Measuring Computing Research Excellence and Vitality

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Measuring Computing Research Excellence and Vitality

Editors

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Preface

Measuring computing excellence and vitality has become an important approach to understanding sustainable information and communication technology (ICT) for societal transformation and development around the world. In particular, developing countries are being encouraged to invest in ICT infrastructure so that they might experience the expected future social and economic benefits. This book is aimed at developing an integrated framework for measuring sustainable research excellence and vitality in computer science, in Uganda and the immediate African regions. Improving the sustainability and vitality of research capacity has become an important problem in information communication and technology (ICT), and more specifically computing research in the higher education setting for both developed and developing countries. There is little research on the factors that influence research excellence and vitality in computer science.

Measuring Research Excellence and Vitality in Computing

Sustainable development was first proposed in the late 1980s as a theory and concept of development. To many proponents of this theory, it provided an alternative but holistic vision of their future nation-states. The World Commission on Environment and Development defined sustainable development as the development that meets the needs of the present generation without compromising the needs of the future generations. Although this concept was thought at first to be a developmental issue only, today it has become an absolute necessity in every field, including computer science. After all, the process of bringing sustainability awareness to different cultures and nations depends on excellence in teaching and research in higher education. This leads to improvements in the quality of life while at the same time creating wealth in nation-states. Higher education institutions have an important role to play through teaching and research in helping to bring about sustainable development theories in supporting communities to improve their livelihoods.

In computer science, the concept of sustainable development is viewed in terms of the way teaching and research are interdependent in an effort to solve problems through efficient and effective design, implementation and improvement of existing systems or solutions relevant to real-world problems in improving the quality of life or creating wealth in nation-states. The above concept means that research-based teaching in computing must address the design tasks faced by practitioners. At the same time these real-world problems must be properly conceptualised and represented and appropriate techniques used in their construction. For computer scientists to accomplish these tasks it means that they must constantly build, evaluate, theorise and justify the same theories, models, methods and artefacts in the research process. This further means that for computer science artefacts to support sustainable development must be conceptualised as 'dynamic' – constantly evolving – rather than as a static entity that is complete at a point in time. Evaluating computer science /information technology artefacts provides an opportunity to determine whether the subject has made any progress. How well progress has improved in turn can be evaluated by the development of metrics and the measurement of artefacts according to those metrics. Some researchers have concluded that the lack of metrics and failure to measure artefact performance according to established criteria result in an inability to effectively research efforts. For higher education institutions to effectively conduct evaluate their own cumulative artefacts, funding from governments and other funding bodies must continue to sustain capacity development in terms of teaching, research and extension work.

The Objectives of This Book

This book contains the edited proceedings of the first international conference on sustainable ICT capacity in developing countries, with the theme 'Measuring Sustainable Research Excellence and Vitality, held 9-12 August 2005 (SREC'05). The objective of this series of annual conferences is to promote international cooperation in ICT research excellence and vitality among researchers, academics, and ICT development practitioners by creating a greater understanding of the need for sustainable ICT capacity issues in developing countries, and by sharing current research, through academic and industrial experiences. SREC'05 attracted papers on a wide range of topics and from many countries.

Who Should Use This Book?

The book is aimed at researchers, academics, ICT managers and policy developers. It is structured around topics that are relevant to developing countries. It has text emphasis, illustrations and an effective glossary of the terms frequently used in ICT research and practice. Libraries, universities, developing countries, research organisations, government ICT regulators, development organisations, ICT companies, NGOs in development, and telecommunication companies will find this book valuable to their work.

Distinctive Features

To reinforce learning and easy reading, the book contains a number of tables, diagrams, text boxes and other illustrations. The twenty-two chapters covered in this book provide a broad spectrum of key topics of practical experience and research in computing in developing countries. These chapters are organised in eight sections:

Part One: Measuring Research Excellence in Computing

Part Two: Computing Research in Higher Education

Part Three: Strategic Planning and Quality Assurance in Higher Education

Part Four: Sustainable Information and Communications Technology Development

Part Five: Research Approaches in Information Technology

Part Six: Gender Information and Communications Technology Development

Part VII. Software Architecture and Web-based Systems

Part VIII. Information and Communications Technology Policies in Developing Countries

The book also provides a unique review of key terms used in computing and ICT research in the form of a glossary. An index has also been provided to enable quick search of key words.

How to Use This Book

Very few journals or books cover topical areas of research in the sustainable development of ICT in developing countries. Neither these journals nor books explore excellence and vitality of ICTs for sustainable development. The book also can be used specifically to support the learning and teaching of computing and related ICT research subjects, including final-year BSc Information Technology, MSc Advanced Information Technology, MSc ICT Policy and Regulation, and as a key reference text for ICT research.

Acknowledgements

We are grateful to the contributors to this book which contains the edited papers containing the proceedings of the first international conference on sustainable ICT capacity in developing countries, with the theme 'Measuring Sustainable Research Excellence and Vitality' (SREC'05), held on 9-12 August 2005, organised by the Faculty of Computing and Information Technology, Makerere University, Uganda. The editors would like to thank the School of Graduate Studies, Makerere for the financial support it provide to produce this volume.

These book chapters are copyrighted in terms of papers. Every effort has been made to acknowledge the owners of other copyright material. However, copyrights of papers remain with the individual authors of chapters. Please note that these book chapters may not be reproduced, transmitted or stored electronically without the express permission of the copyright owners. We are grateful to the reviewers for the excellent job they did in providing superb comments to individual authors to improve their papers which are presented in this volume. The editors would also like to thank Linda Wandira and Hassan Ssozi for their contribution towards ensuring that the book is completed.

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February 2006

Part One

Measuring Research Excellence in Computing

1

An Investigation of Heads of Computing Departments in Higher Education

Ddembe Williams and Venansius Baryamureeba

Over twenty-five computing departments have been established in East Africa since 1970. Most of these were established from 1985. The purpose of this research was to survey the current research activity and the level of contributions of these departments in terms of computing excellence. Notwithstanding the rapid advances in computing research and Information and Communication Technology (ICT), a growing gap indicates that higher education institutions in developing countries still lag behind. Two potential causes of this lag is lack of academic research networks between developed and developing countries, higher education institutions and lack of sustainable research strategies among computing departments in developing countries. A survey finds that developing a framework for measuring computing research excellence and vitality in developing countries might help research collaboration and networking with business organisations and government funding agencies that can sustain computing research excellence. However, the survey finds that the heads of computing departments do not view key computing sustainable strategies the same way. Williams and Baryamureeba argue that this difference in sustainable computing strategies in developing countries is a possible source of lag behind their counterparts in developing countries.

