MOBILE BASED SYSTEM FOR ELECTRONIC LEARNING CONTENT DELIVERY AND ACCESSIBILITY:

A Case of Higher Education Institutions in Tanzania

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A Dissertation Submitted in Partial Fulfilment of the Requirements for the Degree of Masters of Science in Information and Communication Science and Engineering of the Nelson Mandela African Institution of Science and Technology.

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ABSTRACT

The advancement in Information and Communication Technology (ICT) has brought new opportunities for learning. Tanzania is adopting the new technologies in Higher Education Institutions (HEIs) through e-learning. However, delivery of learning contents is becoming a challenge for HEIs due to the constraints in resources and network bandwidth. Although challenges exist, development of innovative and emerging mobile computing technologies have brought potential opportunities for enhancements of learning contents delivery and accessibility. The objective of this study was to develop a mobile application based system for e-learning content delivery and accessibility as a solution to high bandwidth costs of the conventional Web application based system. The proposed system can synchronize contents from some original servers to local database in mobile devices for offline use.

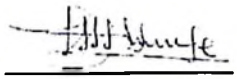
The study was conducted in HEIs in Tanzania. Survey methodology was used to identify and assess ICTs for e-learning and system design requirements. During the survey different methods including interview, structured questionnaire and review of empirical literatures were used. Quantitative data were analysed using Statistical Package for Social Sciences (SPSS) while qualitative data were analysed through content analysis. A prototype for Mobile-LCDS was developed using UML, MySQL, PHP, XML, ANDROID and Java; and tested using a black box testing technique.

Findings show that 85% of students own laptop, 65% own smartphone and 78% own mobile phone. The results provide empirical evidence that students own more than one mobile devices that can be used as tools for facilitating learning process. However, the results provide empirical evidence that the rate of adoption of mobile phones for mobile-learning in Tanzania has reached 20.3% which is still low due to fact that even though e-learning systems exist, they are not fully operational. This is caused by poor ICT infrastructures, constraints in resources and bandwidth. The results of numerical evaluation revealed that synchronizing learning contents locally in mobile devices is significant for bandwidth usage cost savings, alleviates network overload, alleviates servers' workload and hence improves e-learning system performance.

In conclusion, in order to improve e-learning content delivery and accessibility under limited resource settings, HEIs in developing countries should make an effective use of emerging mobile computing technologies which are relevant to their respective environments.

DECLARATION

I, **Michael P.J. Mahenge** do hereby declare to the Senate of Nelson Mandela African Institution of Science and Technology that this dissertation is my own original work and that it has neither been submitted nor being concurrently submitted for degree award in any other institution.



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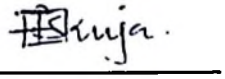

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CERTIFICATION

The undersigned certify that they. have read and found that the dissertation conform to the standard and format acceptable for examination, therefore do hereby recommends for examination of dissertation entitled "**Mobile Based System For Electronic Learning Content Delivery And Accessibility: A Case of Higher Education Institutions in Tanzania**", in fulfilment of the requirements for the degree of Master of Science in Information and Communication Science and Engineering at Nelson Mandela African Institution of Science and Technology.

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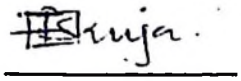

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DEDICATION

This work is dedicated to my lovely mother T. E. Mhando, who for the entire period of my study encouraged and always wished a best of luck. Thank you my lovely mother. My prayer is that GOD bless you and your family abundantly and grant more wisdom for the goodness of the coming generations.

TABLE OF CONTENTS

ABSTRACT i

DECLARATION ii

COPYRIGHT iii

CERTIFICATION iv

ACKNOWLEDGEMENT v

DEDICATION vi

TABLE OF CONTENTS vii

LIST OF TABLES xii

LIST OF FIGURES xiii

LIST OF ABBREVIATIONS AND SYMBOLS xv

CHAPTER ONE 1

General Introduction 1

Introduction 1

1.1 Background information 1

1.1.1 E-learning in Tanzania 3

1.1.2 Motivation factors of this study 4

1.2 Research problem and justification of study 6

1.3 Objectives 7

1.3.1 General objective 7

1.3.2 Specific objectives 7

1.4 Research questions 7

1.5 Significance of the research 8

1.6 Scope and focus of the study 8

1.7 Dissertation organization 9

CHAPTER TWO 10

ICTs for e-learning in Higher Education Institutions in Tanzania 10

2.1 Introduction 10

2.1 Methods 13

2.1.1 Study design and sampling 14

2.1.2 Data collection 14

2.1.3 Data analysis 14

2.2 Results and discussions 15

2.2.1 Demographic characteristics of respondents 15

2.2.2 Applications supporting delivery and accessibility of learning materials 16

2.2.3 Learners' perceptions of e-learning content delivery and accessibility 18

2.2.4 Mobile computing/communication devices ownership 20

2.2.5 Learning activities supported by mobile devices 22

2.3 Conclusion and recommendations 23

2.3.1 Recommendations 24

CHAPTER THREE 26

Mobile-based system for cost-effective learning contents delivery and accessibility 26

3.1 Background information 26

3.2 Methodology 28

3.2.1 Software development life cycle (SDLC) 29

3.2.2 Tools and technologies used 30

3.3 Design requirements 30

3.4 System Architecture 31

3.4.1 Synchronization and caching 33

3.4.2 Use case modelling 36

3.4.3 Mobile-LCDS data flow sequence 37

3.4.4 Interface and different components of the system 39

3.5 Results and discussions 43

3.6 Conclusion and future works 45

CHAPTER FOUR 46

Synchronization and caching solution for cost-effective e-learning in resource and bandwidth constrained environments 46

4.1 Background information 46

4.2 System architecture 50

4.2.1 Activity sequence 51

4.3 Bandwidth conservation models for numerical studies 54

4.4 Results and discussion 57

4.4.1 Significant bandwidth usage cost savings 57

4.4.2 Reduction of Internet usage workload 59

4.4.3 System usability testing 60

4.5 Conclusion and future work 62

CHAPTER FIVE 63

General discussions, conclusions and recommendations 63

5.1 General discussion 63

5.1.1 General discussions of the objectives of the study 63

5.1.2 The main findings of the study 64

5.2 Research contributions 65

5.2.1 Social contribution 66

5.2.2 Economical contribution 66

5.2.3 Pedagogical contribution 67

Pedagogical contribution includes; 67

5.3 Limitations of the research 67

5.4 Conclusion 68

5.5 Recommendations 69

REFERENCES 71

APPENDICES 76

APPENDIX 1: QUESTIONAIRE GUIDE FOR INFORMATION NEEDS ASSESSMENT. 76

A PPENDIX 2: SYSTEM VALIDATION QUESTIONNAIRE 80

A. System usability evaluation 80

B. System design requirement validation 81

APPENDIX 3: Mobile-LCDS: PREVIEW ON THE WEB 82

APPENDIX 4: SAMPLE SOURCE CODE FOR COURSE SYNC 85

APPENDIX 5: ACADEMIC PAPER ACCEPTANCE LETTER 89

LIST OF TABLES

Table 1: Applications used for learning materials delivery and accessibility 17

Table 2: Learning activities supported by mobile devices 22

Table 3: Mobile-LCDS DFD-level 0 description 39

LIST OF FIGURES

Figure 1: Active mobile-broadband subscriptions per 100 inhabitants, 2007-2014* 4

Figure 2: Mobile penetration rate in Tanzania 2005 - March 2014 5

Figure 3: Smartphone adoption 12

Figure 4: Integrated learning solution (Adapted from Brown, 2010) 13

Figure 5: Gender of the respondents 15

Figure 6: Learners' perceptions of e-learning content delivery and accessibility 19

Figure 7: Mobile computing devices ownership 21

Figure 8: Evolutionary development model 29

Figure 9: Mobile-LCDS system architecture 32

Figure 10: Contents sync and caching 36

Figure 11: Mobile-LCDS use case diagram 37

Figure 12: Mobile-LCDS data flow diagram level 0 38

Figure 13: Interface and system components 40

Figure 14: Mobile-LCDS Student Forum 40

Figure 15: More operation on synced data 41

Figure 16: System admin and Instructor Dashboard 42

Figure 17: User acceptance functional requirements testing results 43

Figure 18: Proposed system architecture (Adapted from Mahenge *et al.*, 2014) 51

Figure 19: Sync and cache activity sequence 53

Figure 20: Client-server bandwidth conservation 56

Figure 21: Monthly bandwidth cost approximation between continuous Internet connections and the sync and caching approach 58

Figure 22: Relationship between access speed and Internet usage workload 60

Figure 23: System usability test results 61

LIST OF ABBREVIATIONS AND SYMBOLS

ANOVA	Analysis of Variance
API	Application Programming Interface
CIPP	Context, Input, Process and Product
DBMS	Database Management System
DFD	Data Flow Diagram
ERD	Entity Relationship Diagram
FOSS	Free and Open Source Software
HEI	Higher Education Institutions
HTTP	Hypertext Transfer Protocol
ICT	Information and Communication Technology
ITU	International Telecommunication Union
LAN	Local Area Network
LCDS	Learning Contents Delivery System
LMS	Learning Management System
MoEVT	Ministry of Education and Vocational Training
MOPTAM	Mobile Phone Technology Adoption Model
NM-AIST	Nelson Mandela African Institution of Science and Technology
ODL	Open and Distance Learning
OUT	Open University of Tanzania
PNO	Process number
SDK	Software Development Kit
SDLC	Software Development Life Cycle
SET	Science, Engineering and Technology
SPSS	Statistical Package for Social Sciences
SQL	Structured Query Language
SUA	Sokoine University of Agriculture
TAM	Technology Adoption Model
TCRA	Tanzania Communication Regulatory Authority
TNIP	Tanzania National ICT policy
UDSM	University of Dar es salaam
UML	Unified Modelling Language
UTAUT	Unified Theory of Acceptance and Use of Technology
VM	Virtual Machine
VSAT	Very Small Aperture Terminal
XML	Extensible Markup Language

CHAPTER ONE

General Introduction

Introduction

This chapter describes the general introduction of the study. It mainly focuses on the background information of the study, ICT for e-learning in Tanzania and motivating factors of the study. Moreover, it discusses the research problem and justification of the study, objectives of study, research questions and significance of the study. It further presents the scope and focus of the study and finally gives the description about the organization of the dissertation.

1.1 Background information

The advancement in Information and Communication Technologies (ICT) brings opportunities in all sectors including education. From the education sector perspective, ICTs enhances interaction among students, information, and systems in ways that never before have been possible (Sife *et al.*, 2007). In particular, wireless and mobile technologies are considered as important tools for reducing the digital divide and hence extending the opportunities for education accessibility. Mobile Technology is constantly evolving and offering new capabilities for supporting higher data transmission, storage, and multimedia formats that can be beneficial for the education acquisition (Cortez, 2012). Electronic learning (e-learning) is growing very fast and majority of Universities in Tanzania are already supported in some way an e-learning solution. However, in developing countries, Tanzania in particular e-learning content delivery and accessibility is still a challenge due to the constraints in resources and network bandwidth.

According to Pinkwart et *al.*, (2003) electronic learning (e-learning) is defined as learning supported by digital "electronic" tools and media while mobile learning (m-learning) is defined as electronic learning that uses mobile devices and wireless transmission. Similarly, Quin (2001), cited by Brown (2003) also defined mobile learning as e-learning through mobile computational devices. Klopfer *et al.*, (2002) argued that, mobility presents a new extent to support and promote meaningful learning activity, social interactivity and context sensitivity. According to Klopfer *et al.*, (2002), cited by Atif *et al.*, (2010), the major advantages of using mobile technologies for learning includes:

i) *Portability* –This is the key feature for mobile learning that allows learning everywhere and anytime without restriction of space and time. Due to portable size of mobile devices, it becomes easy for learners carry them everywhere.

ii) *Social interactivity* – The mobile devices allow one to interact with instructors and fellow students for the exchange of information and other learning activities which increase the social interactivity, collaboration and participation of learners in learning activities.

iii) *Context sensitivity* – Mobile technologies can assist learners to gather the unique information from some locations where may not be accessible longer. This kind of information can be gathered from some remote servers and stored locally on mobile devices.

iv) *Connectivity* – Mobile devices provide easy connectivity to its network every time and everywhere. This continuous connectivity allows the learner to stay connected with colleagues in a learning domain and instructors for up-to-date and current activities in the learning process. It also facilitates learning activities anytime and everywhere.

1.1.1 E-learning in Tanzania

A review of literatures (Suhail and Lubega, 2011; Lujara, 2008; Lwoga, 2012 and Mtega *et al.*, 2014) reveals that e-learning systems and mobile learning applications are becoming increasingly popular in Higher Education Institutions (HEIs) bringing opportunities for enhancing content delivery and supporting innovative practice in learning processes. While these opportunities exist, the government of Tanzania through the Ministry of Education and Vocational Training (MoEVT) recognizes the potential of ICT to act as a tool for improving education delivery, outcomes and impact, as evidenced through the national plans, policies and strategies (National ICT policy 2003; Mshangi, 2013). In the same vein, the majority of HEIs is supporting e-learning solution in some ways. For example, in 2008 there were two HEIs in Tanzania making use of digital learning environments, namely the University of Dar es salaam (UDSM) and the Open University of Tanzania (Swarts and Wachira, 2010). Also in 2012 Sokoine university of Agriculture adopted free and open source software (Moodle) for learning which was used only for ICT courses. Despite the great opportunity brought about by the existing learning management systems (LMS) like Moodle, a web-based learning management system which is popular in majority of learning environments; learning content delivery and accessibility is still a challenge in Tanzania due to the constraints in resource and bandwidth (Mahai, 2012). A review of empirical literatures reveals the main challenges in e-learning contents delivery and accessibility which are considered as the obstacles for achieving effective and efficient learning. These challenges includes; the cost of bandwidth connection and usage, the existing e-learning systems require a continuous internet connection, limited mobility and portability features, un-accessibility of e-learning contents during an offline period, and shortage of ICT facilities (hardware and software) to facilitate delivery and accessibility of e-learning

contents (Milovanovic, 2010; Trifonova, 2006; Swarts and Wachira, 2010). Furthermore, it has been reported by Sakharkar (2009) that in developing countries sustainable internet connectivity, fund allocation on ICT and the number of computers per student are still limited for both public and private HEIs which limits access to e-learning system even though the systems exist. For HEIs with resource and bandwidth constrained environment in developing countries, the extension of the scope of e-learning content delivery and accessibility to mobile computing devices for supporting cost-effective e-learning is still a considerable gap. Therefore, effective implementation of innovative and emerging mobile technologies is crucial towards overcoming challenges facing education sector, particularly in e-learning contents delivery and accessibility.

1.1.2 Motivation factors of this study

Mobile technologies and access to the Internet are growing very fast as shown in Figure 1, bringing along lots of opportunities for availability and flexibility of e-learning activities.

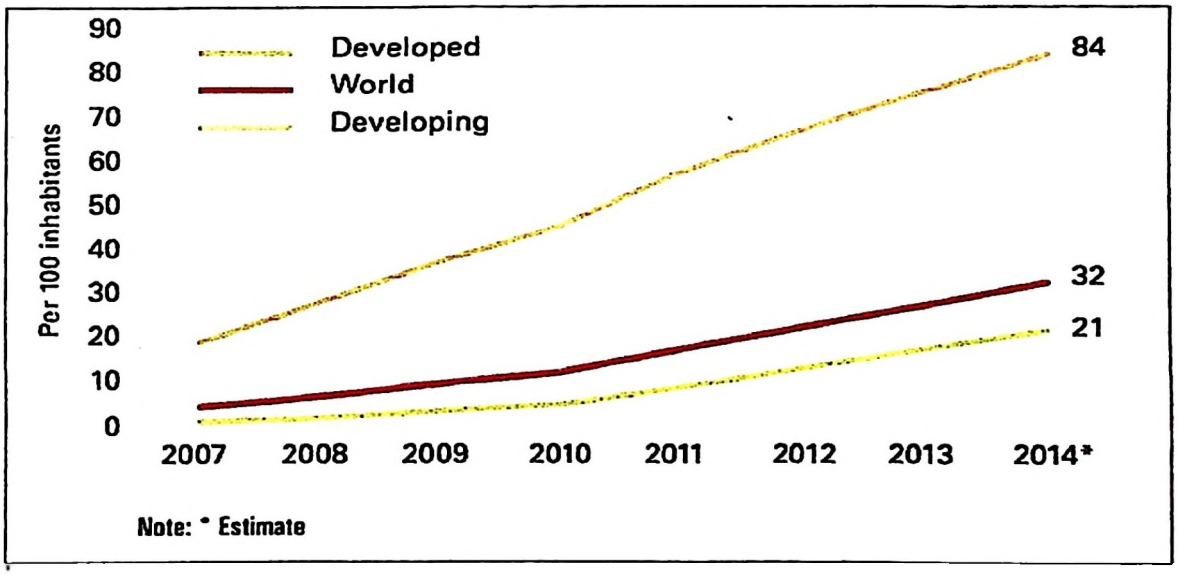


Figure 1: Active mobile-broadband subscriptions per 100 inhabitants, 2007-2014*

SOURCE: ITU World Telecommunication/ICT Indicators database (2014)

According to ITU (2014), by 2014 mobile-broadband penetration reached 32% globally, 84% in developed countries and 21% in developing countries. Likewise, Internet user penetration has reached 40% globally, 78% in developed countries and 32% in developing countries. It has been further reported that, mobile broadband is growing faster in developing countries, than in developed countries.

Other studies indicate that there is an exponential growth in bandwidth and decline in cost specifically, the global bandwidth is expected to grow by 32% per year from 2010 to 2015 while the cost of bandwidth is expected to decline by 18% per year (Scott, 2012; Telegeograhy, 2012). It also indicates that the new subsea cable construction and upgrading of existing systems have resulted in bandwidth price reduction worldwide.

In view of Tanzania as an example, the trends of mobile subscriptions increase rapidly from 2005 to March 2014 as shown in figure 2.

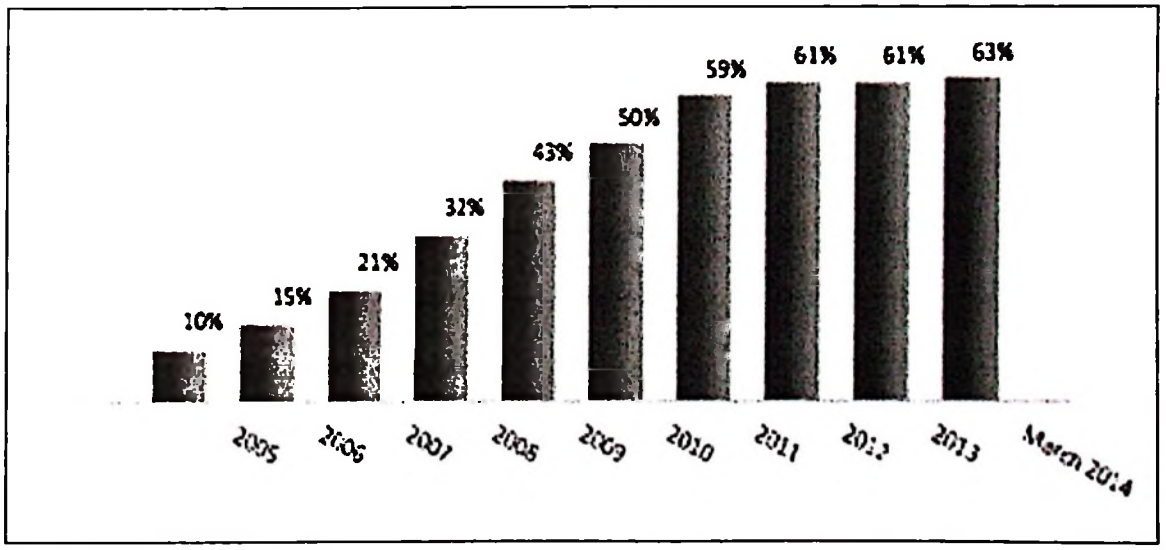


Figure 2: Mobile penetration rate in Tanzania 2005 - March 2014

SOURCE: TCRA (2014)

According to TCRA (2014), the trends of mobile subscriptions increased from 2, 963,737 in 2005 to 27,986,314 in March 2014 leading to a penetration rate to rise from 10% in 2005 to 63% in March 2014. The statistics on mobile penetration trends provide empirical evidence that there is much high mobile penetration in Tanzania (63%) compared to the global (32%) which bring opportunities for developing countries to adopt mobile technology for learning. Similarly, smartphone adoption has increased from 3% in 2010 to 9% in 2014 and even more in the coming years (TCRA, 2014).

The survey results of this study conducted in HEIs found that on average 85% of students own laptops, 65% own smartphones and 78% own mobile phones. This means that the majority of the students own more than one mobile computing devices which can be used as a tool to facilitate teaching and learning process. Likewise, review of empirical literatures revealed that students were already using their mobile phones for other activities like mobile banking, mobile money and social networking (Mtega *et al.*, 2014). Similarly, students are using their mobile phones for learning activities via Twitter, YouTube, Skype, Facebook and other social media. Therefore, existence of innovative and emerging mobile computing technologies provides potential opportunities for enhancements of learning content delivery and accessibility. This study explores the opportunities brought by mobile technologies to find out a cost-effective solution for e-learning content delivery and accessibility in HEIs of Tanzania.

1.2 Research problem and justification of study

The existing e-learning systems in higher education institutions in Tanzania face challenges in delivery and accessibility of learning content. The majority of these systems requires continuous Internet connectivity as a result, the delivery and accessibility of contents become a challenge due to the constraints in resources and bandwidth (Swarts and Wachira, 2010; Mahai, 2012; Sakharkar 2009 and Jordi, 2012). The cost of bandwidth usage due to need of persistent internet

connectivity, limited flexibility in learning process, inability to access e-learning content during offline, server workloads and internet usage overheads are problems that need to be addressed. To address the mentioned challenges, this research explores the opportunities brought by mobile technologies for synchronization of learning contents from some remote server(s) to local server for offline use. Therefore, this study intends to develop a system that will facilitate mobile based e-learning content delivery and accessibility in HEIs of Tanzania.

