to network and collaborate with each other during their courses and beyond. They are able to socialize and interact with other students from diverse backgrounds, who may be in distant parts of the world. Adding this social feature to the interface makes the virtual university experience more valuable, as students build relationships as well as developing skills and knowledge. The social aspects are illustrated in Table 8-4.

**Table 8-4: Social Aspects**

Social Aspect											
Features	Student Union	Clubs/Social Events	Group Seminars	TV/ Radio	Online Interface	Social Media			Social Networking		
						Facebook	Twitter	LinkedIn	Chat	Forums	Discussion Board
OU	√	√	√	√	×	√	√	√	√	√	×
IVU	×	×	×	×	√	×	×	×	√	√	×
VUKSA	×	×	√	×	√	√	√	√	√	√	√

### 8.2.5 Additional Facilities

The OU provides a mobile application allowing its students to access the virtual interface at any time, and from personal mobile devices such as mobile phones and tablets. This adds flexibility and means that it is even more convenient for students to fit their studies into a busy lifestyle.

The proposed VUKSA provides similar mobile applications, but with more student immersion, allowing them to access the databases and online library from their mobile devices. The resources available to students on mobile devices include forums, personal email, supportive materials, and recorded lectures.

One very important feature to be provided by VUKSA is the facility to translate not only written documents but also audiovisual material. The two main languages in which VUKSA materials are written are Arabic and English. This will allow students in the KSA to learn in their mother language without the trouble of having to translate every lecture if they are unable to understand it. The additional facilities of OU, IVU and VUKSA are depicted in Table 8-5.



**Table 8-5: Additional Facilities**

Additional Facilities							
Features	Mobile application	Virtual trips	Shopping	Translation	Cloud computing	Online registration	Online payments
OU	✓	×	✓	×	×	✓	✓
IVU	✓	×	×	×	×	✓	✓
VUKSA	✓	✓	×	✓	✓	✓	✓

### 8.3 Expert Review Panel Evaluation

The following subsections present and discuss the findings of the expert panel evaluation of the proposed VUKSA system. The selection and functioning of the panel are explained in Chapter 3, section 3.10.

#### 8.3.1 Findings

Interestingly, the four most frequently mentioned benefits were closely related to the three main challenges. These benefits were on-time availability and delivery of educational resources, equitability of all students with an internet connection, regardless of geographical location, reduced financial and technology costs, and standardisation and flexibility, while the challenges which emerged were standardisation, restricted knowledge flow and poor interaction between students and their institutions. This researcher has classified these factors as either technical or operational.

One possible solution to the interaction challenge would be through the social media section of VUKSA, by establishing social networks for future employment through university clubs, meetings, seminars and exhibitions. Although the university is virtual, some monthly or annual events could be organized in different parts of the country, depending on the concentration of students. Generally, virtual universities have very similar teaching environments, including private areas for staff, students and lecturers, and providing all related teaching technology: Blackboard, online courses and libraries, online examination systems, virtual private networks for clients and communication tools between students and their lecturers and among students themselves. A short account of each of these tools and their use in the UK is given in Chapter 4, section 4.3.

The evaluation of students' abilities is very difficult, because tutors may never have the opportunity to meet them. One solution to this problem is to use an interactive online blackboard system, which is very similar to a physical blackboard or whiteboard used in the classroom, in that when the lecturer draws or writes on a screen using a keyboard, mouse or e-pen, all of this information will appear on the screens of the students attending the lecture online. The lecturer can also use his or her voice to explain the lesson. Additionally, there is provision for students to submit assignments, providing a convenient record of their work and progress while facilitating the monitoring of originality and research input from the students. There is also the possibility of the incorporation of electronic student application and registration; electronic submission of assignments, marking and recording; electronic tutorials and other interactions. Students should be able to fill in their details and give reasons for applying online. The acceptance and registration processes can also be carried out online. Electronic tutorials can also incorporate practical training with specific members of staff, and more work-oriented assignments. Some departments, such as those of economics and statistics can, for instance, make good use of interactive whiteboard facilities and even one-to-one tutorials. On the other hand, university administrators warned of a plagiarism problem.