Introduction

The measurement of research excellence and vitality within academic disciplines, and computing in particular, has become an important area of research and professional practice. In computing, the concept of sustainable development is viewed as the way in which teaching and research are interdependent in an effort to solve problems through efficient and effective design, implementation and improvement of existing systems or solutions relevant to real-world problems. These solutions are aimed at improving the quality of life or creating wealth in nation-states. The above concept means that research-based teaching in Computing (Computer Science, Computing Engineering and Applied Computing) must address the design tasks faced by practitioners. These real problems must be properly conceptualised, represented and appropriate techniques used in their construction (March and Smith, 1995). For computer scientists to accomplish these tasks means that they must constantly build, evaluate, theorise and justify the same theories, models, methods and artefacts in the research process. This further means that for computing artifacts to support sustainable development they must be conceptualised as 'dynamic', constantly evolving, rather than as a static entity that is complete at a point in time (March and Smith, 1995). Evaluating computer science

/information technology artefacts provides an opportunity to determine whether the subject has made any progress. How well progress has improved in turn can be evaluated by measurement of artefacts according to defined metrics. March and Smith (1995) conclude that "lack of metrics and failure to measure performance according to established criteria result in an inability to effectively measure research efforts" (p. 258). For higher education institutions to effectively evaluate their own cumulative artefacts, funding from governments and other funding bodies must continue to sustain capacity development in terms of teaching, research and professional work.

The rest of this chapter, which presents an analysis of a pilot survey of four university computing departments, was first performed to formulate a research model and an experimental survey instrument. The demographic characteristics of four departments located in three countries are discussed. The research scope and research capacities are also described. Finally, the wide range of departmental activities, including research publications, seminars, workshops, PhD research programmes and current research themes, are discussed in detail.

Related Research

Computing research critically contributes to the creation of wealth, health and well-being and underpins numerable developments that enhance our quality of life. The Royal Academy of Engineering highlights that "... though the contribution of computer engineering to our quality of life may often be drastically underestimated, computer engineering enables us to surf the Internet, use mobile phones, manage transport networks and systems of trading in goods and finance besides other disciplines" (RAOE, 2003). In their further analysis, the Academy categorised computing research as the generator of a bank of knowledge and information that feeds future computing development. In other words, computing research creates the understanding and insight required for design and development of new computing systems. It is therefore axiomatic that a framework for sustainable research capacity in computing be defined, implemented and integrated in national research strategies, bearing in mind that research is a continuous and interactive process whereby any new information is fed back to the appropriate stage of design or development in order to refine the output.

Although research excellence is based on a large number of stakeholders, expertise and funding resources, research collaboration, institutional cooperation/networking and coordination are vital to its sustainability (*UNU Monitor*, 2003). Computing research requires large capital investments, and thus regional coordination among computing departments is vital for sharing resources such as infrastructure and human expertise that aids good research performance focused on stakeholders' (students, companies, investors, the community, government and financial analysts) satisfaction.

Collaboration

According to the *UNU Monitor* (2003), networking is a relatively new programmatic and pragmatic concept based on the voluntary alliances of universities or research institutes who understand that their own autonomy and independence will best be served by working together (*UNU Monitor* 2003). There is a need for integration through collaborative networks, especially in the field of computing and research. There is need to establish extensive research networks, with institutions around the globe. By sharing knowledge and research data, departments are able to achieve our goals faster and more efficiently. According to Bozeman et al. (2004) a wide variety of factors, including inter-institutional structures, formal and informal research networks, research alliances and covenants, arrangements for sharing expensive or scarce scientific resources and equipment, govern collaboration choices (Bozeman et al, 2004). The concept itself has some strengths and weakness. Bozeman et al, (2004) points out the key advantages as a measure of collaboration, including its verifiability, stability over time, data availability and ease of measurement. But they also note that co-authorship is not a more partial indicator of collaboration, for instance Hagstrom (1965) found evidence that some publications listed authors for purely social reasons. Sometimes a researcher may be listed as a co-author simply by virtue of providing material or performing a routine assay (Bozeman et al.,2004).

Funding

In order for research to be geared towards sustainability and excellence, it is important that funding of the research be given high priority and consideration. Most computing departments in East Africa are not in themselves self-sustaining as far as funding research projects is concerned. This means that the lack or inadequency of funds has made it very difficult for them to realise their goals of aiming towards sustainability and excellence. In this section we shall discuss the factors that have been great obstacles to funding and also suggest possible courses of action.

Many computing departments have received little or no funding at all over the past years. According to the *UNU Monitor* financing of institutions has been difficult in most countries during the last ten years. Future prospects are predicted not to be any rosier (*UNU Monitor,* 2003). This could be attributed to the politically motivated and donor- driven policies of the governments rather than the outcomes of empirical investigations. It is also easy to notice that most government departments charged with implementing policies are by culture not research-oriented. Besides that until the 1990s many higher institutions of learning, for example Makerere University, were more of teaching and undergraduate universities than research centres. Even today research is construed more as an income-supporting and career-promotion avenue activity than a critical inquiry aimed at unearthing the intricacies of phenomena and meeting the needs of society. This probably explains why local computing researchers have not yet formed formidable bodies or professional associations that could lobby the government to recognise the importance of sustainable research excellence and develop a culture of funding it.

Besides that, the problem of not knowing has constrained computing research. For, with the exception of those that put up adverts calling for research proposals or pre-proposals, the others are not well publicised. Even when researchers know the addresses of the funding agencies, the latter's mandate is often narrowed to specific research areas. Thus researchers with interests outside the mandate of the funders may not acquire funding. Furthermore, some funding agencies take too long to approve and release research funds. By the time the research funds are released the phenomena the researcher had intended to investigate could have been overtaken by events. This renders the research findings practical and immediate applicability less relevant. There is also a lack of forums that could enable researchers to receive feedback on their capabilities and weaknesses, hence improving on the quality not only of their proposal writing but also of their research products, which could in turn ease their bids for research funds. Owing to this handicap consultancy firms, which are better organised outcompete the individual researchers who may at times be more competent to conduct the researches in question.