1.3 Objectives

The objectives are divided into general objective and specific objectives.

1.3.1 General objective

To design and develop a system that will facilitate mobile based e-learning content delivery and accessibility in higher learning institutions of Tanzania.

1.3.2 Specific objectives

a) To identify and analyse ICT for e-learning information needs and system design requirements.

b) To design and develop a mobile application for delivery of e-learning contents.

c) To test and validate the developed mobile application.

1.4 Research questions

1) What is required to develop a mobile application for accessing e-learning contents?

2) How can a mobile application for accessing e-learning contents be designed and developed?

3) How can a developed mobile application for delivery of e-learning contents be tested and validated?

1.5 Significance of the research

The study contributed to the provision of a better e-learning content delivery tools in higher learning institution of Tanzania by extending content delivery and availability through mobile computing devices. The solution favours HEIs with resource and bandwidth constrained environments by offering a cost-effective way of content delivery and accessibility. Also contribute to the body of knowledge in the field of Information and Communication Technologies (ICT) specifically on mobile technologies by proposing an application that can interact directly with the user in the learning domain. Similarly, the proposed system is potential for significant bandwidth usage cost savings due to less dependence on the Internet achieved by synchronizing learning contents from some remote servers to mobile devices for offline use; improving learning system performance by cutting down the servers' workload and internet usage overheads; cut down costs of purchasing and maintaining hardware to a particular institution due to fact that the contents will be synchronized and made available in devices owned by the learners and finally, increased motivation in learning activities by allowing learners to access learning contents anywhere and anytime without restriction of space and time. Furthermore, the study contributed to future research in the field of mobile technologies and learning by proposing future research problems.

1.6 Scope and focus of the study

This study reports on challenges facing e-learning in developing countries, Tanzania in particular and how the opportunities brought by mobile technologies can be explored to enhance e-learning particularly in resource and bandwidth constrained learning environments. This is significant because while owning ICT facilities is expensive for both public and private HEIs in Tanzania, the growth of mobile technology brings opportunities in the education sector to enhance

availability and accessibility of learning resources in a reliable, cost-effective, timely and increased motivation and participation of learners in learning activities. This study proposed a Mobile Based Learning Content Delivery System (Mobile-LCDS) to facilitate cost-effective mobile based e-learning content delivery and accessibility particularly in HEIs facing challenges of resource and bandwidth constraints. However, deployment of the proposed system to the intended HEIs, measuring the extent level of performance improvements and impact assessments was not covered by this study; therefore it was recommended for future studies.

1.7 Dissertation organization

This dissertation consists of five chapters. The rest of this dissertation is organized as follows; Chapter Two gives an overview of the ICT for e-learning in HEIs. It also presents the results from a survey conducted in this study. Chapter Three discusses the mobile-based system for cost-effective e-learning contents delivery and accessibility. It also presents the methodologies used to design and implement the system. Also the results of system design requirements and acceptance test were presented. Chapter Four covers the theoretical review of synchronization and caching approach for cost-effective e-learning in resource and bandwidth constrained learning environments. Chapter Five gives concluding remarks, where the final conclusion, main contribution, the work done so far and future works are explained.

CHAPTER TWO

ICTs for e-learning in Higher Education Institutions in Tanzania[1]

Abstract

The advancement in Information and Communication Technology (ICT) has brought new opportunities for learning. Tanzania is adopting the new technologies in Higher Education Institutions (HEIs) through e-learning and m-learning. However, delivery of learning contents is becoming a challenge for HEIs due to the constraints in resources and network bandwidth. This study discussed learners' perceptions of using e-learning applications and mobile devices for learning in HEIs in Tanzania. Findings show that the majority of the students owns more than one mobile device which can be used as a tool for facilitating the learning process. It is suggested that in order to improve e-learning content delivery and accessibility under limited resource settings, HEIs in developing countries should make an effective use of emerging mobile computing technologies which are relevant to their respective environments.

2.1 Introduction

Information and Communication Technology (ICT) has brought many opportunities in all sectors including education. The advance in e-learning and mobile technology has brought prospects for personalized and smart learning. While personalized learning is a blended approach for delivery of education both within and beyond the traditional classroom environment (Cachia *et al.*, 2010). Smart learning in this context refers to knowledge delivery and accessibility through the use of ICT tools at anytime and anywhere (i.e. Dynamic and mobility in content delivery). Sife *et al.*, (2007) argue that mobile technology is evolving at a rapid pace offering new capabilities for sustaining data transmission, storage, and sharing different multimedia formats that can be advantageous for the education sector. On the other side, ICTs enhance interactions among students, instructors, and information systems in ways that have never been possible before.

[1] Knowledge Management & E-Learning: An International Journal, Vol. 6, No.3

Applying ICT to the education sector is one of the national strategies to eradicate poverty in Tanzania (Lujara, 2008). The Government of Tanzania through the Ministry of Education and Vocational Training (MoEVT) recognizes the potential of ICT acting as a means of improving education delivery, outcomes and impact, as evidenced in the national plans, policies and strategies (TNIP, 2003; Mshangi, 2013). In 2008, there were two HEIs in Tanzania using digital learning applications: the University of Dar es Salaam (UDSM) and the Open University of Tanzania (OUT) (Swarts and Wachira, 2010). In 2012, Sokoine University of Agriculture (SUA) adopted Moodle as the free and open source software for learning management system, but only for ICT courses. Although students in Tanzania appreciate the use of ICT for support of their learning at anytime and anywhere, they are facing a number of challenges, including the cost of Internet services, poor interaction between students, their peers and instructors, inadequate computer skills, and lack of access to ICT facilities Mahai (2012). This study aimed to investigate the learners' perceptions of using e-learning applications and mobile devices for learning in three HEIs in Tanzania: SUA, OUT, and Nelson Mandela African Institution of Science and Technology (NM-AIST).

The rate of mobile phones adoption and access to Internet in Tanzania is generally growing at a rapid rate. As evidenced by Shah (2013), smart phone adoption in Tanzania has increased from 3% in 2010 to 9% in 2014 and even more in the coming years (Figure 3). Implementing m-learning in HEIs is possible because the students have already been using their mobile phones for other activities like mobile banking, mobile money (e.g. M-PESA, TIGO-PESA and AIRTEL MONEY), and social networking (Mtega, 2010; Ngugi, 2010).

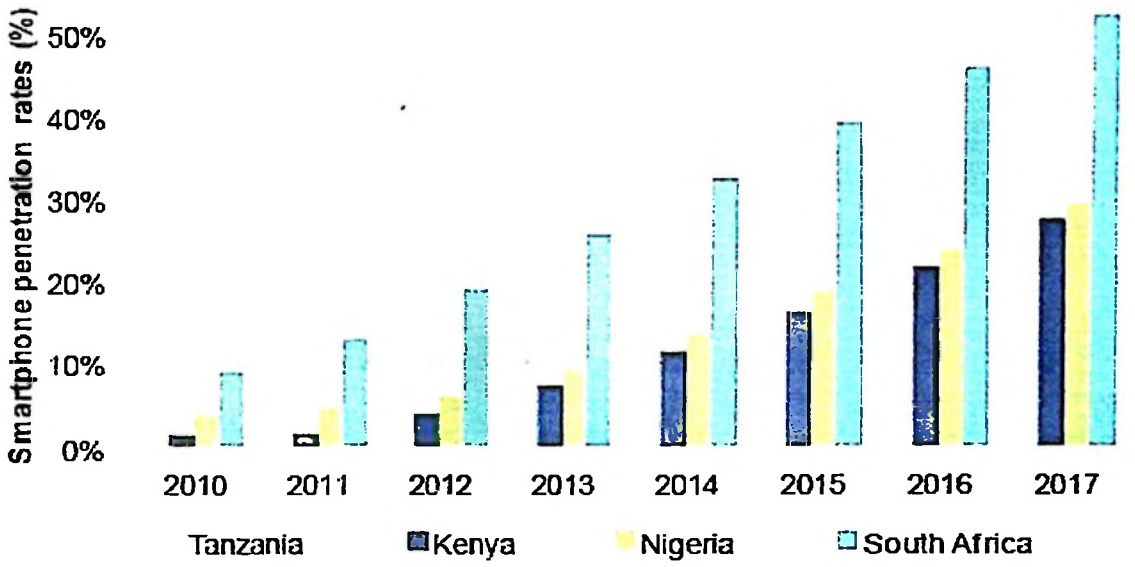


Figure 3: Smartphone adoption

Source: Strategy Analytics, Wireless Intelligence (2012)

However, Bakari *et al.*, (2010) commented that the learning and teaching processes in HEIs in Tanzanian are still performed mainly through the face-to-face mode. The adoption of modern ICTs such as computers, the Internet, mobile phones, IPAD, e-readers and personal digital assistants (PDAs) in education can significantly help to improve education service delivery together with the use of other ICTs such as radio and television. According to Tanzania Communications Regulatory Authority (TCRA) (2011) there were a total of 25.7 million mobile phone subscribers by June 2011. The rise in the use of these mobile computing devices, in particular mobile phones by students from HEIs, needs to be studied to understand how the mobile devices can provide a cost effective solution for teaching and learning. In particular, the solution needs to integrate face-to-face learning; e-learning and mobile learning (i.e. Blended learning) (Brown, 2010). The integrated solution provides opportunities to facilitate flexible learning through supporting online and mobile learning as shown in Figure 4.

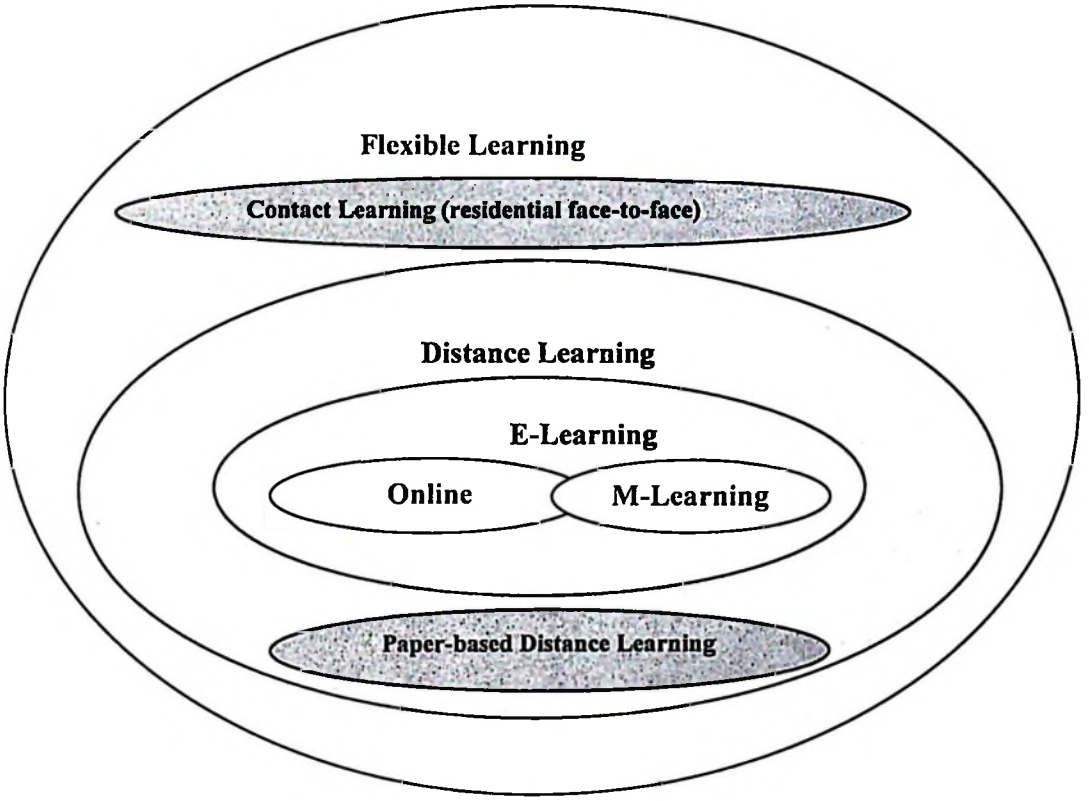


Figure 4: Integrated learning solution (Adapted from Brown, 2010)

2.1 Methods

This study was carried out in three HEIs in Tanzania namely: SUA, OUT and NM-AIST. All of these higher education institutions own basic ICT infrastructure such as Local Area Network (LAN), Internet, computers, and mobile technology that form the basis for the establishment of e-learning and m-learning. Therefore, the selected HEIs provided a good setting for study. The population for this study was made up of students, instructors, researchers and administrators from the HEIs. In addition, key informants such as students, researchers and IT personnel available in the institutions were effectively involved in this study in order to give their views on the researched problem.

2.1.1 Study design and sampling

Survey methodology was used to identify and assess ICT for e-learning. During the survey different methods, including interview, structured questionnaire and review of empirical literature were used. Respondents involved in the survey process included students, instructors, administrators and IT personnel responsible for ICT services in HEIs. The random sampling technique was used to determine the sample to represent the population under the study.

2.1.2 Data collection

The field work for the study was conducted from December 2013 to January 2014. Data was collected using a structured questionnaire. The structured questionnaire comprised of dichotomous items and closed ended questions whereby the respondents had to select the response they thought was most correct. The interview was conducted for ICT technical staff for each institution to generate a holistic view of the problem under study. Also, the interview was done in order to have opinions of the interviewee on how to improve learning content delivery and accessibility in HEIs.

2.1.3 Data analysis

Collected data were categorized into themes in relation to variables pertaining to the researched problem. To this end, whereby quantitative data were analysed using Statistical Package for Social Sciences (SPSS). In addition, descriptive statistics involved frequencies and percentages. Other qualitative data were analysed through content analysis in order to have more information which was important in the comparison of the data and making a generalization of the findings. Seemingly, ANOVA was used to compare the analysed continuous data to determine if there was a significant statistical difference between the results obtained from the three case studies. In addition, the Chi-square test was used to determine the statistic significant relationship between two categorical values within individual institution.

2.2 Results and discussions

2.2.1 Demographic characteristics of respondents

Demographic characteristics such as gender, level of education and designation were assessed. The characteristics provided an overview on the background information of the respondents, which in turn provided an overview about the appropriateness of the study population. Generally, the survey involved 202 respondents, among these, 145 (73.2%) were male and the remaining 57 (26.8%) were female. For individual institution, gender of the respondents involved in the survey is as shown in Figure 5

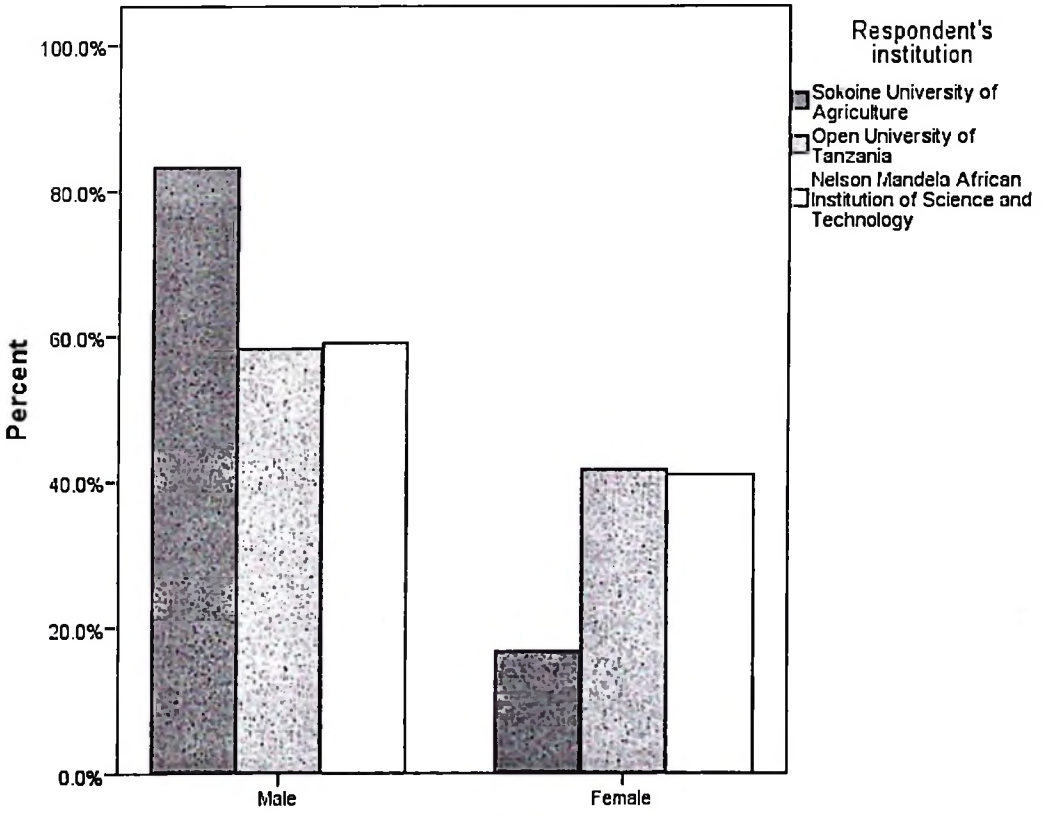


Figure 5: Gender of the respondents

Out of 202 respondents 164 (81.2%) were students, 35 (17.5%) were instructors and 3 (1.2%) were administrators. In the same vein, amongst 164 students, 47 (28.7%) were female and 117

(71.3%) were male. This implies that relatively few female students are enrolled to pursue science subjects in HEIs than male. Similar results were also observed by Sanga *et al.*, (2013). Furthermore, out of 164 students, 6 (3.7%) were diploma students, 110 (67.1%) were first degree students, 22 (26.8%) were master's students and 4 (2.4%) were PhD students. In light of the academic qualifications of the respondents, it was learnt that the higher of the qualification the higher acceptance of using ICT devices in teaching and learning process in the study institutions.

2.2.2 Applications supporting the delivery and accessibility of learning materials

In order to realize the applications that are used to support the delivery and accessing to learning materials in HEIs, a number of applications were assessed through multiple-response questions. Findings in Table 1 provide empirical evidence that, the HEIs employ Web 2.0 technologies such as social networking artifacts (e.g. YouTube, Facebook and Twitter), wikis, blogs and discussion forum in delivering and accessing learning contents. Moreover, the use of e-learning indicated by the respondents from SUA (65.9%), OUT (63.6%) and NM-AIST (42.1%) showed that they use e-learning platform for accessing learning contents. Also, it was revealed that students access YouTube, Twitter, Facebook and other social media tools on their mobile devices to do some learning activities in certain courses. However, findings indicated low rate of using mobile phones for mobile learning evidenced by 12.2% (SUA), 25.0% (OUT) and 23.7% (NM-AIST). These results reaffirm to the findings reported by Mtega *et al.*, (2014) that the level of usage of Web 2.0 tools for non-academic activities were higher than for academic purposes. Additionally, these findings concur with the study by Lwoga (2012) who established that the adoption of e-learning and Web 2.0 technologies is still in its infancy in Tanzania's public universities. However, there were much enthusiasm amongst respondents for developing the potential of e-learning and Web 2.0 tools (i.e. e-learning 2.0 or education 2.0) in their universities. Therefore,

this study remark issues in the current applications for learning contents delivery and accessibility. The recent integration of social media (web 2.0) to e-learning has created a new term called e-learning 2.0 or education 2.0 (Silius *et al.*, 2010; Lwoga, 2012). On the other hand, the advantage of embedding social network artifacts of e-learning is to promote new forms of learning. This includes: inquiry-based and exploratory learning; new forms of communication and collaboration; new forms of creativity, co-creation and production; and richer contextualization of learning. The learning and teaching approaches adopted when social network artifacts are fused into e-learning result into problem-based, reflective, constructivist, collaborative, experiential and participatory (Tlhapane and Simelane, 2010).

Table 1: Applications used for learning materials delivery and accessibility

S/N	Applications	SUA n = 102		OUT n = 54		NM-AIST n = 46	
		freq	%	freq	%	freq	%
1	YouTube	69	68.3	35	65.9	37	81.6
2	Facebook	24	24.4	22	40.9	24	52.6
3	Twitter	64	63.4	29	54.5	27	60.5
4	Wikis	57	56.1	25	47.7	20	44.7
5	Skype	24	24.4	19	36.4	35	76.3
6	Discussion forum	73	72.0	28	52.3	38	84.2
7	E-learning platform	67	65.9	34	63.6	19	42.1
8	Mobile learning platform	12	12.2	13	25.0	10	23.7

The findings presented in Table 1 also agree with the previous study conducted by Reuben (2010) which found that social media offers great opportunity among instructors and continuing students for keeping in touch with alumni after they graduate. Also, social media gives institutional management and staff the opportunity to harmonize stories of students and alumni of their institutions, which can create trustworthiness and bring in future business and eventually

add value to the discussion forum. Moreover, finding from this study agrees with the study conducted by Mtega (2012) which remarked that most of the mobile Web 2.0 applications can in one way or another be adopted in teaching and learning process. Furthermore, Web 2.0 supports constructivist approaches to learning with great potential to socialize online learning by providing technologies that foster interactive, collaborative, and participative roles of instructors and learners.