From a security perspective, VUKSA, like any other computer system, has four goals: the confidentiality and integrity of the data and the availability and privacy of the system. Authentication is necessary to verify the identity of the user via a username and password. Data integrity means that an unapproved system client ought not to have the capacity to change any information without the holder's consent. Protection, i.e. ensuring people are protected from the abuse of their personal data, is closely related to other legal and moral issues.

Assessment and evaluation are very important issues in e-learning. There is general agreement among researchers that assessment has a powerful impact on learning processes. Examinations at a virtual university can be done in either of two ways, depending on the type of course and department and on university policy. In assessment by assignments, students submit original written work on a specific chosen topic, previously discussed with the examiner or lecturer. The alternative is online examinations. The process starts when the University Examinations Manager sends

emails to the students involved in the examinations announcing the time at which the examinations are scheduled to take place. Once students have responded to this message, each can access a personal link to the examination website, which is a temporary site, accessible only during the examination period. The site comprises a number of pages containing examination questions of various types, including multiple-choice and filling in spaces, some of which may need detailed explanations to be written by the student on camera in a virtual classroom. Once students have finished the examination or at the end of the specified time, they will submit their answers and exit the exam website permanently. Students can write the examination at home or in any place of their choice in the case of an open examination, where they are permitted to use textbooks and works of reference. This type of examination will comprise questions so designed that students must have understood the course material very well to be able to answer them. An alternative is for students to sit examinations at an educational centre, an arrangement used by King Abdul-Aziz University for its external students.

The technical challenges identified in the feedback of the software professionals were compatibility and distributed architecture, which are closely related to the core of this research: service-oriented architecture. As previously mentioned, standardisation is a technical challenge in the virtualization of higher education. One software professional commented that systems must be able to integrate with other educational services provided in the KSA. This ties in well with the core of this research: SOA allows peripheral services and applications to be added and integrated quickly, with the minimum of effort and with no compatibility issues. The system will be able to integrate with any current service including those of the Ministry of Higher Education, in order to update student records as soon as they are ready.

The third technical challenge is distributed architecture. Virtual learning environments support huge numbers of geographically distributed users, which may be difficult to manage efficiently. This is confirmed by a comment from a software professional that inappropriate and incompatible software and hardware compromises data storage and sharing, resulting in uncontrolled costs. This observation reflects the generic security challenge facing any web-based system: that of providing a safe and secure system.

### **8.3.2 Discussion of Findings**

As the experts pointed out, a virtual university has become feasible in Saudi Arabia in recent years, as a result of an existing Internet infrastructure that ensures the ready availability of computers in this country. The use of advanced Internet programs and VU tools, if properly implemented, would be adequate to support higher education in the KSA. It is now time for education in Saudi Arabia to fully embrace the new technology and establish a new type of education, that is, the virtual university and e-learning, and support its students, tutors, academics and administrators throughout the educational process. The Saudi Government should support and encourage the private sector to establish this new kind of education, which uses technology and communications, as well as considering plans for the virtual university model as a solution to the current admission problems of traditional universities. It is the duty of the government to impose a degree of control with regard to educational content, in order to preserve social and cultural values and maintain social cohesion.

The Ministry of Higher Education should be the body responsible for exercising government powers and evaluating the effectiveness of the virtual university as a teaching method. It needs to embrace the knowledge, success and experience of virtual universities in other countries, ensuring that the quality of the education provided and its potential benefits meet society's needs, and that the course content is compatible with Islamic principles. The Ministry of Higher Education should act on behalf of the Saudi government and the private sector, to oversee planned VUs and establish the foundations necessary to ensure the provision of equal educational opportunities for both males and females. Moreover, the Ministry should actively promote the legislation necessary to support and facilitate the establishment of virtual universities via Internet-based technology.