The majority of the researchers do not keep abreast of current literature, methodologies and analytical modules largely owing to the inability to acquire current literature on a regular basis. Major libraries both in institutions of learning and in government ministries, do not make regular subscriptions to journal publishers, hence literature supply is erratic. Nonetheless, the low availability of current literature, methodologies and analytical modules not withstanding, researchers lack the motivation to search for the former or utilise whatever little or "out-of-date" literature is available.

The actual or assumed availability of current literature is therefore affecting the computing research manpower quality in most departments. This is exhibited in inadequate proposal writing skills and reckless and poor quality proposals submitted to donor agencies. These types of proposals stand little chance of securing funding from highly competitive research funding environments, for to the funders the poorly written proposals implies that the data collection, analysis and final report would be equally as poorly done, thereby not meriting the risk of providing the research funds.

Poor infrastructure has also been a stumbling block to funding. Many computing departments do not have, say, high computing laboratories to support computing research. The few computers available are used as word processors instead of research aides. Most research softwaresuch as spreadsheets, ethnography, EPI, INFO, and SPSS are either not installed in most computers, or where they have been installed, they are foreign to many researchers who have not received training in their application.

Supply of skilled labour

The future of national wealth-creating capability depends substantially on the knowledge and skills of the working population. (RAOE, 2003). This means that it is vital that computing departments supply skilled ICT graduates to business and industry. It is important also to introduce advanced research methodology as a subject in computing research. At degree level modernisation of university degree courses through incorporation of subjects such as business and communication skills into the syllabus could help to broaden the appeal of engineering (computing) as well as produce well rounded graduates.

Gender and computing

In as much as some governments like Uganda have gone a step further in supporting gender equity and equality in higher institutions of learning, much more has to be done in supporting women in ICT courses. Multiple approaches are needed to target school-age children, university applicants and students, women who are already taking career breaks or returning form career breaks (RAOE, 2003). The Academy proposes that grants should be made available for women returning to work after career breaks to undergo a short, intensive period of training to update their skills and knowledge, and women taking career breaks should be given access to relevant journals and other sources of information to enable them to keep abreast of important developments during their time away from work.

Centres of expertise and excellence

It is very important to build centres of research excellence. However, rather than attempting to artificially induce or assemble centres of excellence, existing centres of excellence should be supported and promoted (RAOE, 2003). Centres of excellence are usually created by a set of exceptionally able people who for one reason or another find themselves in the same place. Virtual centres of excellence can also evolve as a result of strong relationships between outstanding individuals or departments located in geographically dispersed locations. According to UNU (2003), the centres of expertise are developed in order to increase connections and networks between companies and researchers of the universities and research institutes. Combing different sorts of skills and knowledge in centres of expertise it is possible to solve serious practical problems critical to the economic and social development of changing societies (UNU, 2003).

Research Methodology

A survey of computing departments in East Africa and their perceptions on sustainable research excellence was conducted to ascertain the initial model in Figure 1. Thereafter detailed interviews were conducted with heads of computing departments to ask pertinent questions about the nature of and their perspectives on sustainable research excellence. Action research (Losekoot et al. (2001), March and Smith, (1995) and Kock (2001), seem best suited for this type of research, since it is vital that we investigate the phenomenon of sustainable research excellence in its own natural settings.

In evaluating computing departmental research excellence, an initial stage should consider government and university computing departments' mission statements. In the UK, The Royal Academy of Engineering (RAOE, 2000) suggests research assessment in the field of science and technology should be linked to EPSRC's general statement and mission (Segovia and Galang, 2002). This means any research assessment should be performed in relation to mission statements (Epstein and Roy 2001; Segovia and Galang, 2002; and RAOE, 2000).

Subjects

A total of 42 academic staff across East Africa in computing departments were randomly selected from three regional universities: the University of Nairobi, University of Dar-es-Salaam and Makerere University. Twenty-seven academics returned the survey for a response rate of 63%. Table 1.1 shows the respondents' demographic information. A wide variety of academic positions and roles within computing departments are presented. Information related to length of service, publications and research students' supervision are also presented. As can be seen from the demographic data of respondents, a wide variety of academic positions within computing departments is represented.

Table 1.1: Summary of Respondents' Demographics

Demographic	Category	%
Academic Level	Head of Department	75
	Professor and Associate Professor	36
	Senior lecturer	18
	Lecturer	33
	Assistant Lecturer	51
Gender	Male	85
	Female	15
Years of Service with Department	1 Year	7.4
	2 Years	14.8
	3 Years	22.2
	4 Years	14.8
	7 years	26

Organisational Data

Table 1.2 shows characteristics of computing departments employing the respondents. thirty-six percent of respondents were either Associate or full Professors, while Senior Lecturers were only 18%. Gender balance is also still a big problem in many East African universities as illustrated; only 15% of respondents were females. Length of service in these departments also shows interesting trends: only 26% of respondents had been with the departments for over seven years of service meaning that these are all new departments in their respective universities.

In terms of organisational size-respondents from both Nairobi and Dar-es-Salaam constituted 26% each while those of Makerere represented 48%.

Table 1.2: Organisational Data for Respondents in Computing Departments

Measure	Category	%
University	Nairobi	26
	Dar-es-Salaam	26
	Makerere	48
Highest Educational Level	BSc/BA	11
	MSc/MA	55
	MBA	4
	PhD	26
	DSc	4
Current Area of Expertise	Scientific Computing	18
	Software Engineering	18
	Information Systems	33
	Networks	26
	Distributed Systems and Artificial Intelligence	30
	Simulation Modelling	5
Nature of Publication	Learned Refereed Journal	10
	Refereed Conference Paper	11
	Professional Journal Publications	6
	Patent Publications	3
Nature of the Research Activity	Study of what is possible (including bio mathematical modelling)	52
	The study of existing naturally occurring information processing systems	52
	Research involving creation of new useful information processing systems	70
	Ccreation and evaluation of tools, formats and techniques to support all activities	52
	Social and economic issues, e.g. IT investment, Ethical and legal issues	52

In terms of highest academic qualification, only 11% of respondents had only the first degree. These constituted mainly teaching assistants and assistant lecturers. While the largest number had a masters degree qualification (50%), a good number also had PhDs (26%). This demonstrates that the computing departments are still young and growing.

In terms of academic area of expertise, six areas were sited: Scientific computing (18%), Software Engineering (18%), Information Systems (33%), Networks (26%), Distributed Systems and Artificial Intelligence (30%), and Simulation Modelling (5%).