2.2.3 Learners' perceptions of e-learning content delivery and accessibility

This section presents the learners' perceptions of e-learning contents delivery and accessibility using existing e-learning systems/applications. Learners' perception was evaluated in terms of cost of bandwidth connection and usage, access to learning content during offline period, satisfaction of learners, performance and portability, depending on internet connection, the ability to share data and manage learning content. Figure 6 presents learners' perceptions of e-learning contents delivery and accessibility rated in percentages (%) based on the responses from respondents. Learners' perceptions were analysed to test a significant relationship between limiting factors and the quality of delivering learning content. Findings show that there is the statistical significant relationship between the quality of the media used for learning process and the satisfaction of the learner in learning process ($p \leq 0.05$). However, it was noted that there is no statistical significant relationship between dependence on the Internet of the devices used to access learning contents and the quality of learning content delivered ($p=0.294$). Likewise, there is no statistical significant relationship between accessibility of learning contents during the offline period and the quality of the content accessed ($p=0.372$). Furthermore, there is no significant relationship between reliability and portability of the media used to access learning contents and the quality of learning contents delivered ($p=0.619$).

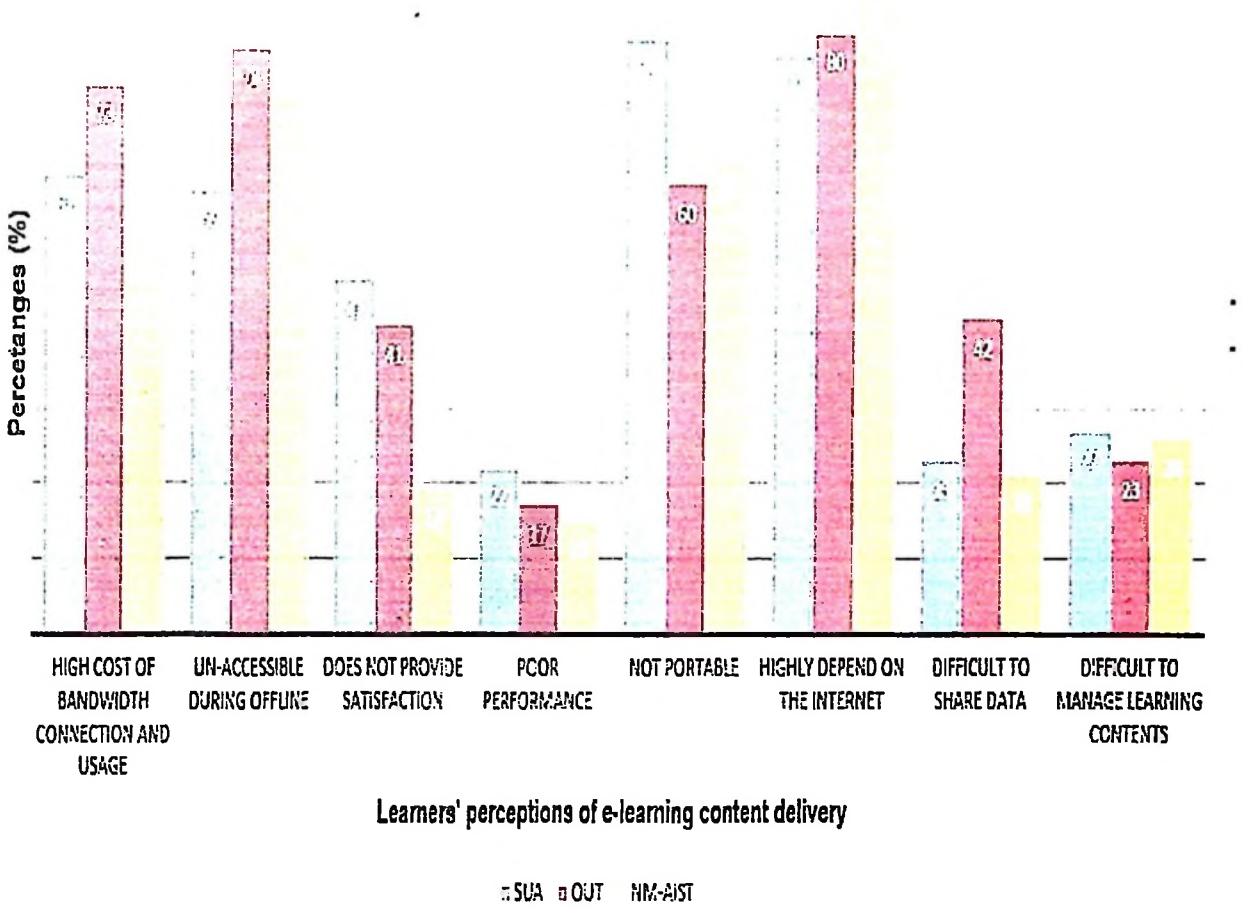


Figure 6: Learners' perceptions of e-learning content delivery and accessibility

Findings presented in Figure 6 agrees with the previous studies (Milovanovic, 2010; Trifonova, 2006; Swarts and Wachira, 2010; Suhail and Lubega, 2011) which pinpointed that delivery and accessibility of learning contents in HEIs for web based learning systems is affected by issues such as: cost of bandwidth connection and usage, need for continuous internet connection for web-based system, limited mobility and portability features, un-accessibility of e-learning contents during the offline period and shortage of ICT facilities (hardware and software).

However, during interview and desk review of existing e-learning systems, it was revealed that the majority of the challenges is caused by highly dependent on the Internet connection, increased number of users that lead to decreased system performance for automated/semi-automated learning systems, constraints in resources and network bandwidth and high cost of internet services.

Furthermore, the majority of respondents in focus group advocated the use of free and open source software (FOSS) to support content authoring, content development, content dissemination, discussion forum and other functionalities in their mobile. This is similar to other studies which advocated the adoption of FOSS in e-learning to lower cost because there is no associated cost for procuring software and paying license (Sanga *et al.*, 2006). However, the operational and maintenance cost of FOSS in e-learning might be high due to fact that it highly depends on the Internet connection. The adoption of FOSS in e-learning has cost implication in terms of funds for acquiring and maintenance of hardware and Internet connectivity. While owning and maintaining the ICT infrastructure for the university community has many challenges, the growth of mobile phones brings new opportunities for universities for educational purposes.

2.2.4 Mobile computing/communication device ownership

The exponential growth worldwide of consumers in electronic devices such as personal computers, cell phones, Smartphones and other electronic devices, has increased the opportunity for mobile computing device ownership (Lalita, 2011). Mobile computing/communication device ownership was analysed to determine whether there was a statistical significant difference in ownership among the three institutions. Results presented in Figure 7 provide empirical evidence that there is a statistical significant difference in smartphone ownership among the

three institutions ($p \leq 0.05$). However, there is no statistical significant difference of cell phone ownership among the three institutions ($p = 0.917$). Similarly, there is no statistical significant difference of laptop ownership among the three institutions ($p = 0.097$). Furthermore, it was found that 17% (NM-AIST) and 11% (SUA) own MP3 player, 15% (NM-AIST) and 19% (SUA) own E-book readers and 19% from OUT owns handheld games.

The findings from this study are promising indicators for universities to adopt mobile technologies for enhancement of learning contents delivery and accessibility in a cost-effective way rather than concentrating on the web based learning only which is costly. The trends of mobile computing device ownership give a favourable and enabling environment for HEIs to deploy blended m-learning for enhancing learning content delivery and accessibility (Muyinda *et al.*, 2011). The results presented in Figure 7 involved only students who assessed the extent to which students own mobile computing device and that can be used for educational purpose.

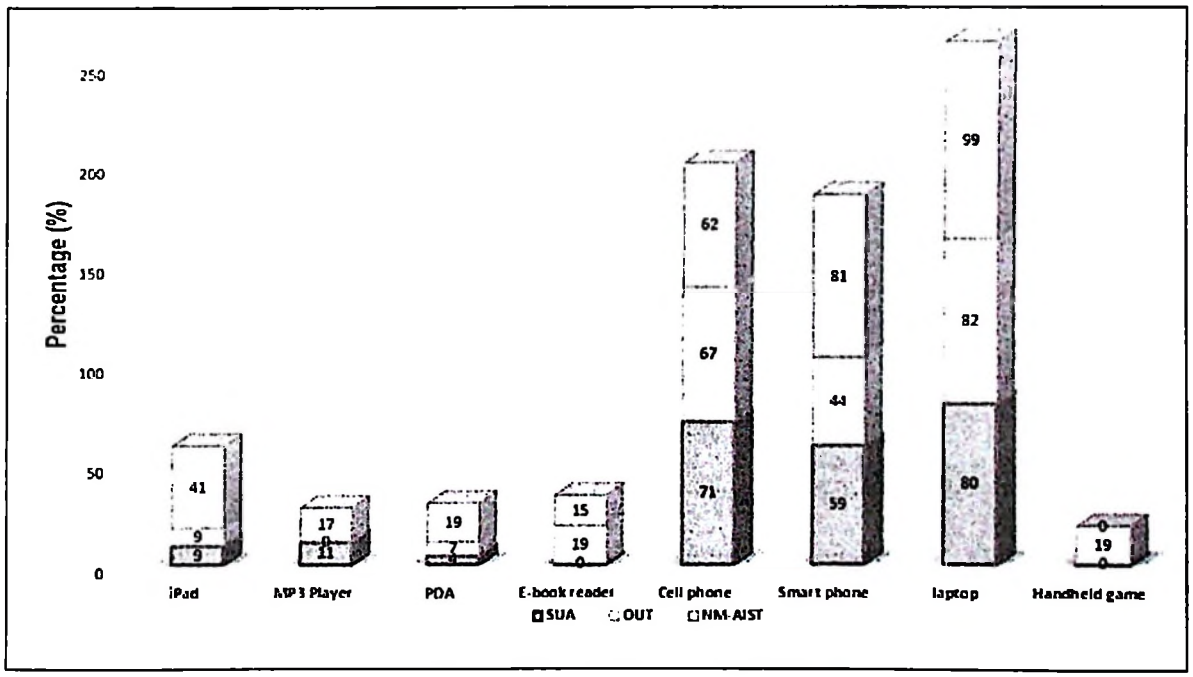


Figure 7: Mobile computing device ownership

2.2.5 Learning activities supported by mobile devices

In order to evaluate the extent to which mobile technologies had improved access to education in HEIs of Tanzania, the respondents were presented with mobile computing/communication activities related to education in which they always engage in. These mobile computing/communication activities were evaluated for each respondent selected in this study from the institutions. The results presented in Table 2 involved only students assessing the extent to which they use mobile computing devices for learning activities.

Table 2: Learning activities supported by mobile devices

S/N	Activities	SUA n=82		OUT n=44		NM-AIST n=38	
		Freq.	%	Freq.	%	Freq.	%
1	Download and listen to audio academic materials	52	63.4	28	63.6	28	73.7
2	Download and view movies/video clips	58	70.7	20	45.5	24	63.2
3	Send and receive text messages	76	92.7	36	81.8	30	78.9
4	Download and read e-books	72	87.8	32	72.7	30	78.9
5	Downloading and reading scholarly materials	78	95.1	40	90.9	36	94.6
6	Transfer files from one place to another	74	90.2	36	81.8	22	52.7
7	Play interactive games via Internet on handling game console	22	26.8	12	27.3	16	42.1
8	Transfer photos or other data via smart phones	58	70.7	28	63.6	32	84.2
9	Send and receive email	30	36.6	20	45.5	31	81.6
10	Collecting data	78	95.1	36	81.8	34	89.4

The findings provide evidence that students are already using mobile computing devices for learning activities as presented in Table 2. This study found that 52.4% of mobile computing device users do use the devices for downloading online resources; 54.9% acknowledged that they

use the devices for viewing movies through YouTube; 76.8% use the devices to send and receive text messages; 70.7% for downloading and reading e-books; 82.9% for sending and receiving emails; 56.1% for transferring files from one place to another; 93.9% for downloading and reading scholarly materials; 24.4% for playing interactive games; 88.6% for data collection purpose and 59.8% used mobile computing devices for sharing data via application installed in Smartphone like WhatsApp, Google Drive and many others. Therefore, the results provided the indicative possibility of implementing m-learning in HEIs in Tanzania. These findings support the study by Cortez and Yueh who argues that mobile technology is constantly evolving and offering new capabilities for supporting higher data transmission, storage, and multimedia formats that can be beneficial for education (Cortez, 2012; Yueh *et al.*, 2012). In addition, the findings confirm the previous study by Barcelos and Tarouco (2010) which observed that the use of mobile devices improved the availability and accessibility to the learning content, which enhances the motivation and learning opportunity for students. Furthermore, these findings agree with the study conducted by Lai (2011) and Zhao and Jiao (2012) which suggested that the use of digital technologies such as podcast could improve the quality of the learning experiences if they are used as a participatory communicative tool to support collaboration and construction of knowledge.

2.3 Conclusion and recommendations

Even though, the study found that the development in ICTs offers great prospects for universities in third world countries to improve the delivery and accessibility of learning contents as it was established that 85% of students owns laptops, 65% owns smartphones and 78% of students owns mobile phones. In the same vein, the majority of universities in Tanzania own basic ICT infrastructure such as Local Area Network (LAN), Internet, computers, and mobile technology that form the basis for the establishment of e-learning. However, the findings provide evidence

that the rate of adoption of m-learning in HEIs of Tanzania is very low. Seemingly, it has been observed that the majority of HEIs in Tanzania does not utilize fully the opportunity brought by ICT for e-learning due to resource and network bandwidth constrained environments. In this regard, it has been argued by Bon (2007) that efficient access to learning contents depends on the quality of the connectivity and the media used for delivery and accessibility. On the other hand, it had been mentioned that the cost of bandwidth (connection and usage charges), limited mobility and portability features in e-learning systems, shortage of ICT facilities (hardware and software) and un-accessibility of e-learning contents during the offline period are major barriers for effective and efficient use of e-learning in Tanzania. Furthermore, it had been reported that the offline period, which occurs for different reasons including power outage, shortage of infrastructure and Internet disconnection. Sometimes, the available Internet connections are too expensive for the user as a result it affects efficient access to educational opportunities. This is true for institutions which are using very small aperture terminal (VSAT) technologies for Internet connectivity.

It was also noted that even if majority of respondents acknowledged that they own and use mobile computing/communication devices for doing some learning activities like downloading and reading e-books and scholarly materials. But there are other HEIs that have adopted e-learning which is not fully operational due to resources, the network bandwidth constraints and financial constraints. In Tanzania, learning and teaching process in HEIs is still mainly done through talk and chalk mode. However, the mentioned mobile computing/communication activities demonstrate great opportunity brought by mobile technology for offering new capabilities in supporting higher data transmission, storage, and multimedia formats in HEIs.

2.3.1 Recommendations

An integrated approach that combines face to face learning and e-learning in a blended manner is

recommended by this study. Currently, there is no an ICT policy at the level of a nation as well as HEIs on how mobile computing devices/ technologies can be used for learning and teaching. There is a need to formulate a national ICT policy to guide the adoption of ICTs in the educational sector. This study suggests that in order to improve the e-learning content delivery and accessibility under limited resource settings, universities in developing countries, Tanzania in particular, should make an effective use of emerging mobile computing technologies which are relevant to their respective environments. A critical successful implementation of a blended m-learning requires a strategic approach which should be owned by the university community and other stakeholders. The approach should take into account significant issues, including pedagogy, mobile infrastructure and appropriate mobile content authoring technologies, human resources, m-learning policy, and capacity building for staff and students, and integration of e-learning, m-learning and digital literacy into HEI's curricula.

CHAPTER THREE

Mobile-based system for cost-effective learning contents delivery and accessibility[2]

Abstract

The advancement in Information and Communication Technologies (ICTs) has brought opportunities for new ways of learning in Higher Education Institutions (HEIs) through e-learning systems. While these opportunities exist, e-learning content delivery and accessibility in third world countries like Tanzania is still a challenge due to resource and network constrained environments. The challenges include: high cost of bandwidth connection and usage; high dependency on the Internet; limited mobility and portability features; inaccessibility during the offline period and shortage of ICT facilities. So there is a need for a technology to bridge these gaps. This study explores the opportunities brought by mobile technologies to find out a cost-effective solution for e-learning content delivery and accessibility in HEIs of Tanzania. Specifically, the study proposes a Cost-effective Mobile Based Learning Content Delivery approach for resource and network constrained environments. The proposed solution has the potential to reduce the cost of bandwidth usage, and cut down server's workload and Internet usage overhead by synchronizing contents from some remote server to a local database in the user's device for offline use. It will also improve the quality of experience and participation of learners as well as facilitate mobility and portability in learning activities.

3.1 Background information

Higher learning institutions (HEIs) require a cost-effective and efficient system for delivery and accessibility of learning contents which favours personalized and innovative learning while minimizing the development and operation cost. However, it has been reported by Bakari *et al.*, (2010) that persistent internet connectivity in third world countries is still a major challenge for both public and private HEIs.

There are existing Learning Management Systems (LMS), such as Moodle, which are adopted by the majority of HEIs in developing countries. Moodle is a web-based LMS which highly depends on the Internet for high performance and reliability. Despite the great opportunity brought about

[2] Proceeding of Pan African International Conference on Information Science, Computing and Telecommunications (2014), 165-170.

by Moodle and other LMSs; learning content delivery and accessibility are still challenges in developing countries due to the constrain in resources and bandwidth (Milovanovic, 2010; Trifonova, 2004,2006; and Jayakumar *et al.*, 2013). These challenges include high cost of bandwidth usage; limited mobility and portability features; un-accessibility of e-learning contents during the offline period; server workloads and Internet usage overhead. Therefore, there is a need for a technology to bridge these gaps. Adaptation of mobile technologies is growing at a rapid pace, bringing along a lot of opportunities that can enhance contents delivery and accessibility for HEIs within resource and network constrained environments. During survey, it was found that majority of HEIs in Tanzania own basic ICT infrastructures such as Local Area Network (LAN), Internet, computers, and mobile technology that form the basis for the establishment of e-learning. Furthermore, it was found that the majority of students owns more than one mobile device which can be used as a vehicle to facilitate access to learning contents. This study explores opportunities brought by mobile technologies to find out a cost-effective solution for e-learning content delivery and accessibility for HEIs in resource constrained environments.

Previous studies (Momo, 2008; MLE, 2009) proposed Mobile Moodle (Momo) and Mobile Learning Engine (MLE). Both applications are based on J2ME, while the MLE project developed a client application and an additional web version to access Moodle courses from mobile browsers. However, the structure of XML schema used in MLE caused problems such as high memory requirement and delay in response time. Jordi *et al.*, (2012) proposed Moodbile; the android application that supports both online and offline accessibility by storing offline contents in memory cache. However, synchronization functionality was not implemented. The proposed systems require continuous and reliable Internet connection during downloading of

contents to memory cache as a result, they favour learning environments with sufficient resources and reliable Internet connectivity. Lujara (2008) proposed Compact Disk Read Only Memory (CD-ROM) for offline delivery; however the proposed solution cannot accommodate the needs due to the rapid growth of the amount of information and increased the number of e-learning users. Furthermore, client-side proxy architecture for supporting offline use of learning contents and bracing approach for increasing web server performance was proposed (Trifonova, 2006; Makker and Rathy, 2011). However, pre-fetching and caching of contents to local memory were done automatically by the system owing to the filling of the cache with documents without any prior knowledge of the user. For third world countries, taking Tanzania as an example; the extension of learning content delivery to mobile computing devices and implementation of cost-effective solutions for HEIs within resource and bandwidth constrained environments is still an open research topic.

This study proposes a Cost-effective Mobile Based Learning Content Delivery approach for HEIs facing the constraints in resource and network bandwidth. The proposed system is significant for enhancing availability and accessibility of learning resources in a reliable, cost-effective and timely manner. In the end, the proposed approach intends to improve the quality and participation of learners as well as facilitating mobility and portability in learning activities.

3.2 Methodology

This study was conducted in Higher Education Institution (HEIs) in Tanzania. The system design requirements were gathered in three HEIs where different techniques and methods for requirement gathering were employed, including interview, rapid prototyping and review of empirical literatures were used.

3.2.1 Software development life cycle (SDLC)

A software development process is often described in terms of a set of activities needed to transform a user's requirements into a software system. At the highest level of abstraction, a development process is sometimes called development life cycle, one of the model used is an evolution development model which includes *exploratory development* and *rapid prototyping*. The major advantage of this model is its flexibility that is; the ability to accommodate changes. Due to facts that customer needs are dynamic they keep changing, thus evolutionary development model can accommodate changes by adding features to the system as proposed by users as the needs arises. Furthermore, due to time limitation, this study will develop the initial version of software which can be evolved to higher versions by other researchers through adding new features. The evolution development model will best support development of higher version.