Certain changes need to be implemented in order to make this planned project possible. First, a new organizational structure is required, incorporating the university presidents. There should be a board of trustees, comprising a mix of educators, education experts, corporate executives from the investment sector, local authorities and representatives of the Ministry of Higher Education; and a strategic planning board, whose members would be those responsible for curriculum development and production, a finance

manager, a marketing and public relations manager, a recruitment manager, a manager of educational support services and a manager of quality assurance and accreditation. The board of trustees should identify the potential needs and requirements of academic staff working in the virtual university, and provide them with the necessary IT skills, rewards, promotion prospects and motivation to encourage them to work satisfactorily in this new environment. The board should also launch a comprehensive national plan to attract, motivate and encourage students to participate in this type of education, as well as facilitating active female involvement and participation in making decisions which affect their education. Finally, it is vitally important for the virtual university to work cooperatively with traditional universities and other well established educational and non-educational organizations to resolve issues related to educational standards, quality assurance, copyright, certification and cultural values.

#### **8.4 Summary**

This chapter has presented a critical evaluation of the desired system in two strands: comparing VUKSA with the OU and IVU, and an expert review. Having considered five key attributes, viz. teaching methods, student-tutor interactions, assessment methods, social aspect and additional facilities, this researcher found it reasonable to conclude that VUKSA compared favourably and competently with existing and experienced institutions of the same kind elsewhere.

The expert review made it clear that there are benefits and challenges associated with virtualising university education. The experts evaluated the VUKSA proposal and generally agreed that four benefits could be achieved by implementing it: on-time availability and delivery of educational courses, equitability of all students with Internet connection, reduced financial and technological costs. The experts also clearly agreed that the VUKSA design ensured security and reliability and was feasible.

The next chapter concludes this thesis by revisiting the research questions and making some suggestions for further research.

## Chapter 9: Conclusions

In the opening pages and at several points elsewhere in this thesis, it has been made clear that the researcher was motivated by the desire to open up higher education to all of the people of Saudi Arabia, regardless of gender, age and or religion. This led him to research the concept of virtual universities and the benefits and challenges of virtual learning environments, and to propose a virtual university model providing benefits such as expanding the time, place, and pace of higher education and enabling learning to become more individualised.

The principal conclusion to be drawn from this work is that a virtual university is feasible in the Kingdom of Saudi Arabia. The literature review produced strong evidence that the phenomenon of virtual universities is a global and one which has begun to gain acceptance in most of the developed countries of Europe and North America. In addition, the data analysis suggests that establishing a virtual university in KSA is crucial. The importance of taking this step and the justification for doing so are set out in chapters three, four and eight. The value of establishing a VU was supported by the positive views of the majority of staff at three universities under investigation, by decision-makers and the expert panel. This proposed project is thus considered one of the most favourable alternative solutions to the limitations of the existing Saudi higher education system, such as the imbalance between need and the available specialisations in Saudi Universities, and a decline or weaknesses in the input and output of education.

An extensive review of the existing literature regarding IT infrastructure leads this study to conclude that the IT infrastructure in Saudi Arabia is adequate for the initiation of the proposed VU.

More specifically, this thesis has provided answers to the research questions set out in the introductory chapter, which are summarised here in the following form: Can SOA support the implementation of virtual universities implemented as services brokers? What services can a virtual university provide, request and register in a service-oriented

architecture? Answers to these questions were derived from a consideration of a broad range of evidence, from a historical account of the development of service oriented architecture to the most recent cloud computing technology.

### **9.1 Can SOA Support the Implementation of a VU?**

Chapter 2 takes a historical perspective, outlining the history of service-oriented architecture from the days of a two-tier architecture comprising of a mainframe and a dumb terminal to the contemporary three-tier architecture, consisting mainly of a database-tier, middle-tier and front-end tier. It concludes that the three-tier architecture is ideal for a virtual university as it utilises XML, SOAP, UDDI and WSDL.