Perceived Measures of Research Excellence

Research outputs in computing departments in terms of publications are still on the lower side. Only 10% of the outputs appeared in international journals. In terms of research activity in the three computing departments, several respondents (70%) stated that they were engaged in the creation of new useful information processing systems. This is consistent with departments' measures of research excellence as illustrated in Table 1.3.

Table 1.3: Measures of Research Excellence in Computing Departments

Measures	Mean (Average)	Rank
Computing research influences stock of useful knowledge	4.32	5
Computing research contributes to wealth-generation in terms of increasing trained skilled graduates	4.50	2
Computing research creates scientific tools and methods	4.33	3
Computing research develops research networks and stimulates social interaction	4.33	3
Computing research increases the capacity for scientific and technological problem-solving	4.52	1
Computing research creates new spin-off companies in the form of technology transfer	4.09	6

Conclusions

An investigation into the current computing research excellence and the level of contribution of computing departments in four East African universities is presented. A survey found that heads of computing departments have a favourable attitude towards computing research excellence and vitality in the region. However, the literature on computing research excellence shows a growing gap in higher education institutions in developing countries. Two potential causes of this lag is lack of academic research networks between developed and developing countries, higher education institutions and lack of sustainable research strategies among computing departments in developing countries.

A survey finds that developing a framework for measuring computing research excellence and vitality in developing countries might help research collaboration and networking with business organisations and government funding agencies that can sustain computing research excellence. However, the survey finds that the heads of computing departments do not view sustainable key computing strategies the same way.

The authors argue that this difference in sustainable computing strategies in developing countries is a possible source of the lag behind their counterparts in developing countries.

While quite revealing, the study does have limitations. These include the relatively small sample sizes in this and prior studies. However, the rankings used are more robust owing to their ordinal nature. Perhaps a longitudinal study may discover strategies employed by heads of departments to address these gaps. Sustainable research capacity in the field of computing is vital. In this chapter the authors have placed emphasis on collaboration, interdisciplinary research, funding and curriculum development in computing. While we were not able to exhaust all the factors that constitute research excellence, we believe that the key factors discussed in this paper will be very useful for computing departments to gear their research towards excellence and vitality.

Kock [6] suggests that conducting organisational action research involves helping an organisation in solving its problems and becoming "better" in terms of key attributes such as productivity and quality of services/products. Immediate beneficiaries of this research are computing departments in developing countries, particularly those pursuing establishment of centres of excellence. Measuring research excellence is increasingly viewed by research grants awarding bodies worldwide as a viable approach to determine the quality of research and its contribution to cumulative scientific knowledge. However, an important obstacle for many computer science departments in developing countries to accessing foreign research funding is that they have no research assessment performance levels of these departments. The work proposed will be of interest to the international community and in particular higher education institutions and research awarding bodies for international collaborative projects. The research will also benefit East African universities in general, in strengthening their computing sustainable research capacity and competitiveness. In future such frameworks can also be generalised to other disciplines to develop specific measures of excellence.

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Part Two

Computing Research in Higher Education

2

Towards Enhancing Learning with Information and Communication Technology in Universities

Farida Muzaki and *Ezra Mugisa*

This chapter explores the expansion of higher education institutions in many developing countries and the corresponding increase in the student population. Putting in place adequate facilities to accommodate the increased numbers of students is very costly. This is particularly true in developing countries of the world where universities are constrained by inadequate funding. In this context great expectation lies in using online learning to enable access to learning resources, provision of instruction and guidelines to learners and for communication between learners and instructors without the two being in the lecture room physically. Online learning provides a strategy to respond to the three major challenges in the provision of university education: cost, demographics and quality. Farida Muzaki and Ezra Mugisa look at how online learning can be adopted in universities and a framework for adaptation is suggested. The framework will identify key areas where centrally coordinated national initiatives are required to enable adaptation of online learning. The framework will be based on the Bates ACTIONS model. Specific organisational issues and existing infrastructure will also be considered. The ACTIONS model looks at access, costs, teaching functions, interaction and user-friendliness, organisational issues, novelty and speed of course development as some of the factors organisations should consider before implementing online learning.

Introduction

Delivering courses via online methods has increasingly become an important issue for universities and an area where a call for research on the implementation challenges and problems has been emphasised. Over the last decade there has been a tremendous shift from conventional teaching and learning to modes where the Internet now plays a key role. Online learning is increasingly forming an integral part of course delivery and instruction, and is shaping traditional learning worldwide (Damonse, 2003). This is due to the ever-increasing number of secondary school leavers. The governments of many countries are expected to expand their higher education institutions to absorb these students. However, putting in place adequate facilities such as lecture rooms as a solution to the problem is very costly. This is particularly true with regard to the poorest countries of the world where inadequate funding is the norm (Zarummai et al., 2004).

Why universities in Uganda should use online learning

Globalisation has made the process of planning for national systems of university education very difficult. Any local planning that does not take into consideration global forces is bound to fail. We seem to be living in a borderless world where whatever happens in one corner of the world affects us all.

It is important to note that higher education is part of the engine of the technology that has brought about globalisation (Kasozi, 2003). Universities have to follow and adapt global education trends in technology and innovation in order to produce graduates that are multiskilled and competitive in the modern workplace (Damoense, 2003).

Higher education systems all over the world are taking advantage of online learning in education delivery. Online learning provides a strategy to respond to the three major challenges in the provision of university education: cost, quality and demographics.

Private universities depend entirely on fees collection to offset institutional expenses while financial support for public universities from government is inadequate and reducing every year. This means that there is need to match improved quality with the limited financial resources that are available.

Maintaining/improving quality with increasing numbers of students can only be effected with fundamental changes in academic instruction and learning how to use new tools and methods. Universities are being evaluated against a different set of standards from those of the past. The emphasis is on outcome. Higher education is judged by what students have learnt, not what they have been taught.

A big percentage of university students are working adults. These students are "place-bound", therefore this dictates that the "classroom" should not be constrained by time and place.

As Bennett et al. (Bennett et al., 1999) points out the "Virtual Campus" may lead to savings in both real estate and teaching costs. Indeed with the ever-increasing advancement and integration of computer and telecommunication technology, online learning can greatly enhance learning by providing access to learning resources, providing instruction and guidelines to learners and for communication between learners and teachers without the teacher and the student being in the lecture room physically.

Challenges to be Addressed

The most serious challenge posed to higher education is the rapid expansion of university enrolments (Kasozi, 2003; Zarummai et al., 2004) yet the educational institutions do not have enough funds to acquire the facilities needed to deliver quality education to increased numbers of students.