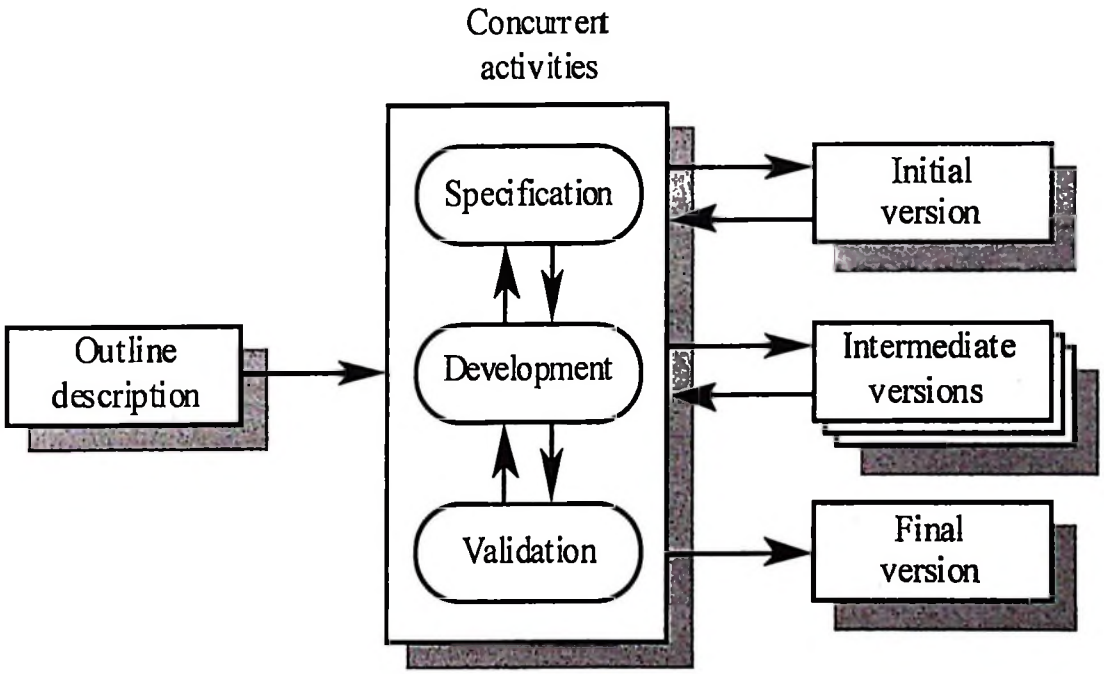


Figure 8: Evolutionary development model

SOURCE: National Physical Laboratory (2005)

3.2.2 Tools and technologies used

The proposed system consists of two main parts; the backend and the front-end. The backend consists of a database management system and a web server. This part of the system enables system administrators and other users to get access to the collected learning contents. The implementation of the backend uses open source relational database management system (MySQL) for main storage of learning contents and server side-scripting language (PHP). The front-end part is the mobile application running on Android mobile operating systems deployed in user's mobile computing devices (smartphone, PDA). This part of the system is used for accessing learning contents. The SQLite database is used for persistent temporary storage of learning content that can be accessible during the offline period. HTTP Protocol is used to manage communication between client and server. The applications for Android are developed in the Java Programming Language and executed in a Virtual Machine (VM) called Dalvik VM. Android Software Development Kit (SDK) used to provide the API libraries and developer tools necessary to build, test, and debug Android Apps. Android is a Linux-based, open-source operating system designed for use on smart phones, e-readers, tablet personal computers, and other mobile computing devices (Rogers *et al.*, 2009). The choice of these technologies based on the fact that, the system developed using these technology is easy to use (with user-friendly interface), easy to manage and maintain, widely used and available.

3.3 Design requirements

Portable computing/communication devices are essential for mobile based e-learning content delivery and accessibility in HEIs. The most significant feature in the mobile environment is mobility itself. It assists users to be in connection while being outside the reach of conventional communication spaces. In the context of learning environments, mobility can be conceptualized in terms of ability to access learning contents anytime, anywhere without the restriction of time

and space. The significant design requirement for the proposed system is the synchronization of learning content from some remote server to a local database (mobile database) to fulfil the following purposes:

i. Extend learning content delivery and accessibility to mobile computing devices;
ii. Synchronize learning content to the mobile devices;
iii. Reduce the cost of bandwidth usage;
iv. Enable offline access to learning content;
v. Enable ubiquitous access to learning content anywhere, anytime without the restriction of time and space;
vi. Reduce internet usage overhead and servers' workload;
vii. Improve the quality and participation of learners in learning activities.

3.4 System Architecture

Figure 9 presents the proposed system architecture. The proposed system consists of two main parts; the backend and the front-end. The backend consist of the data access layer and data storage layer, and the front-end consists of the presentation layer. The details are as follows:

a) **Presentation layer**: This is the topmost layer of the application that provide the interface between the user and the system. It consist of the following building blocks:

i. *Mobile application interface*: The front-end part is the mobile application running on Android mobile operating systems deployed on the user's mobile computing device. The mobile application interface is used for accessing learning contents;
ii. *Persistent temporary storage*: SQLite database is used for storing synchronized learning contents for offline use;
iii. *HTTP connection Manager*: The purpose of an HTTP connection manager is to serve as a factory for new HTTP connections, to manage the life cycle of persistent

connections and to synchronize access to persistent connections making sure that only one thread can have access to a connection at a time;

iv. *Synchronize and cache*: It synchronizes learning content from some remote servers and store locally on mobile devices for offline use;

v. *Web interface*: Serves the purpose of user management, uploading and updating learning contents;

b) **Data access layer**: The purpose of data access layer is to control an application's functionality by performing detailed processing. This layer coordinates the application processes commands and makes logical decisions. It moves and processes data between the presentation layer and data layer. Thus the data access layer is the implementation of a web server which can be done by the apache server to serve the purpose of content management.

c) **Data storage layer**: This layer consists of database servers that form the main storage. This layer keeps data neutral and independent from application servers or business logic.

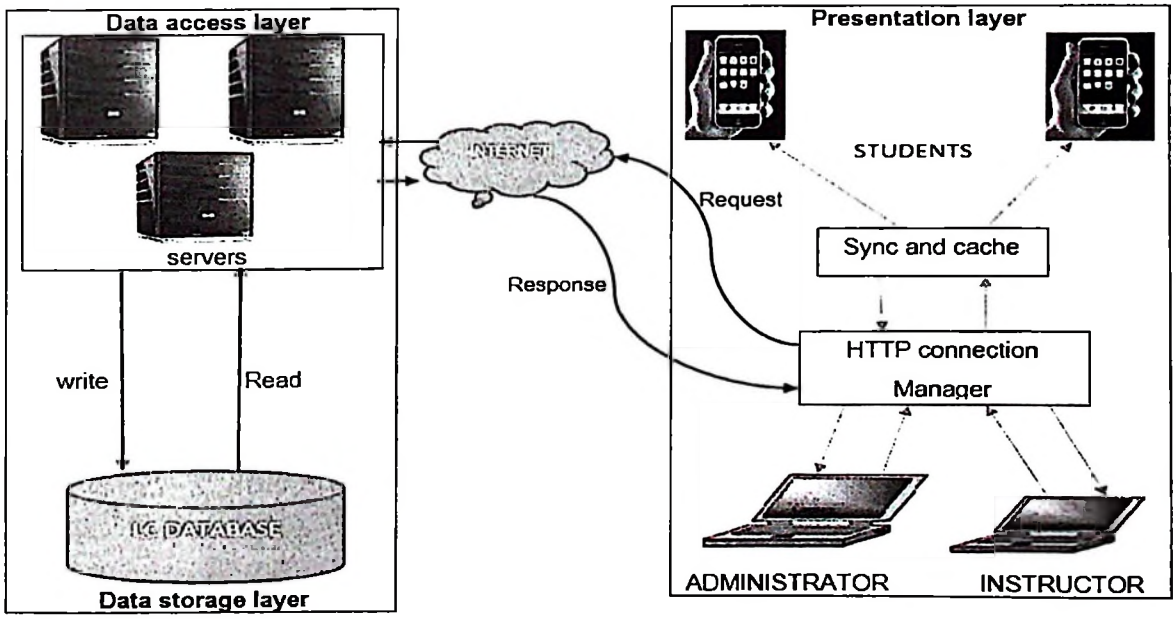


Figure 9: Mobile-LCDS system architecture

When the proposed system; that is Mobile Based Learning Content Delivery System (Mobile-LCDS) is installed in users' access devices; it will provide the mobile with a user interface to interact with the system and persistent storage for temporary storage of synchronized contents. When a user makes a request; the Application Programming Interface (API) accepts the request by GET or POST methods; then it interacts with PHP classes to get data from database or store data into database; and finally return the output to the requesting user/device in a JSON/XML format which is human-readable. The user can synchronize contents from the remote database when internet is available; the persistent storage stores synchronized content locally in mobile device for offline use.

3.4.1 Synchronization and caching

This part discusses an alternative approach (synchronize and cache) for learning content delivery and accessibility without highly depending on the Internet. The advancement in mobile application provides an opportunity of being able to work offline. Synchronization for data-driven applications means that a subset of the application data can be stored locally in the access device and data synchronization mechanism is implemented to keep the local database and server data (main storage) in a synchronized state. Cache means temporary storage of synchronized data. The goal is to find an efficient and cost-effective approach for learning content delivery in HEIs with resource and network constrained environments.

Without the synchronization and caching policy the user accesses content from the main storage and will need a continuous internet connection which is costly in terms of bandwidth connection and usage. Also, it takes long time to access content from the main storage due to fact that it highly depends on the Internet, as a result it is affected by the following factors:

i. *Web server's Performance*: Different web servers types used for hosting content, depending on its technical specifications, could have different processing power. For example, web servers configured with high-powered central processing units and huge amounts of memory would have superior processing capability, compared to those that are insignificantly configured. Also servers could still be overloaded when the number of concurrent accesses exceeds the webserver's capability;

ii. *Location of web servers*: Typically, web servers are hosted on the backbone of networks to facilitate the delivery of content. On the occasion where the web server is hosted on a remote site (for security/ management purposes), a leased line connection is required for a network service provider. In this case, the provided bandwidth of the leased line becomes the bottleneck if users are demanding more bandwidth than available capacity;

iii. *Firewalls and Security*: Where security features are installed in a network, the investigation and filtering of packets with every additional layer of firewall may decrease effective throughput of the system;

iv. *Internet speed*: The internet speed can vary depending on the differing expectations of speed of download and access of various end-users hence causing some delay in contents delivery;

The majority of HEIs in third world countries like Tanzania face the challenge of resource and network bandwidth constraints as a result delivery and accessibility of learning contents using internet based learning system become a challenge. Contents synchronization and caching is an alternative approach for content delivery and accessibility without heavily depending on the internet connection. For the contents that have been synchronized and stored locally in access device for future use, every time a user needs such contents, is able to access it offline from

temporary storage. The storage capacity of most mobile computing devices is large enough to store huge amount of data. It has been reported by Randell (2013) that, Apple's reasonably priced iPhone, the 5c, is the most generous of the 16GB phones recently tested, giving the user 12.6GB of memory (79% of the total space) unused space. Also, Google's new Nexus 5, which runs on the Android operating system like the S4, offers relatively free 12.28GB (77%) of usable space, the iPhone 5s provide 12.2GB (76%) of usable storage, The Samsung Galaxy S4 has just 8.56 GB and others have reasonable memory space that can allow storage large amount of data. This is a promising indicative possibility for storing huge amount of data locally in mobile computing devices. This study employs the opportunity brought by android built-in SQLite database for temporary storage of synchronized contents. However, the memory size of the phone will limit how much data can be retrieved from a query.

With synchronization and caching policy the proposed system (Mobile-LCDS) would support offline accessibility of learning content. When the Internet is available; the system synchronizes the subset of contents stored in permanent storage or remote server to a local database where they can be used offline. Therefore the proposed system reduces the access time since no delay due to independence of internet connection; cuts down the cost of bandwidth connection and usage: alleviates servers' workload and internet usage overhead; and improves the quality of experience and participation of learners in learning activities.

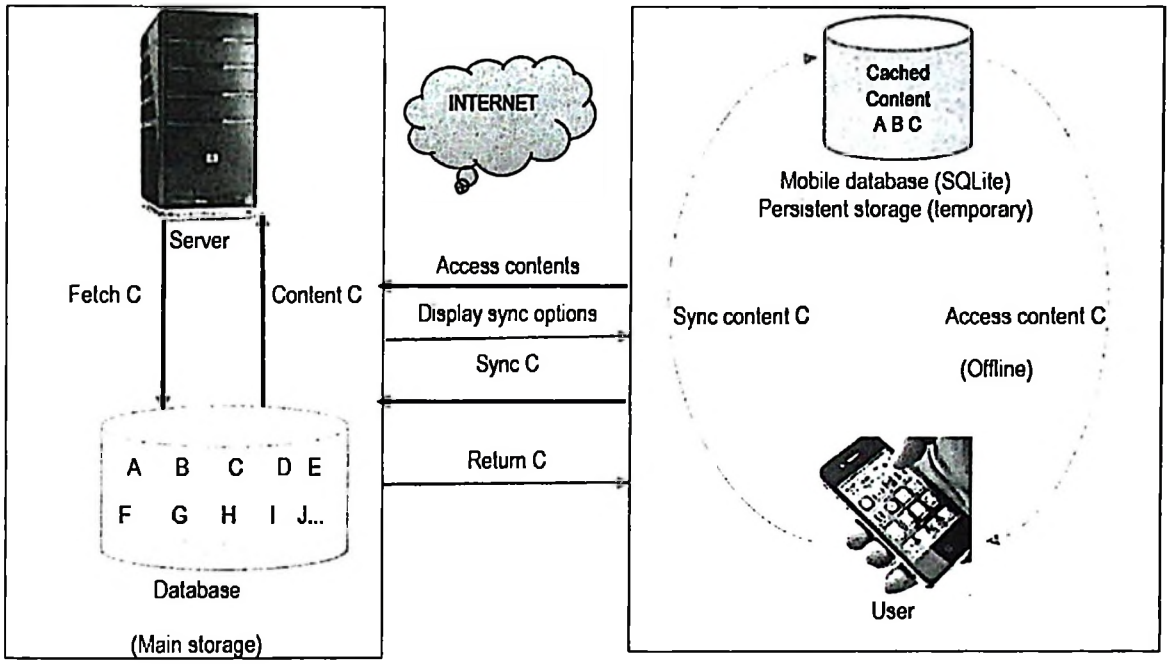


Figure 10: Contents sync and caching

3.4.2 Use case modelling

A use case model shows a view of the system from the user perspective, thus describing *what* a system does without describing *how* the system does it. A use case provides developers with a view of what the users want (Kendall K. and Kendall J, 2011). It describes a function provided by the system that yields a visible result to the actors. An actor describes an entity that interacts with the system. The actor can be either a human or a computer interaction. The use case diagram model was preferred in this study because it demonstrates the user's view of the system. The model gathers design requirements of the system and shows the interaction between the actors (users of the system) and the system itself. The system consists of three actors; Student, Instructor and the System administrator with the role of each actor shown in Figure 11.

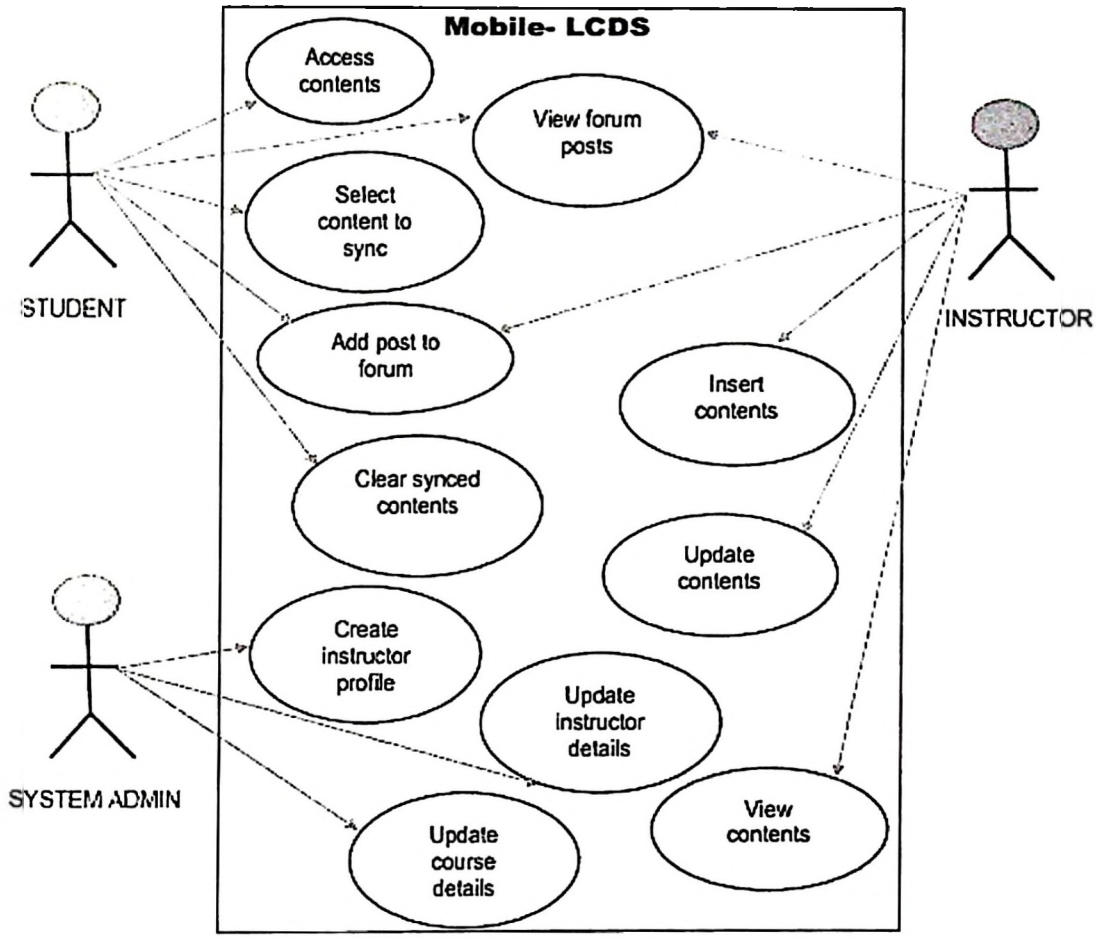


Figure 11: Mobile-LCDS use case diagram

3.4.3 Mobile-LCDS data flow sequence

A data flow diagram (DFDs) is a structured analysis technique used to put together a graphical representation of data processes that a Mobile-LCDS comprises. The DFD level-0 represents the system's major processes within the context process, data flows and data stores at a high level of detail. It is the decomposition of the context diagram. The major processes in the DFD level-0 represent the major functions of the Mobile-LCDS.

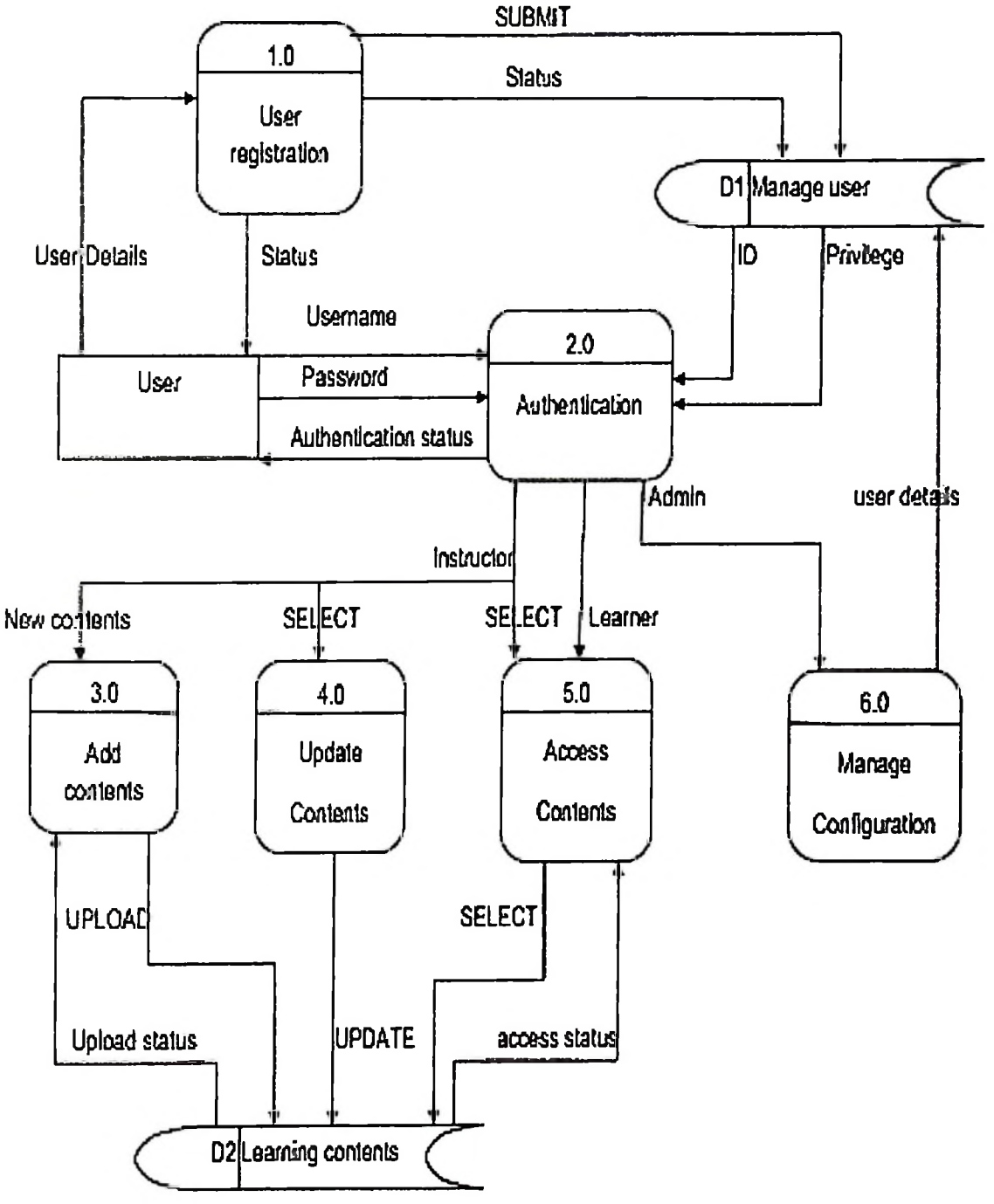


Figure 12: Mobile-LCDS data flow diagram level 0

The details of Mobile-LCDS DFD-level 0 descriptions are shown in table 3

Table 3: Mobile-LCDS DFD-level 0 description

PNO	PROCESS	FUNCTIONAL REQUIREMENTS	TASKS	EXTERNAL ENTITIES
1.	User Registration	Register user	Accept user details, process captured data and send to manage user data store for storage	Every user
2.	Authenticatio n	Authenticate user	To verify username and password	Every user
3.	Add contents	Insert new contents	To verify the format of the uploaded file and send it to learning content data store for storage	Instructor
4.	Update contents	Delete/edit contents	To modify the contents stored in the system	Instructor
5.	View contents	View contents	To view the learning contents	Learner
6.	Manage configuration	Configure user settings	To manage user settings and system configurations	System administrator

3.4.4 Interface and different components of the system

Figure 13 presents the interface and system components for the mobile client application for users with preference and intentions of synchronizing the required contents for working offline in future. The application presents to user sync options based on user needs and preference. The system allows a user to sync learning content in a semester basis, yearly basis or sync all contents – depending on the device's storage capacity. The sync options are significant for allowing user to sync only required contents as a result, it avoids filling the local database (cache) with unnecessary contents. Synchronizing learning contents locally in mobile devices has

several advantages, including reducing the cost of bandwidth connection and usage; ability to access learning contents anywhere, anytime without the restriction of time and space; reduction of the internet usage overhead and servers' workload; and speedy and smooth access to learning content due to the fact that all required contents will be available in mobile device –thus the user does not need to re-connect to the internet.