The methodology chapter presents and justifies the research methods employed to collect, analyse and present the research data. The main sources of data were published works such as textbooks, journals and websites, because these would have been professionally reviewed and therefore provide more accurate information. A commitment to ethical research is registered in section 3.12 and is of particular relevance to the collection of primary data by means of a questionnaire.

The literature review addressed several themes including the concept of virtual universities, service-oriented architecture and approaches, technologies and research issues, the impact of SOA, comparison of web services, Java RMI and CORBA, and comparative studies of SOAP and REST. It established that the advantages of virtualising universities outweigh the disadvantages, using the already available technology. The literature review also strongly suggested that SOA could support the implementation of a virtual university.

Chapter 5, on application-to-application technologies, critically discussed web services, the fundamentals of SOA, service integration, remote procedure calls, transport protocols, sequencing network services, SOAP and the concept of XML. It was established that the available technologies are ideal for a virtual university and can support its implementation. The chapter addressed messaging technology in detail, giving an account of JMS and transaction, a message-passing system and WS-Reliable Messaging. It was established that there are four basic delivery assurances that end points provide: at least once delivery, at most once delivery, exactly once delivery and

in order delivery. With the four delivery assurances in place this researcher concludes that the available technology can fully support the implementation of a virtual university.

The registry and discovery of web services are two core functions of SOA discussed in Chapter six, which indicated that in junction with UDDI as a registry that contains relatively lightweight data, with the prime purpose of providing network addresses to the resources it describes, SOA can support the implementation of a virtual university. This chapter also addressed issues pertaining to WS security, securing and protecting system contents, threats, authentication, authorisation and session control. It concluded that for a virtual university to be successful, its security features must give system users confidence and trust in the system.

## **9.2 What Services can a VU Provide, Request and Register in SOA?**

An instant messaging application case study, presented in Chapter 7, showed how the system would enable two or more participants to exchange messages in an asynchronous manner, thus indicating that it would be possible to implement a purely virtual university. Finally, on the second question, Chapter 7 presents a model of a virtual university designed using the existing technologies. The model proposes four steps, utilising XML, SOAP WSDL and UDDI.

## **9.3 Further Research**

The virtual university model is relatively new in the world and further research needs to be carried out in the future to decide whether or not there is a need for virtual universities. During time I spent working at King Abdulaziz University, there was much discussion among colleagues and myself as to how to solve the problem of a rising student population and limited places at traditional universities. Some colleagues proposed extending e-education and the virtual university model, while others viewed this as a double-edged activity. Those who pointed to the advantages of the virtual university referred to its contribution to educational development, arguing that e-learning improves both students' and employees' skills. In addition, a virtual university is a good revenue resource for universities, and the revenue it provides can be used to build other facilities. Moreover, the virtual university can serve as an educational



opportunity through increasing student numbers and providing a wide range of course materials and subjects to meet students' widely differing needs. In contrast, there were colleagues who argued that virtual universities could have a negative impact on the quality of education provided, and since e-learning is developing rapidly, it might be difficult to control it in the long term. The differing views among my colleagues substantiate my argument that further research is required into the need for virtual universities, their advantages and limitations. This would involve studying the existing models in terms of their organisational and administrative structure and comparing them with those of traditional universities, in order to investigate the common factors that lead to the success of the virtual university model. Research is also recommended into the question of adding more programming and bringing in more functions, in order to add clarity and comprehensibility to the virtual university model.