The system currently in use, especially in universities in developing countries, is that of only face-to-face lectures, because of the rapid increase in the student populations. Lecture rooms, textbooks, and laboratories are not enough. Given the problem of inadequate facilities, online learning can greatly enhance learning by providing access to learning resources, providing instruction and guidelines to learners and for communication between learners and teachers without the teacher and the student being in the lecture room physically (Zarummai, et al., 2004). Unfortunately the majority of the universities have not set strategies/policies to address factors such as resistance to change, inadequate skilled personnel, infrastructure, among others, that are barriers to the implementation of online learning (Tusubira and Mulira , 2004).

Universities must address issues related to the majority of the students being working adults and inadequate facilities with the use of online learning, so that learning can be separated from the current norm of place and time. That is, course materials are made available to students any time, anywhere. But before universities can embark on putting in place online learning there is need for a clear framework, which acts as a basis on which decisions on online learning are made. In dealing with this problem this paper looks at the following:

- What kinds of techniques are used for online learning by other universities?
- How can these techniques be adapted to universities in Uganda?

We then propose a framework for adaptation of online learning in Uganda.

Literature Review

In this section we attempt to provide the scope and depth of the literature on online learning. Whereas the focus is enhancing learning with ICT in universities, the phenomena are treated more generally.

Online learning has been used by universities in Australia, the United States, the United Kingdom , Canada and other places to supplement face-to-face teaching and enhance learning (Housego and Freeman, 2000). It has also been pointed out by Bennett et al. (Bennett et al., 1999) that there is growing interest among Australian universities in the use of the Internet and World Wide Web for teaching and learning. The following are some of the universities currently using online learning:

- University of Western Sydney.
- Open University, United Kingdom.
- University of Phoenix.
- University of South Australia.
- Massey University

It should be observed that the need to cope with increased teaching loads and dwindling resources is one of the reasons why universities have began incorporating online learning in higher education in recent years. This is supported by Zarummai et al., (2004) who argue that in many developing countries government expenditure on university education is reducing every year.

Housego and Freeman (2000), in their case studies on integrating the use of web-based learning systems into student learning, found that integration of web-based learning systems in teaching and learning can be done in a number of ways. These include improving access to information and resources, use of frequently asked questions and announcements to improve administration, providing additional discussion forums for feedback and social chat, among others. They also found that the most effective uses of technology-supported teaching are possible when underpinned by student-centred teaching practices that encourage students to adopt a deep approach to learning.

Bennett et al. (Bennett et al., 1999) studied staff development options for online teachers and present a model in which a first-hand experience of online learning becomes the basis upon which university teachers can build to form their own ideas about a particular approach to teaching and learning online. They found out this method provided a genuine learning context allowing staff to experience online learning as students would. The success of this approach as a preliminary staff development tool suggests that for academic staff with little experience of teaching and learning using the Internet, learning about online learning should begin at the first point with hands-on experience of an online course. Participating in such a course and having the opportunity to reflect on and critically appraise it enable staff to draw upon their own teaching knowledge and experience in face-to-face modes and make connections to the new medium. This experience can then become the basis for subsequent staff development programmes focusing on technological issues specific to individual contexts.

Zarummai et al. (Zarummai et al., 2004) highlight the deployment of free open source software tools for distance e-learning in African universities. They observe that given the limited financial resources and capabilities, open source software provides a way for African educational institutions to help themselves, not to wait for the First World to provide help. This will help African countries to leapfrog into the information age through reduced costs, less dependence on imported technology and its ability to be customised to local languages. Moreover, by giving users access to its inner workings, open source software could stimulate the local software industry.

In a study by Ladyshewsky (2004) he found that student performance in online learning environments is in some cases better when compared to face-to-face mode of delivery. He emphasises that when a high degree of pedagogical thought goes into the design and delivery of online learning, and is supported by adequate resources, students can achieve positive educational outcomes. But it is important to observe that to ensure that there is a pedagogical focus to a unit that is offered in technologically supported learning environments, a variety of principles should be followed. These principles include: student-teacher contact through email and bulletin boards, active learning techniques which involve problem solving, inquiry, and project based tasks, prompt feedback, both person-to-person and within the group, communication of high expectations by making criteria and learning outcomes explicit, time on task which involves fostering awareness of time constraints and making contributions relevant, respect for diverse learning communities, learners are given freedom to control and explore, and reciprocity and collaboration among students.

Matovu (2003) carried out a study on information and communication technology issues in Uganda's education sector in the central region. His findings and conclusions were that there are still many challenges facing ICT spread in the education sector. He highlights the challenges as initial capital being prohibitive, high recurring expenditure and inadequacy of technical personnel. However, it should be observed that he investigated the level of computer literacy and competence among employees in the education sector. He did not investigate online learning in universities. This renders his study of little use for the enhancement of learning with ICT in universities.

Kasozi (2003), in a study of the capacity of African universities to participate in global higher education supply and production, surveyed tertiary institutions in Uganda. He considers computers and Internet access as indicators of the capacity to generate knowledge. The study found that the average computer-to-student ratio for institutions surveyed was one computer to over fifty students. The study also found that the ICT infrastructure of the institutions surveyed was extremely weak. However, the study did not go ahead to investigate staff access to computers, which is very relevant to this study.

Mulira (2004), in an ongoing study, looks at a service approach to information systems implementation in institutions of higher learning. The study highlights that the services-based approach to information systems implementation proposes a solution that will mitigate the socio-economic inhibitors that have led to the negligible efficiency gains in the deployment of automated information systems.

Research Methodology

A descriptive survey design was used for the study. Data was collected through document analysis. We chose this method because, given the nature of this study, it provides valuable information about the problem. According to Krishnaswami (Krishnaswami, 2002) document analysis is a research technique for making inferences by objectively and systematically identifying specified characteristics of contents of documents.

Articles and surveys in the literature of online learning implementation in universities was used to develop the theoretical framework.

This research takes the case of Uganda's universities and explores how to develop a framework for adapting online learning techniques that are being used elsewhere in the world to enhance learning in Uganda's university education.

The population of this study consisted of universities in Uganda. These universities fall in two categories listed below:

- Public universities: Universities sponsored, ruled and funded by government. These include Makerere, Kyambogo, Gulu and Mbarara universities.
- Private universities: These include Nkozi, Nkumba, Mukono, Islamic University in Uganda, Kampala International University, Kampala University, Bugema, Namasagali, Ndejje and Aga Khan. These private universities have been founded and are owned by non-governmental organisations mostly religious organisations, or by private entrepreneurs. Most of the private universities are still very small and very fragile. They are not well funded.