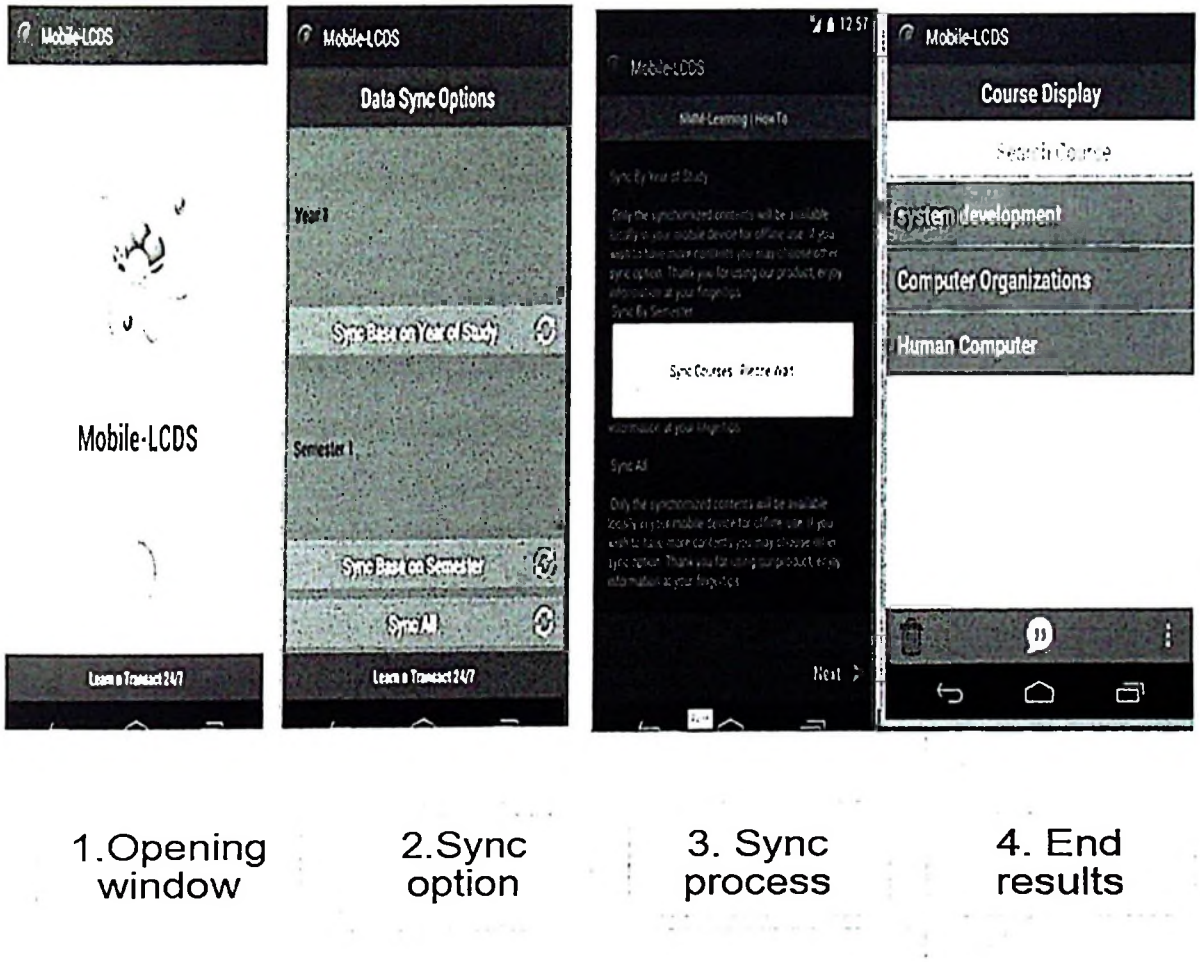


Figure 13: Interface and system components

Figure 14 presents Mobile-LCDS student forum. Student forum is an important feature to improve the collaboration and student participation in learning activities. Student forum

implemented in order to improve the quality of experience and participation of learners in learning activities; encourage collaboration among students and instructors using messages and discussion forum regardless of their physical location. It helps student interact and share Information like assignment resources, problems faced in the field, tutorials and innovation ideas.

Student Forum allows users to;

i. View other students Posts to the forum;

ii. Add his/her own post to the forum;

iii. Refresh to get recently added posts to the forum;

Contents synchronized can be cleared out to free memory space in order to accommodate more data (Figure 15)

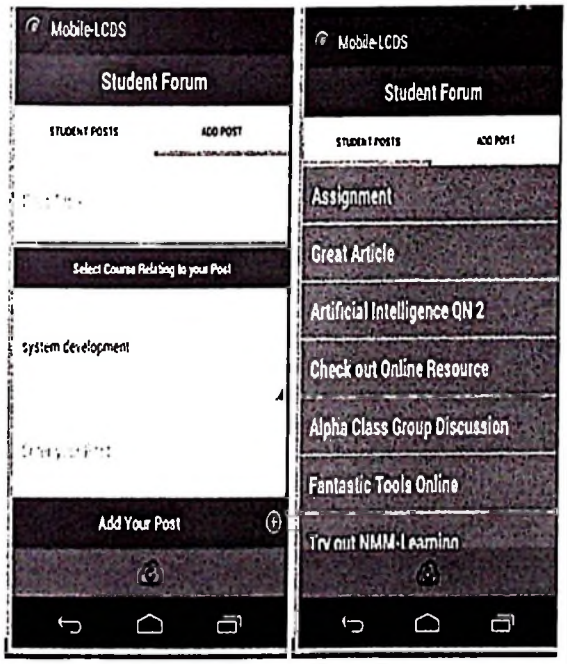


Figure 14: Mobile-LCDS Student Forum

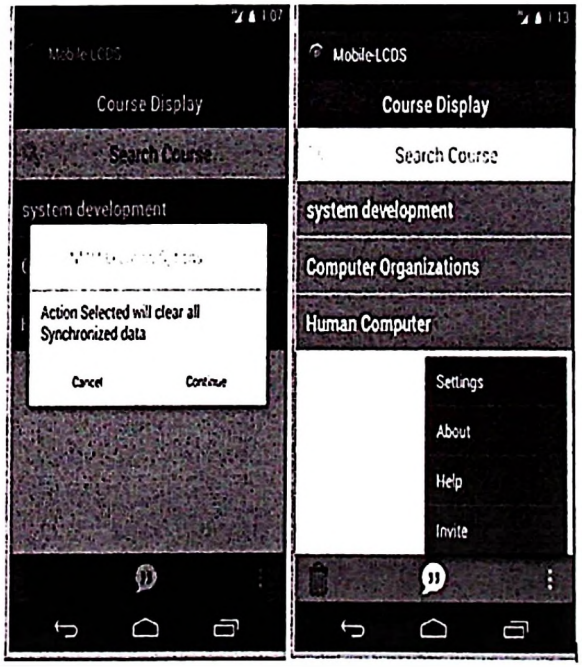


Figure 15: More operation on syncing data

The proposed system also comprises of web-interface components to be used by system administrators for managing users of the system and instructors for uploading and updating learning contents.

The system admin can perform the following actions after login to the system;

i. Create a new instructor profile;
ii. View, edit and delete instructors;
iii. Edit course details;
iv. Change password;
v. Logout ;

The instructor can perform the following actions after login to the system

i. Insert course details;
ii. View students' feedback;
iii. Edit course details;
iv. Change password;
v. Logout;

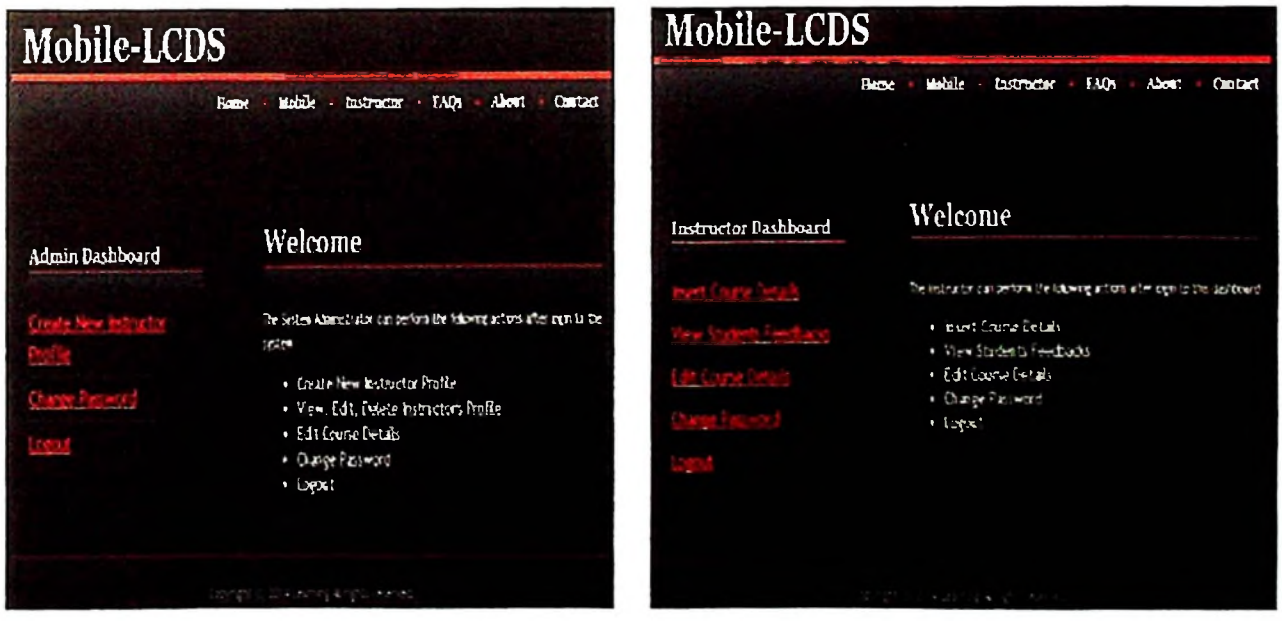
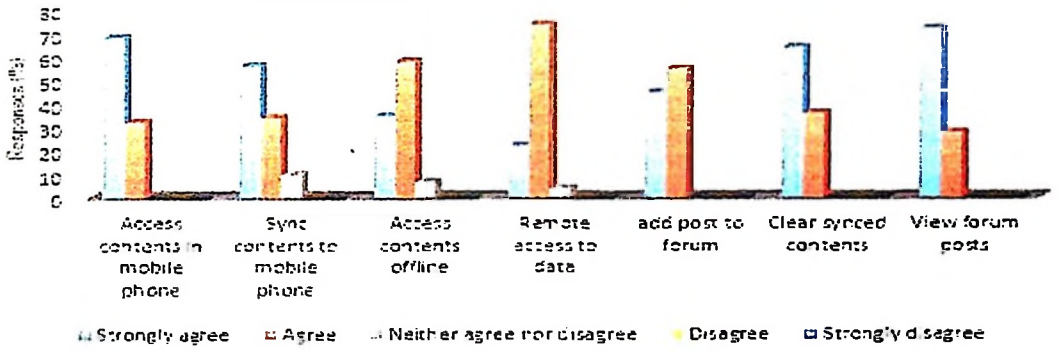


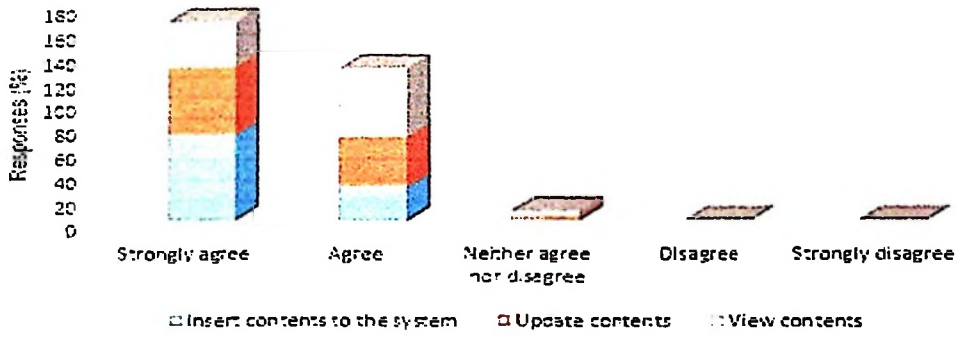
Figure 16: System admin and Instructor Dashboard

3.5 Results and discussions

This section presents the results from user acceptance functional requirements testing. Testing and validation of the proposed system was conducted in order to evaluate the system against the system design requirements specified. System testing is the process of evaluating a system or system component in order to verify that it satisfies requirements or to identify differences between expected and actual results (Glenford *et al.*, 2004). System validation is the confirmation by examination and the provision of objective evidence that the particular requirements for a specific intended use are fulfilled (Carl, 2004).



(a) Leaners



(b) Instructors

Figure 17: User acceptance functional requirements testing results

The results indicate that the system developed satisfy the system design requirements specified as revealed in the results presented in Figure 17 (a) and (b). Majority of users' agreements ranged from strongly agree to agree as evidenced by the results presented. This study explored the opportunities brought by mobile technologies in order to improve learning contents delivery and accessibility especially in resource and bandwidth constrained environments. The study proposed a mobile based system for cost-effective learning content delivery that bridges the gaps in existing e-learning systems by allowing significant bandwidth savings through offline use of learning contents. The proposed system can synchronize learning contents locally in mobile devices when the Internet connection is available. The synchronized contents can be used offline as a result; it reduces the cost of bandwidth connection and usage, reduces internet usage overhead and servers' workload, improves e-learning system performance, speedy internet access and improves the quality of experience and participation of learners in learning activities.

Compared to existing Internet based learning system like Moodle, the proposed system do not highly depend on the Internet connectivity as a result, it can benefit HEIs within resource and network constrained environments, which is the major problem facing the majority of HEIs in third world countries particularly Tanzania. In the proposed system, learning experience is considered in terms of offline accessibility; mobility and portability; increased motivation in learning activities; increased collaboration through integration with social networking tools; social interaction (for example discussion forum); cost-effectiveness and ability to learn anytime, anywhere. The learning outcome could be improved individual skills, acquisition of new skills, improved social skills, quality and participation of learners in learning activities. The proposed system is underpinned by the traditional learning environment and also supported by effective learning policies, rules and regulations, human resources, the Internet and technologies to

facilitate access of learning materials. On the other hand, successful implementation of a blended mobile-learning requires a strategic approach which should be owned by the university management, academic staff and students as well as other stakeholders.

3.6 Conclusion and future work

Even though internet based learning management system exists, the constraints on resources and Internet connectivity in third world countries like Tanzania is still a major challenge for both public and private HEIs. The majority of third world countries, face similar problems of resource and bandwidth constrained environments. This study has designed a mobile based system for cost-effective content delivery to facilitate learning contents delivery, particularly in resource and bandwidth constrained environments. The system employs the opportunity brought by android built-in SQLite database for temporary storage of synchronized contents for offline use. The results of this work can be applied to other third world countries because they experience similar challenges as Tanzania. While owning and maintaining ICT infrastructure for HEIs has many challenges including the cost of hardware, software and human-ware; the growth of mobile phones brings new opportunity for them to be used for education purpose.

The future work is to implement and test the system in real working environments. The system would be tested using a black box testing technique to deduce errors. From the mobile side, usability evaluation would be conducted using different mobile computing devices. The System Usability Scale questionnaire, a recognized usability instrument, would be used to measure the usability and user satisfaction of the system.

CHAPTER FOUR

Synchronization and caching solution for cost-effective e-learning in resource and bandwidth constrained environments[3]

Abstract

E-learning has received significant research attention over the years in order to ensure reliability, availability and cost-effectiveness through Information and Communication Technologies (ICTs).The development of mobile computing devices, especially smartphones bring prospects in overcoming the inherent limitations of the Internet when accessing contents on the web. Among the potential opportunity revealed, includes the ability to work offline. Therefore, this study aims to analyze the existing online and offline e-learning systems in order to explore the uniqueness, technical problems and opportunities in this field. Similarly, this study proposes synchronization and caching solution for cost-effective e-learning content delivery. The proposed approach synchronizes the contents from the original servers to local database in mobile computing devices for offline users. It therefore contributes to reliability, cost-effectiveness, timely and increase motivation in learning activities.

4.1 Background information

The advancement in Internet and mobile technologies brings a new paradigm of learning over the Internet. In educational environment perspectives, learning over the Internet has become popular and significant for supporting flexible and cost-effective learning activities especially for Higher Education Institutions (HEIs). Flexibility and accessibility are important factors that need to be considered when implementing e-learning solutions. According to Olson *et al.*, (2011), flexibility refers to the standard measure of e-learning being learning for anyone, without restriction of time and space (learn anywhere and anytime) while accessibility refers to the quality of the connectivity.

Mobile phone technology evolves very rapidly, offering new capabilities for supporting higher data transmission, storage, and multimedia (Cortez, 2012; Randell, 2013). Furthermore, the rate of mobile phones adoption and access to the Internet is generally growing at a rapid rate, bringing opportunities for reliability and availability of learning contents in HEIs. In view of

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Tanzania as an example; the trends of mobile subscriptions increase rapidly. According to TCRA (2014) the trends of mobile subscriptions increased from 2, 963,737 in 2005 to 27,986,314 in March 2014 leading to a penetration rate to rise from 10% in 2005 to 63% in March 2014. Similarly, smartphone adoption has increased from 3% in 2010 to 9% in 2014 and promises even more growth in coming years (TCRA, 2014). Furthermore, Mahenge and Sanga (2014) reported that the majority of students in HEIs in Tanzania owns more than one mobile device that can be used as a tool for facilitating access to education. Similarly, it has been reported that, already students are using their mobile phones for other activities like mobile banking, mobile money and social networking (Mtega *et al.*, 2014). Correspondingly, students are using their mobile phones for learning activities via Twitter, YouTube, Skype, Facebook and other social media. Therefore, these are indicative possibility of implementing cost-effective m-learning in HEIs in Tanzania.

Majority of HEIs in Tanzania has adopted web based e-learning system to support learning activities. In view of Moodle (www.moodle.org), as a free web based Learning Management System (LMS) has been popular in academic environments for supporting learning activities. However, web based e-learning systems are subjected to some challenges for learning environment with resource and bandwidth constraint, especially for HEIs in developing countries, Tanzania as an example. These challenges include:

i. Running web based e-learning system requires continuous and persistent Internet connection which leads to high cost of bandwidth usage;
ii. Some HEIs can't afford to provide sufficient bandwidth to satisfy a number of available Internet users around the institution to access learning contents through web based learning system;

iii. Some students may have difficulties in accessing the Internet when they are outside the institutional environment, even though they own mobile computing devices and some time may be costly;

iv. Learners may not access learning contents when they are offline;

v. Due to financial constraints, some institutions can't afford the cost of purchasing hardware and software required for supporting e-learning to satisfy the number of available e-learning users;

Employing the opportunities and capability of mobile computing devices for supporting offline e-learning would provide a cost-effective approach of learning content delivery and accessibility especially in HEIs.

Several previous studies proposed solutions for supporting both online and offline delivery of learning content, however, there are still considerable gaps to be addressed in order to improve efficiency of e-learning systems as well as content availability. The proposed solutions include; Trifonova *et al.*, (2004, 2006) proposed Mobile ELDIT to support both online and offline content delivery. The proposed system can work offline by utilizing a caching proxy. However, the main shortcoming is a single point of failure due to the fact that all data came through the proxy server, if this server was compromised all users connected to such server are subject to the risk of running out of service and information / data theft. Royyana *et al.*, (2010) proposed offline web application and quiz synchronization for e-learning activities to support offline web application for Moodle task/assignment. One technical problem is the implementation of quiz point where the students with Wi-Fi capable phones can download the quizzes and store in their mobile memory. The Quiz engine performance depends upon the number of questions in the quiz as a result the time to display the first question is proportional to the number of questions in the quiz

likewise memory requirement is directly proportional to the number of questions in the quiz. But also the proposed system requires continuous Internet connection during downloading. Jordi *et al.*, (2012) proposed Moodbile; the android application that supports both online and offline accessibility by storing offline contents in memory cache. However, synchronization functionality was not implemented. The proposed systems require continuous and reliable Internet connection during downloading of contents to memory cache as a result, they favour learning environment with sufficient resources and reliable Internet connectivity.

Studies indicate that there is an exponential growth in bandwidth and decline in cost: specifically, the global bandwidth is expected to grow by 32% per year from 2010 to 2015 while the cost of bandwidth is expected to decline by 18% per year (Scott, 2012; Telegeograhy, 2012). It is also indicates that the new subsea cable construction and upgrading of existing systems have resulted in bandwidth price reduction worldwide. Although bandwidth prices have dropped globally, significant geographical differences in bandwidth usage cost remain. Lujara (2008) proposed Compact Disk Read Only Memory (CD-ROM) for offline delivery, however, tremendous growth of the amount of information and increased the number of e-learning users do not match with the capacity of CD-ROM for supporting offline learning.