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# Appendix

# Questionnaires

*Please help us for fill out this survey which takes a few moments. The results will be returned to us automatically via the web.*

## **1-Gender**

- Male  
 Female

## **3.Highest academic qualification**

- Ph.D.Degree  
 Master's Degree  
 Bachelor's Degree  
 Other:

## **4. Do you agree with the concept of establishing a virtual university in Saudi Arabia?**

- YES  NO

## **5-Do you think the establishment of a virtual university supports the following statements below?**

	Agree	Unsure	Disagree
<i>Equal opportunities</i>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<i>Provide students with the required knowledge in IT</i>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<i>Allow students who have dropped out of universities to proceed with their studies</i>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<i>Minimise government expenditure on higher education</i>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<i>Assist the universities in coping with the rapid growth of students seeking higher education degree</i>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<i>Support of saudization within all sectors of the domestic economy through Increase the number of skilled and educated</i>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<i>Lower cost for students than traditional universities</i>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<i>Support to women to access higher</i>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

<i>education</i>			
<i>Open up the economy and to create new jobs through the expanded flows of foreign direct investment to support Saudization program during increasing employment for Saudi</i>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**6-What is your opinion of the virtual university offering courses in the following degrees ?**

- Bachelor's
- Master's
- Other:

**7 -what is a suitable evaluation method in virtual university from your view?**

- Online Exam
- Open book Exam
- Summative Assessment
- Formative Assessment
- Combination of summative and Formative Assessment
- Assessment for Learning
- Other:

**8-Please write down any suggestion or comments you may wish to add.**

**Thank you very much for your co-operation.**

**Nasser Albagami**

Finish Thank you

### **To establish the existing structure of virtual universities**

My name is Nasser Albaqami, PhD researcher at De Montfort University. I am researching virtual universities, supervised by Dr Jordan.

To help me to understand practical issues and gain relevant knowledge about virtual universities and e-learning, I would appreciate if you could avail me of interview time. The interview basically is structured into three themes: ICT structure, architecture and functionalities.

As required by DMU research guidelines and the British Educational Research Council (2012), this research is being conducted in an ethical way. There will be no misrepresentation, deception or undue intrusion. This researcher guarantees confidentiality of data, protection of participants' identities, security of collected data and informed consent.

Interview questions are as shown below and depending on some answers I may ask more or less questions.

**1. How is the ICT service structured?**

- Bus topology**
- Star topology
- Ring topology
- Any other. Please specify.....

**2. What would you say are the strengths and weaknesses of the structure you are using?**

- 
- 

**3. Do you currently use any virtual learning environment?**

- Yes**
- No

**4. If 'yes' which one? Else go to question 9**

- Blackboard**
- Moodle
- Any other. Please specify

**5. Briefly, what are the top two benefits and disbenefits of using your specific virtual learning environment?**

- 
- 

**6. What devices can be run on the system?**

**7. What is the estimated time a prospective system user can take to learn the system?**

- Less than one week**
- 1 – 2 weeks
- More than 2 weeks

**8. What are the top ten functionalities of your system?**

No	Functionality	Strength	Weakness	Any Comments
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

**9. In a few words please explain how you think the weaknesses you mentioned above can be addressed in a new model?**

## **Experts' Review and Evaluation - Written Feedback**

- Exams must be taken in classrooms (Ministry of Education)
- The university lecturers are not very willing to use the virtual learning environment. (Education professional)
- The evaluation of the student's ability is very difficult, because the tutor may never have the opportunity to meet the students (education professional)
- Plagiarism may be a problem because identifying users of computers is extremely difficult and the biggest problem in this regard is related to examinations and how students may be reliably tested over the Internet. (University administrations)
- Technical knowledge is important for the tutor to deliver his course successfully via computers and the internet. (University administrations)
- Cultural transmission of values:
- Social integration aspect of a university will be deteriorated through a virtual university (education professional)
- The government must practise a degree of control with regard to education content to preserve social and cultural values and maintain social cohesion. (Ministry of Education)
- The software professionals identified some technical challenges, which are standardisation, scalability and distributed architecture.
- Software experts suggested that a centralized database is important for data security and ease of access
- The system must be able to integrate with other educational services provided in KSA (software professionals)