Proposed Solution

This paper proposes a framework for the adaptation of online learning to the Ugandan environment.

A framework is a model that can be used to guide policy, decision-making or future strategic planning. It will provide a direction for the adaptation of online learning in Uganda's universities.

The framework will identify key areas where centrally coordinated national initiatives are required to enable efficient and effective online learning adaptation. It will also include a vision and set of principles for adaptation of online learning in Uganda.

We will develop a framework basing on the Bates ACTIONS model for organisational frameworks for consideration of educational technology. This model discusses access, costs, teaching functions, Interaction and user-friendliness, organisational issues, novelty and speed of course development/adaptation as some of the factors for consideration in the organisational framework for consideration of online learning. The ACTIONS model proposed by Bates (Bates, 1997) also focuses on institutional strategies.

Interim Lessons

Literature analysed in this study indicates that:

Online learning in universities where it has been implemented is not treated as an overnight task. It is accepted that the process takes time and resources and motivation is also an important consideration if the outcomes are to be of appropriate quality. For example, at Massey University in New Zealand, it has been left to individual colleges to decide, the extent to which online services are compulsory or voluntary for students and to what extent the teaching, servicing and communication with students is conducted online.

At Massey University staff training is run by the central computing support and training and development unit, with the help of instructional design consultants. These range from use of WebCT to creating effective online courses. This is because they have realised that providing a tool does not guarantee quality without proper instructional guidance. Lecturers are allowed a certain level of creativity and flexibility required to create courses. This means some online courses may use delivery platforms other than WebCT, or may create particular tools outside the WebCT environment to suit the individual needs. The university provides centralised support for WebCT, but individual colleges and departments can use other solutions as justified by the needs of individual programmes as long as there are adequate resources available to support that solution within the college or department.

Quality assurance in online learning and teaching at Massey University is the responsibility of the centralised online learning-monitoring group. This approach ensures that the rules are the same for all regardless of campus, department or course. The majority of the standards for the development, delivery, support, and assessment of online courses including instructional design still remain the responsibility of various central units. The quality assurance of actual curriculum and content and its adequacy to the overall programme remains with the departments and colleges.

At the University of South Australia they developed a system for online learning called University of South Australia network (Unisanet). This system is available to every staff member and all students. It accommodates as many courses as possible without further technical development. It involves linking of both existing corporate databases and custom-built data stores to webpages, operated through a standard web interface using web forms and wizards. These are prepared by the Unisanet project team and allow academic staff to create content and shape the teaching and learning arrangements of online subjects without requiring specialist or other necessary support.

At the University of Phoenix, all instruction is organised around a collaborative model that positions the instructor as a learning facilitator. Programmes are developed by faculty teams to ensure that course objectives and outcomes are presented in a sequence that builds both knowledge and confidence. This learner-centric approach is complemented by a customer orientation that places high value on all aspects of customer service.

Each student is provided with a team of specialised counsellors who work together from their respective areas of expertise to ensure accurate and timely assistance with enrolment, finance and academic services. The University of Phoenix offers complete degree programmes entirely online. This includes all administration, registration and acquisition of course materials.

The curriculum is outcomes-based and workplace-oriented. All faculty must be employed in the area they teach. Every student works in a study group or team to develop workplace skills such as critical thinking, teamwork and so on. Testing takes place to ensure that the students are learning and that faculty is teaching what they are supposed to teach. The curriculum is professionally developed on a master curriculum calendar and is assessed every year, ensuring that courses are kept up to date.

At the University of Western Sydney, webCT is the online learning software being used. The university has incorporated the theme of enhanced flexibility into a five-year strategic plan to provide high quality education offerings. The goal is to ensure there is online content for every unit of study by the end of 2005, and that every course would have at least one core unit of study that is completely online. A number of steps have been taken to ensure quick and acceptable implementation of WebCT. They had to ensure that WebCT is supported by the university's existing information technology infrastructure. A robust interface was developed between WebCT and other enterprise level systems, especially for student administration.The existing learning materials were consolidated from other systems to WebCT as quickly as possible by enabling staff to migrate content themselves.

An online support service for staff and students was established, creating business practices that embeded quality improvement and assurance measures.

Staff training addressed diverse needs since some staff had never used online learning before while others were well known online learning innovators. Two members of staff completed WebCT's certified trainer programme. These conducted workshops on maximising the use of WebCT, as well as identifying the best practices from across all colleges and schools. In particular attention was paid to ensuring that the learning management system is supported by the university's existing IT infrastructure.

Framework for Adaptation of online Learning

The proposed online learning adaptation framework portrays the issues that need to be considered when a decision on the adaptation of online learning is to be made. A framework is a blueprint or model that can be used to guide policy, decision-making or future strategic planning.

The ACTIONS model developed by Bates (Bates, 1997) will be used in coming up with the proposed framework.. The reason for the choice of the ACTIONS model is that it provides room for including the organisational issues, both external and internal, that are specific to a given institution. It also looks at the existing infrastructure of a given country and government initiatives as influencing factors in online learning consideration. However, in the context of a developing country like Uganda, the existing infrastructure, power supply, resistance to change, Internet access and access to computers are important factors that cannot enable us to implement online learning techniques as they exist in the developed world, and this calls for adaptation.

The ACTIONS model looks at the following issues:

Access

The minimum requirement for use of online learning is a computer, communication program and access to the Internet. Therefore issues of access to computers and the Internet both at home and at university should be considered. In Uganda very few university students have access to a computer and Internet at home. Universities must have enough computers on campus to enable students access to online learning materials.

Kasozi (Kasozi, 2003) observes that computers have increasingly become both exercise books and textbooks for University students. For every four students there should be one computer as well as access to the Internet. Students need at least six hours of computer hands-on-practice each day in order to gainfully use them.

In a study by Kasozi (Kasozi, 2003), it was found that in the academic year 1998/99 at Mbarara University of Science and Technology there where 10 computers for the 419 registered students. For about every 41 students there is only one computer. It is also important to observe that there is one Internet user for every 5000 people in Africa in (World Bank, 2000).

Costs

The costs associated with using online learning generally include capital costs for the purchase of equipment and operational costs as instructional development costs, staff costs, and maintenance costs.