In order to overcome such problems, this study proposes synchronization and caching approach for cost-effective learning content delivery and accessibility. By utilizing the capability of mobile computing devices owned by users, a learner can synchronize the contents of a remote server to mobile devices within a short time when the Internet is available and working offline afterwards. With this approach only minimal amounts of time is needed for a user to be connected to the Internet, most of the time, the user works offline. Therefore, the approach has the potential for reducing the cost of bandwidth usage, improving system performance by cutting

down the servers' workload and Internet usage overheads; cutting down costs of purchasing hardware and increase motivation in learning activities by allowing learners to access learning contents anywhere and anytime.

4.2 System architecture

This section presents the proposed system architecture. The proposed system comprises of three layers; data storage layer, business logic/ data access layer and presentation layer.

a) *The presentation layer*: This layer is the front-end component responsible for providing portable presentation of contents and logistics to allow the user to interact with the server. Physically, it resides on a client machine and is responsible for transforming the output of the data access layer into usable and readable format by the user. It provides the mobile devices with a user interface to interact with the back-end of the system and persistent storage for temporary storage of synchronized contents for offline use.

b) *The business logic/data access layer*: This is an intermediate layer between presentation layer and data storage layer. Physically, it is located on the server that hosts the web services. It is responsible for handling application business logic and business process validation including sending clients' data requests to the data storage layer and returns the output to the requesting user.

c) *Data storage layer*: This layer is made by the database management system (DBMS) component, namely MySQL which offers mechanisms for data storage and retrieval. It is responsible for permanent storage of learning contents, for example, the database keeps tracks of learning contents A, B, C, D, E, F, G, H....of which a user can synchronize and store the subset of these learning contents locally on their mobile device for offline use.

When a user makes a request; the Application Programming Interface (APIs) accepts the request by GET or POST methods; then it interacts with PHP classes in the data access layer to get data

from database or store data into database; and finally returns the output to the requesting user/device in a usable and readable format.

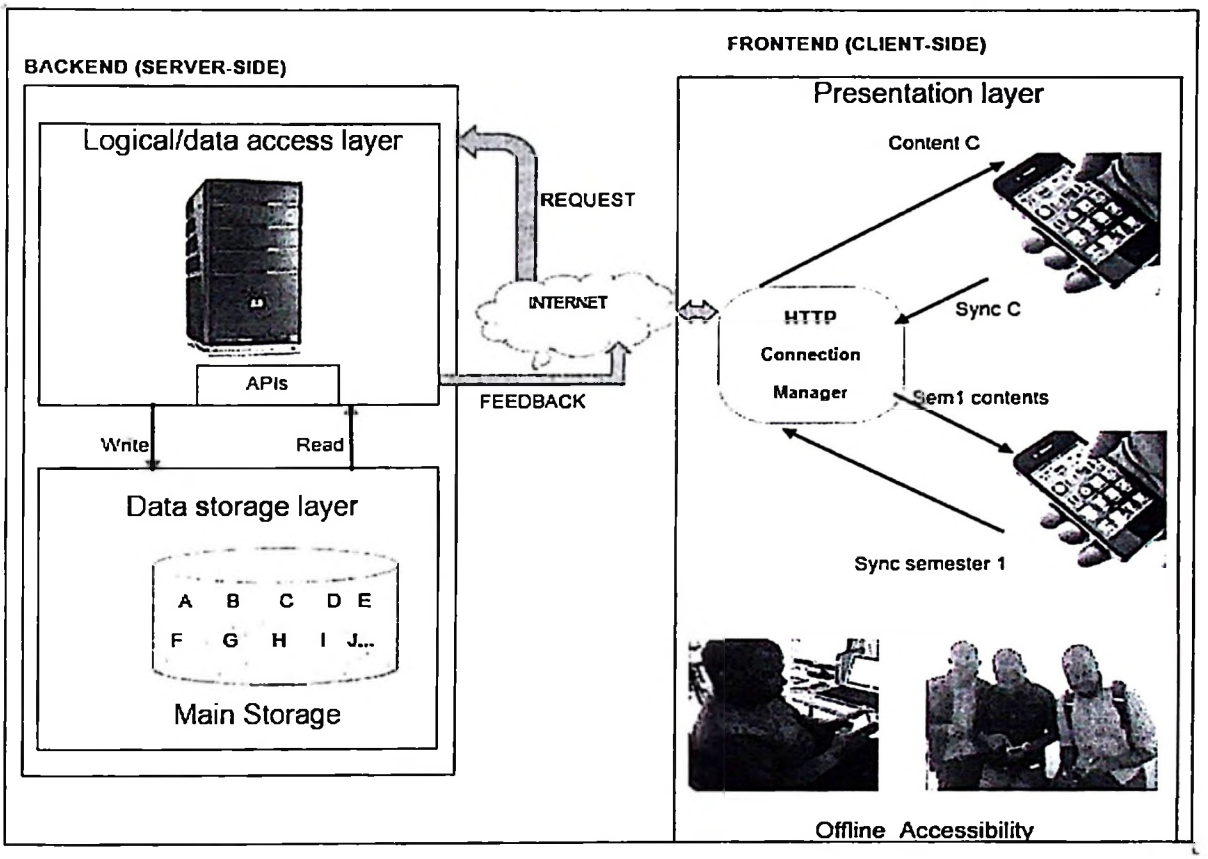

Figure 18: Proposed system architecture (Adapted from Mahenge *et al.*, 2014)

4.2.1 Activity sequence

This section describes the synchronization and caching activity sequence of the proposed system. The activity sequence shows the sequence of activities in a process and logical decisions that are made (Kendall. K and Kendall. J, 2011). The list of activities gives an overview of how the system achieves the synchronization and caching process. The process consists of activities and logical decision building blocks described below;

a) **Activities building blocks**: The activity building block includes:

i. *Display sync options activity:* filtered on a semester basis, yearly basis, sync all and sync only specific contents. Sync options implemented to help the user synchronizing only required contents to avoid filling a cache with unnecessary contents. This is due to fact that the storage capacity of the mobile devices is limited;

ii. *Read selected content activity*: reads contents from the remote server when the Internet is available;

iii. *Cache selected content activity*: synchronizes contents and caches the synced contents locally on a mobile device;

iv. *Enquiry learning content activity*;

v. *Return learning content activity*: Display the contents from the local database if the contents were cached locally in a device otherwise retrieve from the remote server.

b) **Logical decision building blocks**: test the logical conditions. There are three logical decision building blocks which include:

i. The logical decision to check the availability of the Internet that guarantees connection to the remote server,

ii. The logical decision to test the sync criteria and

iii. The logical decision to check if the accessed contents were cached and available in the local database (cache). Figure 19 presents the sync and a caching activity sequence

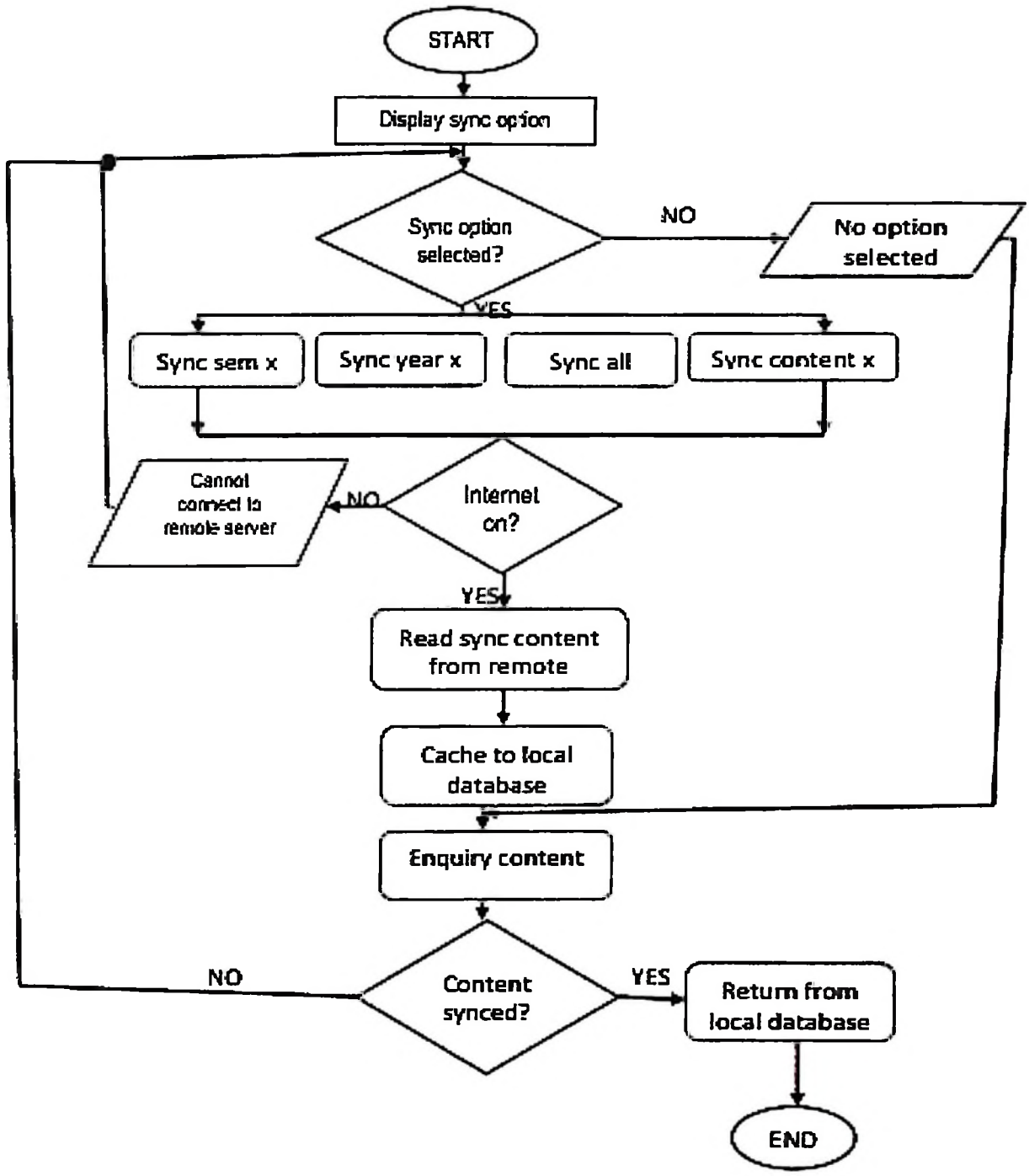

Figure 19: Sync and cache activity sequence

4.3 Bandwidth conservation models for numerical studies

In this section, we introduce the models for bandwidth conservation law and bandwidth allocation for fixed population. The motivation behind bandwidth conservation models is to gain insight on the behaviour/properties corresponding in some ways to a proposed system for content delivery and adopt some of these models in order to predict the cost implications of the proposed system especially in terms of bandwidth requirements. Specifically, these models are required in order to:

a) *Gain understanding of the proposed system*: Generally, if we have a mathematical model which accurately reflects some behaviors of the real-world system, we can also gain improved understanding of the system through analysis of these models. Also models will tell us which factors (For example; cost of bandwidth usage, access speed, server workloads and Internet usage overhead) are most important in the system and how the different parts relate.

b) *Predict or simulate*: Basically, we intended to know what value the proposed system will bring in future with respect to the cost of bandwidth, reduction of Internet usage overhead and server workloads and efficiency in e-learning content delivery and accessibility. Also the models are needed to judge the cost-effectiveness of the proposed system.

The assumptions made while adopting and using the models include:

a) Fixed population

b) The effect of implicit overhead is negligible for static view of contents.

According to Bendadis (2008), the bandwidth conservation law can be expressed as

$$\sum_{i \in u} d(u) \leq min(N_u d_{max}, U_u + U_s + U_g) \quad \ldots\ldots (1)$$

where $U_X = \sum_{n \in X} U_n$ indicates the total upload capacity of nodes in set X, *d(u)* denotes download rate of users, Nu denotes the number of users, dmax denotes maximum allocated bandwidth, Uu denotes the uploading capacity of users, Us denotes the uploading capacity of content providers and Ue denotes the uploading capacity of the servers. Users in this context refer to users that use the application, content providers refer to actors that provide content to the system and servers refer to external servers dedicated to the service offered by the application.

For the fixed population, it is assumed that U_e, N_u, P_u, N_S and P_S are known, therefore; for uniform bandwidth allocation another model can be derived from equation (1), that is:

$N_u \times d = min(N_u \overline{U}_u + N_S \overline{U}_S + U_s)$

$$d = min\left(d_{max}, \overline{U}_u + \beta \overline{u}_s + \frac{U_s}{N_u}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ldots (2)$$

where $\beta = {}^{N_s}/_{N_u}$. The models (1) and (2) work for peer-to-peer architecture where each workstation acts as both a service provider and service consumer. The scenario for client-server architecture would be different, but slightly similar in-terms of bandwidth conservation. The bandwidth requirement for client-server architecture is calculated based on the services offered by the system including both static view and dynamic services (Figure 20).

$$B = d(s) + d(n) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

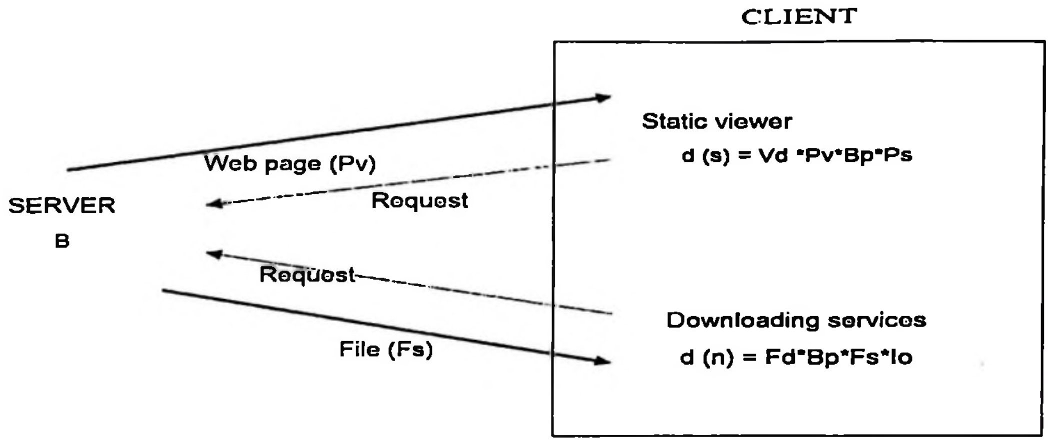

Figure 20: Client-server bandwidth conservation

Where B denotes the maximum allocated bandwidth for a particular application hosted on a server, d (s) denotes bandwidth required for static services and d (n) denotes bandwidth required for downloading services. The bandwidth required for static services d(s) is calculated using equation (4),

$$d(s) = Vd * Pv * Bp * Ps \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where Vd denotes average daily visitors, Pv denotes average page viewed, Bp denotes the billing period and Ps denotes the average page size.

The bandwidth required for dynamic services is calculated using equation (5)

$$d(n) = Fd * Bp * Fs * Io \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where Fd denotes an average file downloaded, Fs denotes the average file size and Io is the Internet usage overhead.

We considered a learning environment with a fixed population that is 600 learners of which 300 learners use Internet based learning system, thus needs continuous Internet connection and the remaining 300 learners use a proposed synchronization and caching approach. Out of 300 users

of synchronized approach, 200 users are working offline after synchronizing their contents locally in their mobile devices and 100 users work online. In the conduct of the study, we considered constant value of parameters {Pv, Ps, Bp, Fd, Fs} which assumed to be {25, 20, 30, 20, 100}. Substituting the values into given equations (3), (4) and (5) forms two linear models:

$$Bc = 58.59375Io + 4394.53125 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

and

$$Bs = 58.59375Io + 1464.84375. \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Linear models (6) and (7) represent a continuous Internet connection based approach and synchronization and caching approach respectively. The value of parameter Io varies based on the user access behaviour.

4.4 Results and discussion

This section discusses the results from this study based on the gaps which this study intended to address. This chapter presents synchronization and caching approach, a mobile based e-learning content delivery system as an alternative content delivery approach without heavily depending on Internet on learning environment facing the constraints of resource and bandwidth. Therefore, the numerical evaluation results are discussed in-terms of contribution of this study, including the significant bandwidth usage cost savings, speed Internet access, reduction of network overloads, reduction of server's workloads and flexibility in learning activities. The details are as follows:

4.4.1 Significant bandwidth usage cost savings

The bandwidth usage cost found to be a limitation for effective and efficient learning content delivery, especially in HEIs with resources and bandwidth constrained environment. In order to

cut down these limitations, this study proposes a sync and cache approach that employs the opportunities brought by the mobile computing devices for persistent storage of learning contents for offline use. Models (6) and (7) estimate the bandwidth requirement based on the values of Io, which varies depending on user access behaviour. The parameter values of Io {0.85, 0.7, 0.55, 0.35, 0.25} represent the system operations under overhead conditions, busy all the time situation, normal Internet usage, sometimes shorter, sometimes longer time is required and when sometimes the system is idle respectively. Figure 21 presents bandwidth cost implications between continuous Internet connections approach and the proposed sync and caching approach.

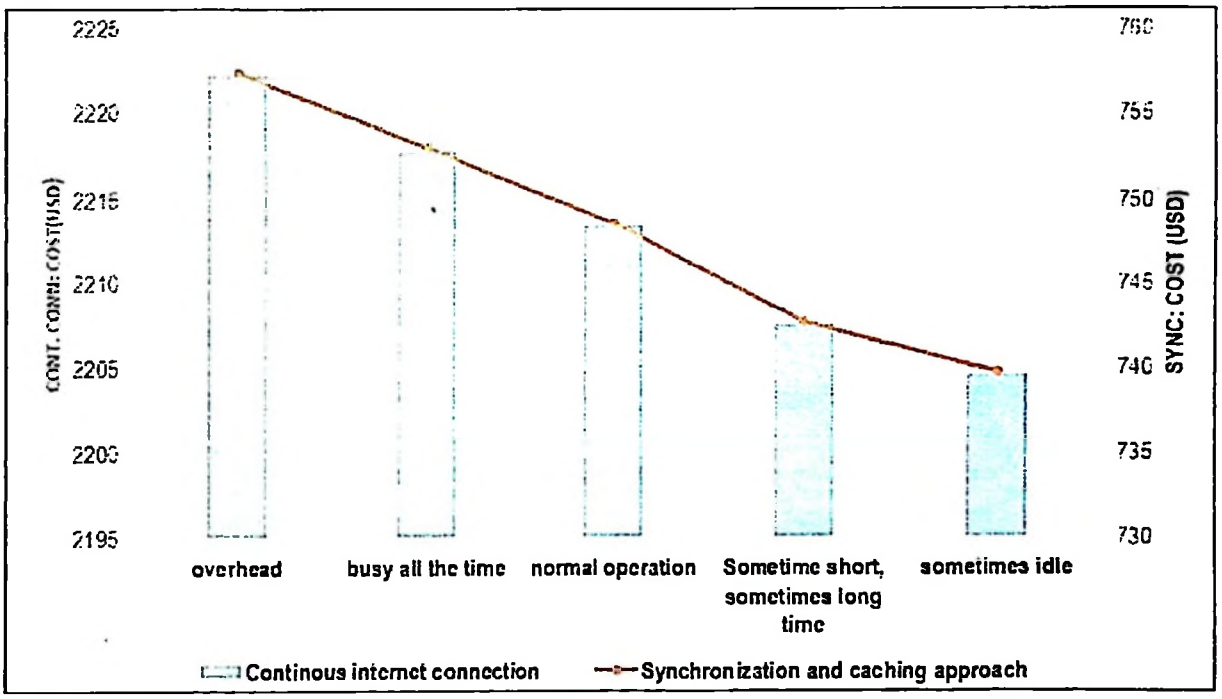

Figure 21: Monthly bandwidth cost approximation between continuous Internet connections and the sync and caching approach

The results provide empirical evidence that synchronizing contents locally in mobile devices for offline use is significant for bandwidth usage costs saving. For example for a learning environment with fixed population, when the system operate under normal situation, the

approximate bandwidth cost would be 747.5USD per month when sync and cache policy used while the cost would be 2212.5 USD without sync and cache policy (fig. 21).

4.4.2 Reduction of Internet usage workload

The proposed synchronization and caching approach is potential for cutting down the Internet usage workload as a result, speedy Internet access, alleviates network overload and servers' workload. The local server keeps track of most of synchronized contents stored locally in its database. Thus, the next time a learner requests such information, the local server returns the cached version of the contents instead of reconnecting to the Internet. As a result a user experiences faster response time due to reduced number of users accessing e-learning contents online. Similarly, the proposed approach is potential for *reduction of network overload.* Network overload is caused by too much legitimate web traffic due to thousands or even millions of clients connecting to the web site in a short interval. The proposed approach guarantees the ability to work offline. Most of the time, the contents can be synchronized and cached locally in mobile device within a minimum amount of time when the internet is available and accessed offline afterward as a result reducing network traffic. Likewise, the proposed approach *alleviates the servers' workload.* A web server (program) has defined load limits, since it can handle only a limited number of concurrent client connections. The persistent storage serves as an intermediary server to manage content offline. Having an intermediate server to retrieve and display contents, there is an enormous reduction of load on the remote server. As the persistent storage has all the contents that are requested by the client in its database, therefore; there is no need to connect to the remote server every time as a result it improves e-learning system performance. Figure 22 presents the relationship between the access speed and Internet usage overhead. The results provide empirical evidence that as the Internet usage workload increases, the response speed

decreases as a result the performance of the system decreases respectively. Reducing Internet usage workload is potential for improving system performance. From the results in Figure 22 below 50% Internet usage workload, the system operates under normal situation, hence offers reasonable access speed while above 50% the system operates under overload situation as a result the average access speed is relatively very slow. Therefore, in order to improve e-learning system performance, the Internet usage workload should be reduced.

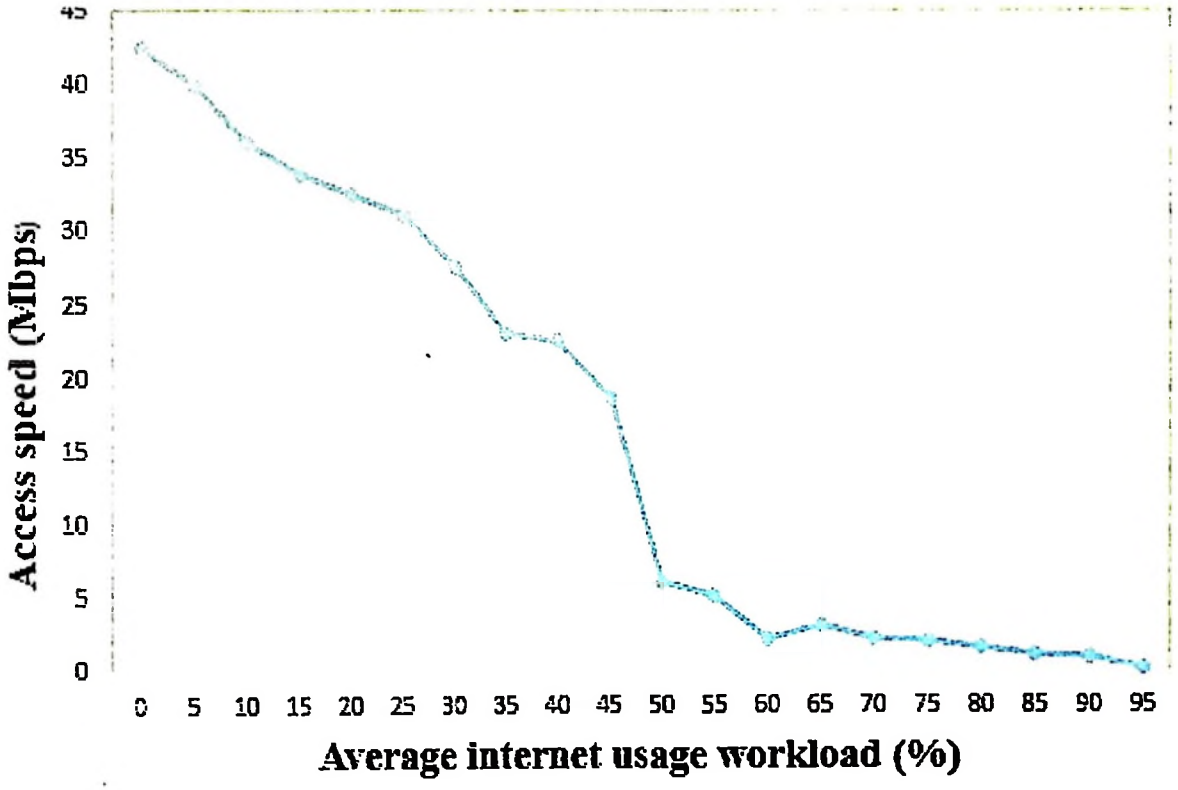

Figure 22: Relationship between access speed and Internet usage workload

4.4.3 System usability testing

The proposed system was exhaustively tested using a black box testing technique in an attempt to test the system externally and to reduce errors. A pilot usability evaluation was conducted in a mobile side which included a small number of users. The System Usability Scale (SUS) questionnaire was used to measure the usability and user satisfaction of the proposed system.

Question items included in the SUS survey have a five-scale ranging from strongly disagree (1) to strongly agree (5). Figure 23 summarizes the results of system usability tests;

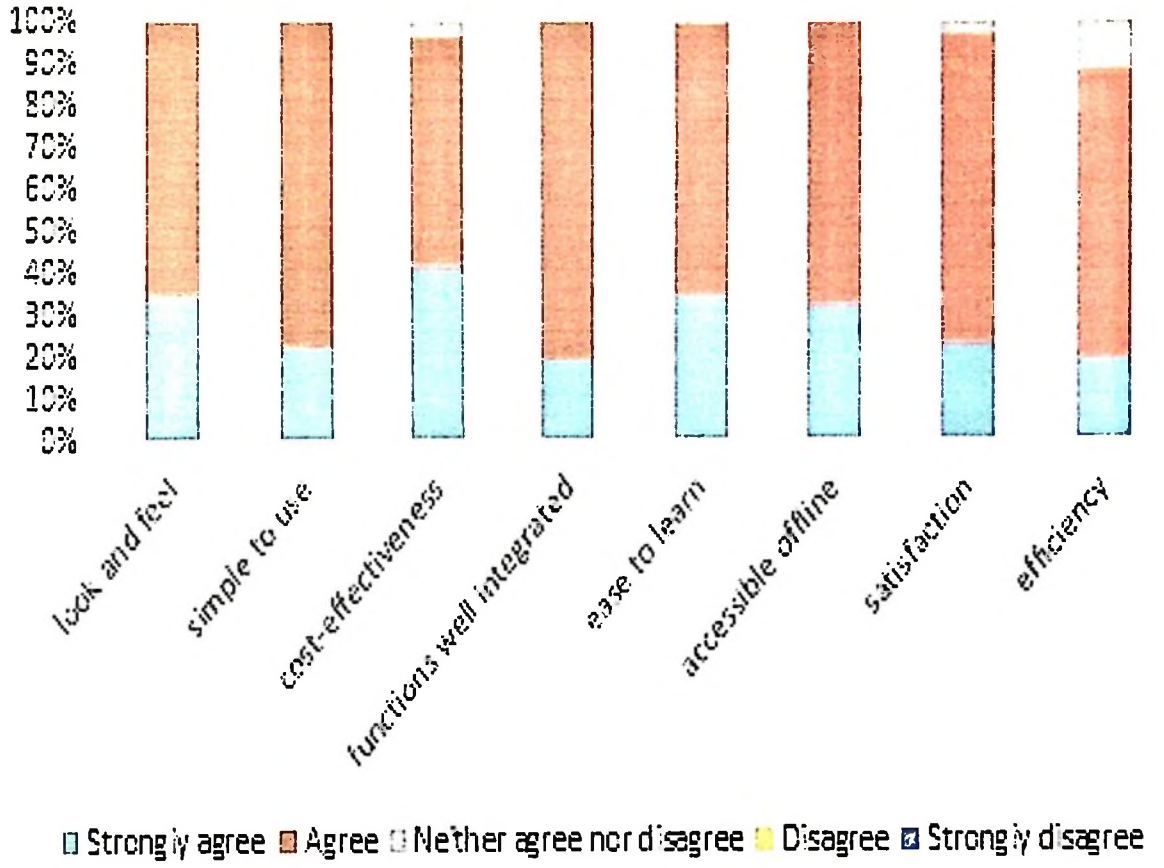

Figure 23: System usability test results

The results presented in Figure 23 show that on average 27.88% of users strongly agreed, 68.88% of users agreed and 3.24% of users neither agree nor disagree with the system usability. Furthermore, neither disagree nor strongly disagree with the usability of the system were reported. The results suggest that the usability of Mobile-LCDS prototype is good as it was agreed by the majority of users. Similarly, the mean rating of students' satisfaction was high

(74%). However, the initial response from the users was agreeable; rational usability testing of the system on a large number of users is proposed for future study.

4.5 Conclusion and future work

This chapter proposed a synchronization and caching approach for cost-effective e-learning content delivery and accessibility. The proposed solution is a mobile based content delivery system that has several contributions in filling the gaps in existing e-learning systems for enhancement of content delivery and accessibility especially in HEIs facing challenges of resources and bandwidth constraints. In the same vein, the proposed approach is significant for users in learning domain to be able to work offline. In learning environment, ability to work offline cuts down several limitations facing Internet based learning systems including; first, significant bandwidth usage cost savings due to less dependence on the Internet; secondly, improving learning system performance by cutting down the servers' workload and Internet usage overheads; thirdly, cutting down costs of purchasing and maintaining hardware in the institution due to the fact that the contents will be synchronized and made available in devices owned by the learners, and fourth, increased motivation in learning activities by allowing learners to access learning contents anywhere and anytime.

After the completion of system implementation, the future plan is to do rigorous impact assessment and implementing further enhancement of the system in real working environment, then deploying the system to the intended HEIs. After rigorous impact assessment and further improvement of the system, we also envision adapting the proposed system to secondary and primary schools.

CHAPTER FIVE

General discussions, conclusions and recommendations

This chapter presents a general discussion on the objectives of the study, the main findings drawn from the study, research contributions, limitations of the research, recommendations for future works related to this study and provides general conclusion from the study.

5.1 General discussion

5.1.1 General discussions of the objectives of the study

The main objective of the research was to develop a system that will facilitate mobile based e-learning contents delivery and accessibility in higher learning institutions. The study was channelled through three specific objectives; the first objective was to identify and analyse ICT for e-learning information needs and system design requirements. This objective was achieved through survey methodology. During survey different methods including structured questionnaire, interview and review of empirical literatures were used and the results were discussed in Chapter 2. The second objective was to design and develop a mobile application for delivery of e-learning contents and the results were presented and discussed in Chapter 3. To achieve this objective, evolutionary development model which combines *exploratory development* and *rapid prototyping* was adopted. A software development process is often described in terms of a set of activities needed to transform a user's requirements into a software system. Generally the process is called Software Development Life Cycle (SDLC), among SDLC one is Evolution Development Model adopted in this study to accomplish objective 2. The major advantage of this model is its flexibility that is; the ability to accommodate changes. Due to facts that customer needs are dynamic they keep changing, thus evolutionary development model can accommodate changes by adding features to the system as proposed by users as the needs arises.

Furthermore, due to time limitation, this study developed an initial version of software which is considered as a prototype that can be evolved to higher versions through adding new features. The evolutionary development model will best support evolvement to higher version. The third objective was to test and validate the developed mobile application. To achieve this objective different approach were used, including bandwidth conservation models, black box and white box methods and system usability scale questionnaire. The results were discussed in Chapter 4.

5.1.2 The main findings of the study

Findings show that the majority of the students owns more than one mobile device which can be used as a tool for facilitating the learning process. It was further argued that the mobile devices are mainly used for communication purposes and other activities like mobile banking, mobile money and social networking. Students access YouTube, Twitter, Facebook and other social media tools on their mobile devices to do some learning activities. However, the results provide empirical evidence that the rate of adoption of mobile phones for mobile-learning in Tanzania is very low.

The findings also revealed that the existing e-learning systems in HEIs of Tanzania face many challenges in delivery of e-learning contents due to resources and bandwidth constrained environments. These challenges include; firstly, running web based e-learning system requires continuous and persistent Internet connections which lead to high cost of bandwidth connection and usage. The coverage and persistent Internet connectivity in the majority of HEIs in third world countries, especially Tanzania is still a major challenge for both public and private HEIs. Secondly, for some reasons, some HEIs can't afford to provide sufficient bandwidth to satisfy a number of available internet users around the institution to access learning contents through web based learning system. Third, some students may have difficulties in accessing the Internet when they are outside the institutional environments even though they own mobile computing devices

and some time may be costly. Fourth, learners may not access learning content when they are offline and fifth, the institution might not afford the cost of purchasing hardware and software to satisfy the increased number of students and instructors due to financial constraints.

However, in view of Tanzania as an example; review of empirical literatures revealed that mobile computing devices like smartphones adoption and ownership by students in HEIs is increasing rapidly bringing opportunities to enhance delivery and access to learning contents. The survey conducted in this study at HEIs in Tanzania, found that on average 85% of students own laptops, 65% own smartphones and 78% own mobile phones that means a majority of students own more than one mobile computing devices that can be used as a tool to facilitate access to learning opportunities. It has been argued that implementing cost-effective mobile learning (m-learning) in HEIs is possible due to fact that already students are using their mobile phones for other activities like mobile banking, mobile money and social networking. Similarly, already students are using their mobile phones for learning activities via Twitter, YouTube, Skype, Facebook and other social media. More importantly, there were much eagerness amongst respondents for developing the potential of mobile based e-learning content delivery and Web 2.0 tools (i.e. e-learning 2.0 or education 2.0) in their universities.

Furthermore, the findings of numerical evaluation revealed that synchronizing learning contents locally on mobile devices are significant for bandwidth usage cost savings, alleviates network overload and servers' workload and hence improves e-learning system performance.

5.2 Research contributions

The study contributed to the provision of a better e-learning content delivery tools in HEIs of Tanzania by extending content delivery and availability through mobile computing devices. The proposed solution favours HEIs with resource and bandwidth constrained environments by

offering a cost-effective way of content delivery. Specifically the contribution of this study is discussed in details in terms of social, economic and pedagogical contributions as follows;

5.2.1 Social contribution

Education is the most important social factor indicating the state of countries' development. The proposed Mobile based e-learning content delivery system will contribute socially in improving personalized and innovative learning. The details are as follows;

i. Personalized learning outcomes could be improved individual skills and acquisition of new skills while innovative learning outcomes could be improved social skills, quality and participation of learners in learning activities;
ii. Encouragement of students to take responsibility for their learning and hence build an attitude and self-confidence in accessing learning materials through their mobile devices;
iii. Increased motivation in learning activities by allowing learners to access learning contents anywhere and anytime. It further improve quality of learning and participation of learners' in the learning process;
iv. It will encourage collaboration among students and instructors through the use of messages and discussion boards regardless of their physical location and time;

5.2.2 Economical contribution

The proposed solution provides a cost-effective approach for enhancement of e-learning contents delivery and accessibility which favours HEIs with resources and bandwidth constrained environments. Economically, the study contributed to;

i. Significant bandwidth usage cost savings due to less dependence on the internet achieved by synchronization and caching of learning contents locally in the mobile devices for offline use;

ii. Improving learning system performance by cutting down the servers' workload and internet usage overheads;

iii. Mobile technology works using the radio spectrum, as such there is no need to rely on physical infrastructure such as roads and phone wires, the base-stations can be powered using their own generators in places where there is no electrical grid as a result allow access to learning content even in remote areas ;

iv. Offers benefits such as mobility and portability in learning process as a result, reduces travel time and cost that would otherwise be spent on traveling seeking for learning materials;

5.2.3 Pedagogical contribution

Pedagogical contribution includes;

i. Provide easy and timely access to teaching and learning materials;

ii. Reduction of shortcoming caused by deficiency of books and other learning resources facing the majority of higher learning institutions especially in Tanzania;

iii. Create equity in access of education resources to higher learning institutions;

iv. Brings learning contents at the fingertips of learners as a result, it contributes to increased access to educational opportunities;

v. Improves the quality of content delivery and learning as well as expanding access to learning opportunities;

5.3 Limitations of the research

The potential limitations of the proposed mobile based e-learning contents delivery systems reside in mobile devices themselves. However, regardless of the limitations, the advantages of using the mobile phone in learning activities outweigh the disadvantages. The limitations include;

a) *Lack of standardization in screen size, key size, and operating systems*: Even though this study confirms that the rate of mobile phone ownership and usage grow at a rapid pace, bringing opportunities for enhancement of learning content delivery and accessibility, variation in the screen size and key size lead to challenges in packaging content for multiple screen sizes and multiple operating systems on mobile devices.

b) *Small screen size of mobile device*: With tremendous increase in e-learning contents and the number of e-learning users, the knowledge is required to repackage content for mobile platforms. The complication of mobile learning increases when it is required to display big data.

c) *Lack of rich graphics and interactive features*: From the study, we found that very few users own mobile devices with very rich graphical and interactive features. This fragmentation poses challenge in developing interactive and graphically rich mobile learning application.

d) *Limited battery life of mobile device*: The mobile devices, especially smartphone battery life is limited and can run out in limited time.

5.4 Conclusion

The advancements in ICTs offers great prospects for HEIs in third world countries to improve the delivery and accessibility of learning content. This study found that the majority of students in HEIs owns mobile computing devices as it was established that on average 85% of students owns laptops, 65% owns smartphones and 78% of students owns mobile phones. Similarly, the majority of HEIs in Tanzania own basic ICT infrastructure such as Local Area Network (LAN), Internet, computers, and mobile technology that form the basis for the establishment of e-learning and m-learning. However, the findings provide evidence that the rate of adoption of

mobile learning in HEIs of Tanzania is very low. This study explores the opportunities brought by mobile technologies to find out a cost-effective solution for e-learning content delivery and accessibility in HEIs of Tanzania. Specifically, the study proposes a Cost-effective Mobile Based Learning Content Delivery approach for HEIs facing a constraint in resource and bandwidth. The proposed solution can synchronize learning content from some remote servers to local database in mobile devices for offline use as a result, it has the potential to reduce the cost of bandwidth usage, and cut down server's workload and Internet usage overhead. It will also improve the quality of experience and participation of learners as well as facilitate mobility and portability in learning activities.

Therefore, implementing cost-effective mobile based system for e-learning contents delivery and accessibility would be a current solution that employs and utilize the value of mobile computing devices owned by the majority of students. Therefore, in order to overcome challenges facing the education sector particularly in e-learning content delivery and accessibility under limited resource settings, HEIs in developing countries should make an effective use of emerging mobile computing technologies which are relevant to their respective environments.

5.5 Recommendations

Review of empirical literatures and survey conducted in HEIs of Tanzania by this study, reveals that currently there is no national as well as HEIs ICT policies which state how mobile computing devices/ technologies can be used for learning and teaching. To this end, this study recommends the formulation of national ICT policy which will be a guide to the Government in adopting ICTs in educational sector and at the same time enforcing. Likewise HEIs should review the current ICT policies so that it can be easy to adopt the new prospects brought by ICTs in the teaching and learning process.

Progressively, this study suggests that in order to improve the e-learning content delivery and accessibility under limited resource settings, HEIs in developing countries, Tanzania in particular should effectively make use of innovative and emerging mobile computing technologies which are relevant to their respective environments. A critical successful implementation of a blended m-learning requires a strategic approach which should be owned by the university community and other stakeholders. The approach should at least take into account significant issues, including pedagogy, mobile infrastructure, appropriate mobile content authoring technologies, human resources, m-learning policy, capacity building for staff and students, integration of e-learning, m-learning and ICT / digital literacy into HEI's curricula.

Furthermore, due to resources and time constraints, this study covered only few HEIs in Tanzania, therefore it is recommended that future studies should consider conducting a rigorous study to cover all HEIs of Tanzania. Additionally, future studies should consider measuring the extent level of performance improvements, conducting rigorous impact assessments and implement further enhancements of the system in real working environments. Additionally, different performance evaluation models could be adopted, for example Adedokun-Shittu and Shittu model which is an extension of Context, Input, Process and Product (CIPP) and the Kirkpatrick models (Adedokun-Shittu and Shittu, 2013).

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APPENDICES

APPENDIX 1: QUESTIONAIRE GUIDE FOR INFORMATION NEEDS ASSESSMENT

Dear Respondent, this questionnaire has been prepared for needs assessment in conducting research for enhancing e-learning content development and delivery in Higher Learning Institutions using mobile technology. The purpose of this questionnaire is to collect information for requirements specifications and engineering. The given questions are closed ended questions which require you to tick the correct answer (s). Kindly you are requested to respond to the given questions as guided in each question.

I appreciate your involvement in this study.

Name of University/Institution:
Date of Participation:

A: RESPONDENT BACKGROUND INFORMATION

Sex: male [ ] female [ ] (tick that apply)

Level of education: Certificate [ ] Diploma [ ] BSC/BA [ ] Masters [ ] PhD [ ]

Others [ ]: specify.....

Title: Student [ ] Instructor [ ] Administrator [ ]

Others [ ]: specify .....

B: EXISTING METHOD/SYSTEM/APPROACH FOR LEARNING MATERIALS DELIVERY AND THE REQUIREMENT FOR NEW SYSTEM

1. What system/method/approach is used currently for learning content delivery and accessibility? (Tick all that apply)

a) Whiteboard [ ] b) Face to face [ ] c) E-mail [ ] d) Blog [ ]

e) Discussion forum [ ] f) E-learning system [ ] g) Mobile learning system [ ]

h) Blended learning approach (mixed method) [ ]

i) Others [ ]: specify.....

2. What are the challenges associated with the existing system/ method/approach for learning content delivery and accessibility? (tick all that apply)

a) Not reliable [ ] b) Un-accessibility of learning contents during offline [ ]

c) Does not provide satisfaction [ ] d) Poor Performance [ ] e) Not Portable [ ]

f) Highly depend on the internet [ ] g) Difficult to share data [ ]

h) Difficult to manage learning contents [ ]

i) Do not allow learning contents to be accessed anywhere at any time [ ]

j) Others [ ]: specify.....

C. THE PROPOSED SYSTEM

3. Proposed system design requirement [Tick all that apply]

a) Extend learning contents delivery and accessibility to mobile computing devices [ ]

b) Synchronize learning contents to the mobile devices [ ]

c) Reduce the cost of bandwidth usage [ ]

d) Enable offline access to learning contents [ ]

e) Enable ubiquitous access to learning contents anywhere, any time without the restriction of time and space [ ]

f) Reduce internet usage overhead and servers' workload [ ]

g) Improve the quality and participation of learners in learning activities [ ]

h) Others [ ] specify.....

4. What features the new learning system must incorporate? (Tick all that apply)

a) Document sharing [ ] b) Desktop and application sharing [ ]

c) Voice over Internet [ ] d) Instant Messaging [ ]

e) Integration with the phone system [ ] f) Video over Internet [ ]

g)Others [] specify.....