It is important that the policy addresses the specifics of how funding will be raised to sustain services and systems. The key recurrent cost elements that should be considered include: cost of bandwidth, cost of maintenance of equipment and applications, recurrent cost of software licences, cost of replacement of equipment. It is important to note that a computer bought today must be replaced in three to five years' time.

Emoluments for ICT professionals have also to be considered; they are generally at levels that are likely to be higher than the average because of competition for the same human resource by the private sector.

The cost issues also impact on decisions such as whether or not to use freeware and to develop internal capacity for software development. It also impacts on the decisions of whether or not to outsource information resource management services.

Teaching and Learning

Bates (Bates, 2000) observes that "the best use of technology occurs when the academic not only has a deep understanding of the subject but also has an imagination and vision of how the subject could be taught differently with technologies". Technology-based learning is best served through teachers utilising a project management model, a central faculty development office, a problem-based approach, and show and tell demonstrations by peers. For the learner enhanced skills in analysis, argumentation, research and critical thinking as well as collaborative project work, and knowledge building are key educational benefits.

But it is important to note that in Uganda the number of people qualified to teach in universities in the whole country is limited and some staff are not fully or adequately trained to do their job properly.

Organisational issues

Online learning will require that a number of organisational arrangements be made and barriers removed.

There is need for such creation of awareness and changing of mindset within the University. Lack of awareness goes along with mindset in that people get stuck to old ways of doing things.

A key to addressing change of mindset is full involvement in the process of creating the online environment and getting key decision-makers to visit other institutions where online learning has been implemented and where its benefits can be seen (Tusubira and Mulira , 2004).

Organising workshops to create awareness can help in addressing awareness and mindset problems.

There is need for ongoing commitment and involvement of top management and the whole team.

It is important to make online learning responsive to the university vision and mission

Telecommunication Infrastructure

Online learning requires Internet access, and transmission of multimedia materials requires high bandwidth.

Universities can tackle some issues themselves. They can come together in order to buy bandwidth in bulk so as to reduce costs. To gain this kind of negotiating power, institutional leaders and IT departments must cooperate. Institutional managers should also have policies for using bandwidth sensibly by defining acceptable use. These cover the kind of data that may be transferred to and from the institution and the type of websites that may be visited.

Summary

Universities in Uganda have the challenge of responding to increased numbers of students leaving secondary school yet there has been no significant increase in funding from government.

This challenge can be resolved through adapting new methods of delivering higher education. Online learning can be used to overcome this challenge. But there is need for a framework that acts as a model in guiding the adaptation of online learning. This study is intended to come up with such a framework.

The findings from this study have not yet been concluded, the framework is not yet complete. However, the interim findings from this study provide universities in Uganda with what other universities in the world have done and this gives them a clear picture of how they can adapt online learning to the Ugandan environment, considering the cultural and economic differences.

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3

The Doctoral Programme in Computing at Makerere University: Lessons Learned and Future Improvements

Venansius Baryamureeba and *Ddembe Williams*

This chapter presents a doctoral programme in computing of Makerere University. It is a research and coursework education programme intended to inform investigators and build the academic field of computing with a comprehensive, multidisciplinary, interdisciplinary and integrative view. Indeed, computing and engineering offers a new design approach which calls for an interdisceplinary approach to research. We first developed an operationalisation of interdisciplinarity, followed by guided interviews and questionnaires. The findings of the study showed that students lack research skills and methodologies in computing. Coursework and dissertation was recommended as opposed to thesis for future improvements. The coursework is aimed at demonstrating an understanding and detailed philisophy and methodology of computing, data representation and procesing, which is directly related to the quality of results. The doctoral programme is intended to catalyse this approach as an academic discipline. Baryamureeba and Williams propose a PhD curriculum consisting of one year of coursework and two years of research. The curriculum is structured in such a way that by the end of the first semester the student will have an approved research proposal and by the end of the first year the student will have published at least a review paper in his/ her area of research. The main advantage of this curriculum is that students will be able to work independently after the first year and as a result they can finish their 2nd and/ or 3rd year at another university. This programme approach will help in producing highly qualified PhD holders in environments where sufficient PhD supervisors are lacking. The proposed PhD programme in computing with a focus on computer science, information technology, information systems and software engineering forms a framework that could be adopted and customised in any discipline where PhD supervisors are scarce yet the demand for PhD training is high.

Introduction

The Makerere University Council established Makerere University Faculty of Computing and Information Technology (CIT) on 19 January 2005 with four academic departments of computer science, information systems, information technology and networks. As a result the Institute of Computer Science, which was established by the Makerere University Council in 1985, was phased out and replaced by the Department of Computer Science within the CIT. The CIT now offers a wide variety of services ranging from teaching and research to consultancy to both the public and private sectors. With the vision of being a leader in ICT/computing training, research and consultancy services on the African continent, the Faculty of Computing and Information Technology is an innovative and market-oriented institution, pursuing inquiry, discovery and application through excellence in teaching and learning, value-added research, cutting-edge consultancy and vibrant student life. To address staff development needs within the region, the faculty started a doctoral programme in computing. The doctoral programme is expected to produce highly skilled and a specialised ICT labour force to cater for the sophisticated IT jobs in the ever-increasing ICT sector in Uganda in particular and the African region in general.

The current research and teaching on the doctoral programme are focused on four areas, namely Computer Science (CS), Information Systems (IS), Software Engineering (SE) and Information Technology (IT). These researches address both local and international needs. Many of the efforts are closely combined with other departments, faculties and universities in East Africa, UK, Norway, and the Netherlands, thus making the postgraduate education a high quality interdisciplinary and internationally collaborative programme. The faculty, in response to the high rate of growth of Information and Communication Technology (ICT) in Uganda specifically, and the African region in general, introduced a doctoral programme in computing in 2002. This was in order to sustain the high growth useful to the economy by grooming highly skilled and specialised ICT labor force to cater for the sophisticated IT jobs. The doctoral programme in computing was structured to enable students from the master's programme pursue further studies in the four areas, which are also the main focus of the master's degrees.

Within the CIT, the doctoral programme will provide the four departments with PhD holders in addition to the existing ones and those currently training abroad and in effect promote sustainable research excellence in computing in the long term.

The core staff on the doctoral programme in computing comprise CIT staff, visiting fellows and part-time staff with PhDs in relevant disciplines from both the private and public sectors. The Netherlands Organisation for International Cooperation in Higher Education (Nuffic) has provided a grant to support staff missions for professors from the University of Groningen and Radboud University in Netherlands in the areas of teaching and research.