5. What are the goals that you would like to achieve in future with respect to learning content delivery and accessibility? (Tick all that apply)

a. High Performance [ ] d. Cost-effective [ ] c. Security [ ]

b. Timely Information delivery [ ] f) Online delivery of learning contents [ ]

c. Offline delivery of learning contents [ ] g) Anywhere, anytime accessibility [ ]

h. Others [ ]: Specify.....

D: **MOBILE APPLICATION FOR LEARNING CONTENT DELIVERY AND ACCESSIBILITY**

6. Which of the following mobile computing/communication devices do you currently own?

a) iPad [ ] b) MP3 Player [ ] c) PDA [ ] d) Pen drive [ ] e) E-book reader [ ]

f) Cell phone [ ] g) Smart phone [ ] h) Laptop [ ] i) Handheld game [ ]

j) Others [ ]: specify.....

7. Which of the following mobile computing/communication activities do you engage in? (tick all that apply)

a) Downloading and listening to audio books [ ] d) Downloading and read e-books [ ]

b) Downloading and view movies/video clips [ ] e)Send and receive e-mail [ ]

c) Send and receive text messages [ ] f) Transfer files from one place to another [ ]

g) Play interactive games via internet on handled game console [ ]

h) Transfer photos or other data via cell/smart phones [ ]

i) E-learning/ m-learning activities [ ]

i) Others [ ]: Specify.....

8. What contributions made by mobile phone towards learning contents delivery and accessibility? (Tick all that apply)

a) Efficient use of e-resources [ ] c) Timely access to learning contents [ ]

b) Efficiency of communication between instructors and learners [ ]

d) Anywhere, anytime accessibility [ ] e) Helps in case of emergencies [ ]

f) No contribution made in learning contents delivery and accessibility [ ]

g) Others [ ]:

Specify.....

9. What contents would you like to access using your mobile?

b) Online books [ ] b) PowerPoint presentation [ ] c) Journals and articles [ ]

d) Grading reports [ ] e) Notifications [ ] f) time table [ ]

g) Others [ ]: specify.....

E: DATABASE SYSTEM

10. What database system do you prefer to use?

a) Oracle [ ] b) SQL Server [ ] c) Access [ ]

d) Adaptive Server [ ] e) MySQL [ ] f) Postgres [ ]

g) Others [ ]:

specify.....

11. What operating system is mostly used at your institutions/university?

a) Windows 7 [ ] b) windows 8 [ ] c) Ubuntu [ ]

d) Windows Xp professional [ ] e) Macintosh OSX [ ]

f) Linux Mint [ ] g) Android [ ] h) Fedora [ ]

i) Red Hat Linux [ ]

j) Others [ ]: Specify.....

----------*THANK YOU FOR YOUR CONTRIBUTION*----------

A PPENDIX 2: SYSTEM VALIDATION QUESTIONNAIRE

QUESTIONNAIRE FOR VALIDATION OF MOBILE-BASED LEARNING CONTENT DELIVERY SYSTEM (Mobile-LCDS) PROPOSED FOR HIGHER EDUCATION INSTITUTIONS

INTRODUCTION

I am **Michael P.J Mahenge,** a masters Candidate from NM-AIST Arusha. I am currently carrying out a study on developing a Mobile based system for e-learning contents delivery and accessibility in Higher Educations Institution. The purpose of this questionnaire is to validate the developed prototype. Please give us feedback based on your evaluation by selecting only one option.

A. System usability evaluation

1. Please indicate the level of agreement with the following statements using the scale provided

S/N		Strongly disagree	Disagree	Neither agree nor Disagree	Agree	Strongly agree
1	The systems' interface look and feel is good	☐	☐	☐	☐	☐
2	I think the system will provide a cost-effective way of accessing learning contents	☐	☐	☐	☐	☐
3	I found the system simple to use	☐	☐	☐	☐	☐
4	I think the system will need a support of technical person to use	☐	☐	☐	☐	☐
5	I found various functions of the system was well integrated	☐	☐	☐	☐	☐

6	I think the system will be very efficient in facilitating timely access to learning resources	☐	☐	☐	☐	☐
7	I would imagine that most people will learn to use the system very quickly	☐	☐	☐	☐	☐
8	I felt very satisfied and confident to use the system	☐	☐	☐	☐	☐

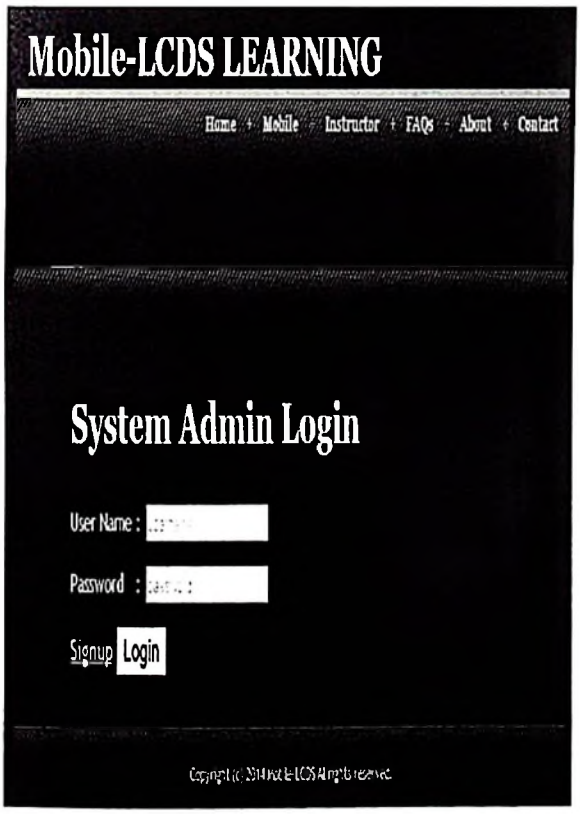
B. System design requirement validation

2. Please indicate the level of agreement with the following statements using the scale provided

S/N		Strongly disagree	Disagree	Neither agree nor Disagree	Agree	Strongly agree
1	The proposed system will enhance access to education by extending learning contents delivery and accessibility to mobile computing devices	☐	☐	☐	☐	☐
2	The proposed system synchronizes learning contents to the mobile devices	☐	☐	☐	☐	☐
3	The proposed system is potential for reduction of the cost of bandwidth usage	☐	☐	☐	☐	☐
4	The proposed system enable offline accessibility of contents	☐	☐	☐	☐	☐
5	The proposed system enables ubiquitous access to learning	☐	☐	☐	☐	☐

	contents anywhere, any time without the restriction of time and space;					
6	I found the proposed system is significant for reduction of internet usage overhead and servers' workload;	☐	☐	☐	☐	☐
7	The proposed system is potential for improving the quality and participation of learners in learning activities	☐	☐	☐	☐	☐

APPENDIX 3: Mobile-LCDS: PREVIEW ON THE WEB

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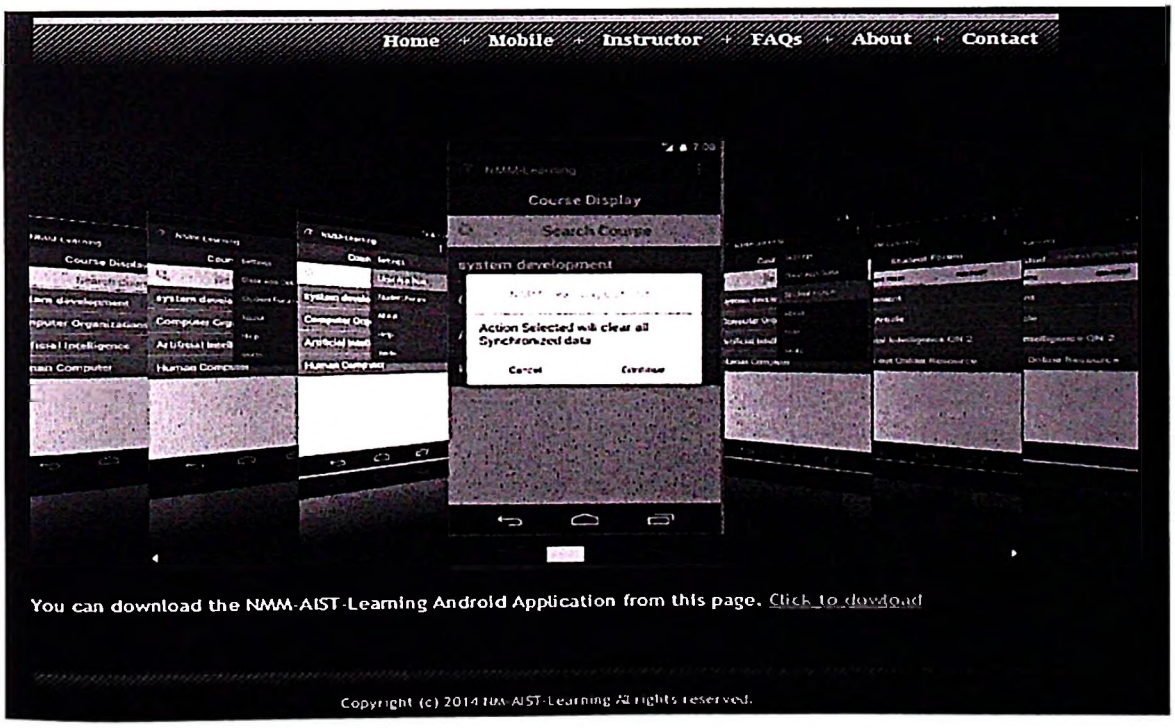
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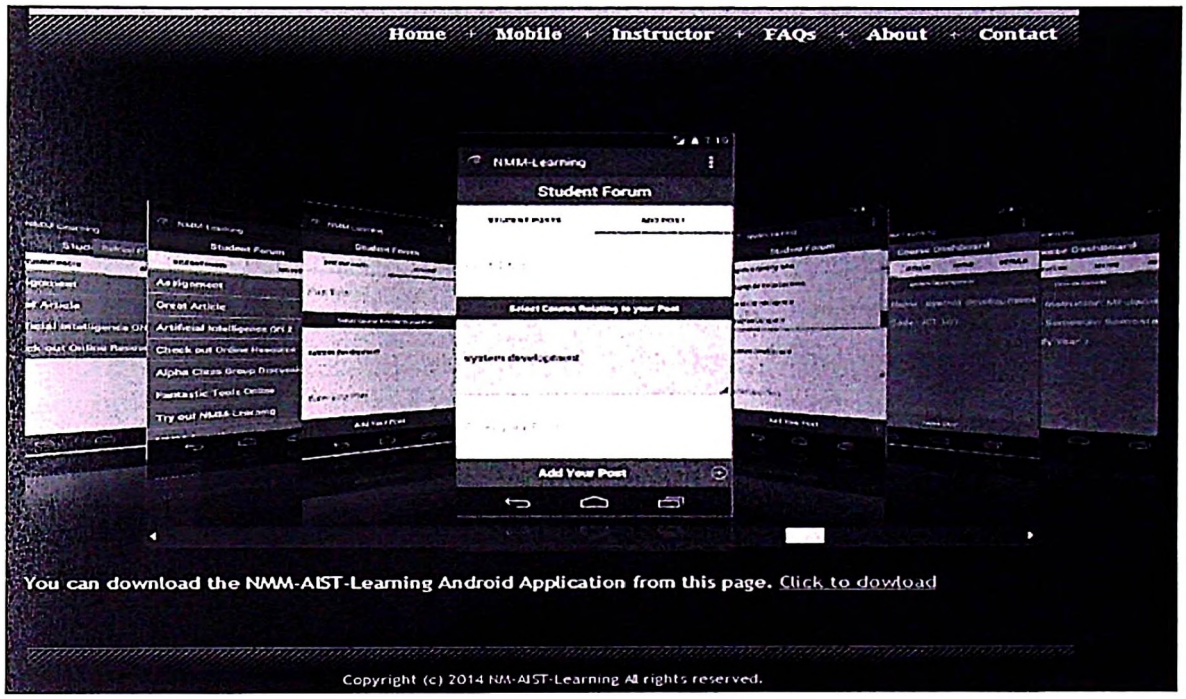
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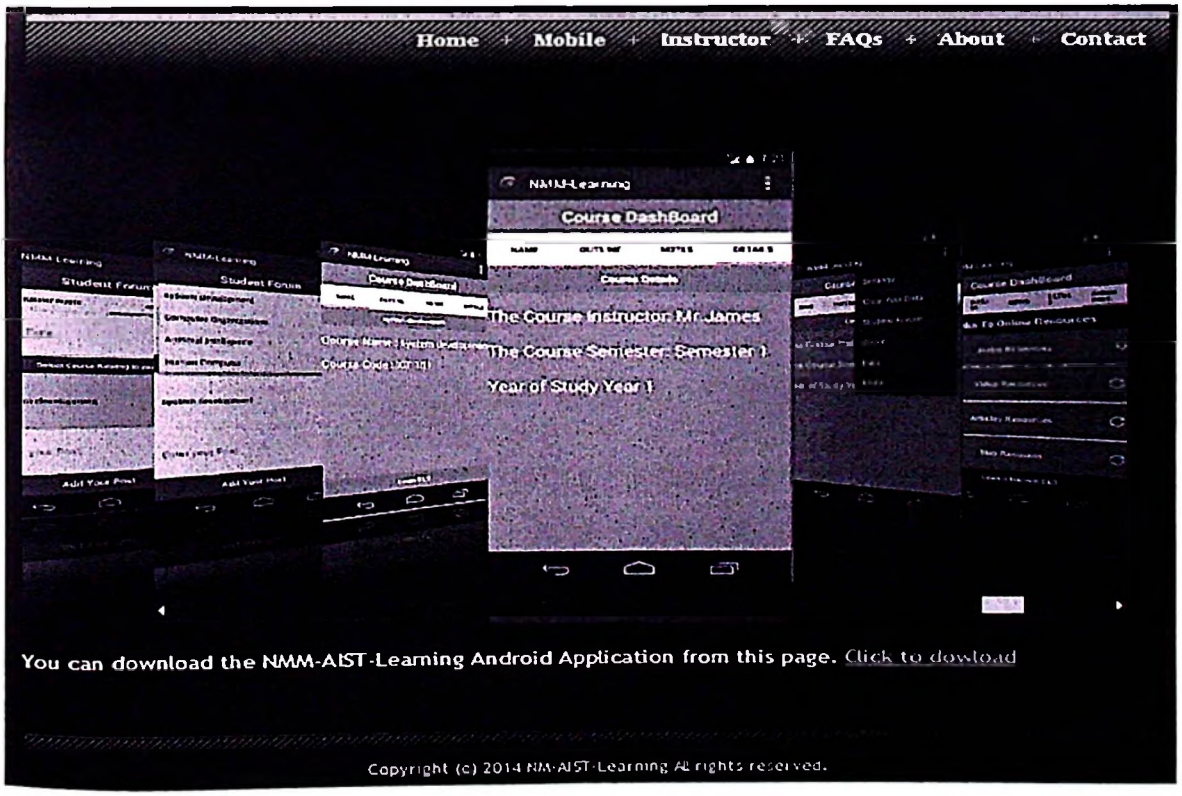
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Course DashBoard
The Course Instructor: Mr James
The Course Semester: Semester 1
Year of Study Year 1
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APPENDIX 4: SAMPLE SOURCE CODE FOR COURSE SYNC

```
package com.michael.nm_learning;
import java.util.ArrayList;
import java.util.List;
import org.apache.http.NameValuePair;
import org.apache.http.message.BasicNameValuePair;
import org.json.JSONArray;
import org.json.JSONException;
import org.json.JSONObject;
import android.app.Activity;
import android.app.ProgressDialog;
import android.content.Context;
import android.content.Intent;
import android.content.SharedPreferences;
import android.content.SharedPreferences.Editor;
import android.net.ConnectivityManager;
import android.net.NetworkInfo;
import android.os.AsyncTask;
import android.os.Bundle;
import android.text.Editable;
import android.text.TextWatcher;
import android.util.Log;
import android.view.View;
import android.view.View.OnClickListener;
import android.widget.AdapterView;
import android.widget.AdapterView.OnItemClickListener;
import android.widget.ArrayAdapter;
import android.widget.Button;
import android.widget.EditText;
import android.widget.ListView;
public class SyncBySemester extends Activity {
        SharedPreferences preferences;
        // Asynch variables
        ProgressDialog pDialog;
        // Creating JSON Parser object
        JSONParser jParser;
        JSONArray course = null;
        // Categories JsonArray
        JSONArray categories = null;
        // private static String url_all_course =
```

```
        private static String url_all_course = "http://10.0.2.2/nmmlearningscripts/getAllCourseSemester.php";
        // JSON Node names
        private static final String TAG_COURSE_SUCCESS = "course_success";
        private static final String TAG_COURSE = "course";
        private static final String TAG_COURSENAME = "course_name";
        private static final String TAG_COURSECODE = "course_code";
        private static final String TAG_COURSEOUTLINE = "course_outline";
        private static final String TAG_COURSENOTES = "course_notes";
        private static final String TAG_INSTRUCTOR = "course_instructor";
        private static final String TAG_YEAR_OF_STUDY = "year_of_study";
        private static final String TAG_SEMESTER = "semester";
        String errors = "";
String semester;
        @Override
        protected void onCreate(Bundle savedInstanceState) {
                // TODO Auto-generated method stub
                super.onCreate(savedInstanceState);
                setContentView(R.layout.sync_activity);
                Bundle bundle=getIntent().getExtras();
                semester=bundle.getString("semesterselected");
                preferences = getSharedPreferences("MyPrefs", MODE_PRIVATE);

                jParser = new JSONParser();
                new LoadAllCourse().execute();
                Editor edit = preferences.edit();
                edit.putBoolean("Active", true);
                edit.commit();
                initialize_views();
        }

        public void initialize_views() {
                // TODO Auto-generated method stub

        }

        // check if net is on
        /**
         * Function to check if network access is available
         *
```

```
 * @return
 */
public boolean checkOnlineState() {
	ConnectivityManager CManager = (ConnectivityManager) getSystemService(Context.CONNECTIVITY_SERVICE);
	NetworkInfo NInfo = CManager.getActiveNetworkInfo();
	if (NInfo != null && NInfo.isConnectedOrConnecting()) {
		return true;
	}
	return false;
}

class LoadAllCourse extends AsyncTask<String, String, String> {
	@Override
	protected void onPreExecute() {
		// TODO Auto-generated method stub
		super.onPreExecute();
		pDialog = new ProgressDialog(SyncBySemester.this);
		pDialog.setMessage("Sync Courses...Please Wait...");
		pDialog.setIndeterminate(false);
		pDialog.setCancelable(false);
		pDialog.show();
		// Toast.makeText(getBaseContext(), "ending pre exercute",
		// Toast.LENGTH_LONG).show();

	}

	@Override
	protected String doInBackground(String... arg0) {
		// TODO Auto-generated method stub

		// building parameters
		List<NameValuePair> params = new ArrayList<NameValuePair>();
		params.add(new BasicNameValuePair("semester", semester));
		// getting the Json string From the URL
		JSONObject json = jParser.makeHttpRequest(url_all_course, "GET",
				params);
		// Check your log cat for JSON reponse
		Log.d("All Products: ", json.toString());
```

```
try {
        int course_success = json.getInt(TAG_COURSE_SUCCESS);

        // .getInt(TAG_COURSE_CATEGORY_SUCCESS);
        /*
         * BocDatabase db = new BocDatabase(GenderWeight.this);
         * db.open();
         */
        if (course success == 1) {

                course = json.getJSONArray(TAG_COURSE);

                // insertin in Sqlite
                for (int i = 0; i < course.length(); i++) {
                        JSONObject jObject = course.getJSONObject(i);
                        String courseName = jObject.getString(TAG_COURSENAME);
                        String courseCode = jObject.getString(TAG_COURSECODE);
                        String courseOutline = jObject.getString(TAG_COURSEOUTLINE);
                        String courseNotes = jObject.getString(TAG_COURSENOTES);
                        String instructor = jObject.getString(TAG_INSTRUCTOR);
                        String yearofstudy = jObject.getString(TAG_YEAR_OF_STUDY);
                        String semester = jObject.getString(TAG_SEMESTER);
                        Log.e("fetching data", "done fetching");
                        SQLiteHandler b = new SQLiteHandler(
                                        getApplicationContext());

                        b.InsertData(courseName, courseCode, courseOutline,
                                        courseNotes,instructor,yearofstudy,semester);
                        Log.e("inserting data", "done inserting");
                }
        }

        else {
                errors += "Could not Load the selected files ... Please Try Later";

        }
```

APPENDIX 5: ACADEMIC PAPER ACCEPTANCE LETTER

Academic Paper Acceptance Letter

Dear Michael P.J. Mahenge and Joseph W. Mwangoka,

It's my pleasure to inform you that, after the peer review, your paper,

Synchronization and caching solution for cost-effective e-learning in resource and bandwidth constrained environments

has been ACCEPTED with content unaltered to publish with **Journal of Information Engineering and Applications**, ISSN (Paper)2224-5782 ISSN (Online)2225-0506.

In order to fit into the publishing and printing schedule, please re-submit your complete publication package by directly replying this acceptance email within 15 days so we can make your article available online/print in the next issue (usually at the end of each month). If you failed to prepare your complete files on time, the publication of your article might be delayed.

Though the reviewers of the journal already confirmed the quality of your paper's current version, you can still add content to it, such as solidifying the literature review, adding more content in the conclusion, giving more information on your analytical process and giving acknowledgement.

To help the editor of the journal process your final paper quickly, you need to prepare your paper based on the attached "publication_package_instruction.pdf".

Again, thank you for working with IISTE. I believe that our collaboration will help to accelerate the global knowledge creation and sharing one step further. IISTE looks forward to your final publication package. Please do not hesitate to contact me if you have any further questions.

Sincerely,

Alexander Docker,

Friday, September 05, 2014

Editor-in-Chief
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