The CIT is in advanced stages of beginning the construction of an 11,000 square metre building to provide more space for the doctoral programme and other programmes in the faculty. The Norwegian Agency for Development Cooperation (NORAD) provided support for the building that currently houses the programme.

The objectives of the doctoral programme can be summarised as follows:

1) To inform investigators and/ or researchers in computing at the highest level of excellence. The PhD graduates are expected to have a broad vision in the subject field of study, consciousness of the role of scientific research in economic development and social change, and ability to become champions in academia.

2) To allow students to develop philosophical and theoretical knowledge and analytical skills in the specific specialist areas defined by their taught units,

and ability to continue updating their knowledge and skills after completion of study in relation to scholarship and research.

3) To enhance the capacity of the CIT to serve as a scientific knowledge hub in sub-Saharan Africa.

The programme is dynamically designed to convey a wide spectrum of scientific and technological disciplines critical to computing, thus it is interdisciplinary and multidisciplinary in nature. The PhD programme emphasises the philosophy and methodology of the representation and transformation of information, including theoretical and experimental aspects.

Design Philosophy of the Doctoral Programme

As computing is developing and becoming more complicated and/ or sophisticated in ways of information processing, information itself is becoming a pervasive integrative theme across the sciences, humanities and engineering (Seguel et al., 2003). Critical questions that touch on the nature and flow of information arise, such as the design of self-optimising, self-healing software, and the logic of vision and perception, among others. In these examples and in many other science and engineering problems, information appears at many levels, and flows between many levels, shaping up information systems. We define information systems as a natural or artificial system whose properties, functionality, structure and /or interfaces are altered by or depend on informational phenomena. Informational phenomena, in turn, refer mostly to the nature and transformation of information, or information processing.

The PhD programme is a major attempt well beyond this scheme, *incorporating information and information processing methodologies and the science and engineering they serve, in a very intimate way*. The programme links researchers with a deep knowledge in a scientific discipline and provide them and their students with an adequate academic framework and the means of becoming creative agents for change. Thus the programme harbours a diverse group of researchers guided by common interests.

Case Studies

A doctoral programme in computing and information sciences and engineering of the University of Puerto Rico.

Structure of the Programme

The main rationale behind this PhD design is that computing cannot be separated from its ever-expanding range of applications without paying a significant price in scientific breadth and depth. Ultimately, this evolves out of collaborative research by computer scientists, engineers, scientists, social scientists and mathematicians. This approach will generate its own collection of research problems, methodologies and results.

This emergent body of science and engineering provides the framework for the doctoral programme. As a consequence of this emphasis on computing and engineering, the programme's coursework starts and consists of core courses in computing, namely:

PhD (Computer Science)

Data types, structures and abstract data types. Efficiency measures (average and worst case), rates of growth, asymptotic behaviour. Algorithmic paradigms (including enumeration, divide-and-conquer, greedy, dynamic programming, tree search, probabilistic). Algorithm design and analysis with correctness proofs. Data processing algorithms (sorting, searching, hash tables etc.); data mining. Numerical algorithms and analysis; statistical algorithms and simulation. Graph theory and graph theoretic algorithms (shortest paths, spanning trees, etc.). Symbolic computation. Other application areas, e.g. sequencing, scheduling and assignment. Parallel and distributed algorithms, implementation issues and efficiency measures.

Year One	**Semester I: 4 Courses**			
Code	Name	LH	CH	CU
	3 Core Courses			
MCS 9100	Philosophy of Computing and Information Technology	45	45	3
MCS 9101	Research and Project Proposal	45	45	3
MCS 9102	Advanced Research Methods in Computing and IT	45	45	3
	1 elective course			
MCS 9103	Managerial Problems in Information Technology	45	45	3
MCS 9104	Research Project management	45	45	3
MCS 9105	Gender and ICT	45	45	3
Year One	Semester II: 4 Courses			
	3 Core Courses			
MCS 9200	Philosophy of Science and Computing Research	45	45	3
MCS 9201	Presentations, Scientific Writing and Research Ethics	45	45	3
MCS 9202	Trends in Computer Science	45	45	3
	1 Elective Course			
MCS 9203	Trends in Information Systems	45	45	3
MCS 9204	Trends in Information Technology	45	45	3
MCS 9205	Trends in Software Engineering	45	45	3
Year Two	Semester One and Two			
	Independent Research and Dissertation Compilation			
Year Three	Semester One and Two			
	Independent Research, Dissertation Compilation and Defence			

The research in computer science will focus on areas such as human computer interaction, programming environments, distributed computing, natural computing, logic in computer science, algorithms and complexity, algebraic specifications, formal languages, language-theoretic modelling, computational geometry, modelling and simulation, artificial intelligence and expert systems.

Other research areas include:

(a). Bio-Informatics: The research on applying computers in solving molecular biology problems (crosscutting problems) is on the increase. The research will focus on areas such as the development of new methods and programs aiming at solving molecular biology problems. This will include analysis of nucleotide and protein sequences and structures; work on problems within functional genomics and especially on the analysis of data on the activity of genes and gene products (proteins); general techniques from a variety of fields will be used, including algorithm development, formal languages, databases and knowledge technology.

(b). Networks: The research will focus on areas such as Internet, network and computer security; the relationship between quality of service and e-commerce (e-business); network optimisation; traffic management, compression and optimisation; pricing issues in multi-service networks; and network architectural design.

A PhD in Computer Science will have a minimum of 24 credit units for the two semesters in Year One.

PhD (Information Systems)

The electronic handling of information is one of the defining technologies of our age. Enormous volumes of information are routinely stored and transmitted worldwide; indeed most aspects of our daily lives would come to a halt should the information infrastructure fail. However, with the benefits deriving from the ability to automatically manage so much information, come major threats to business, governments and individuals.

The research in information systems will focus on areas such as theory and intellectual development of information systems in organisations, institutions, the economy and society.

It will also focus on other areas such as e-governance: Internet governance, database design for nationwide information systems, security and trust issues in e- governance, public-private partnership for e-government, e-filing for content and knowledge management in government, application of expert systems in e-governance, impact of e-governance in decentralised district administration, electronic voting in developing countries, secure methods for electronic management of student academic records in a tertiary institution, systems development for e-government, e-tendering, a multi-level analysis of IT effectiveness in the government, e-governance and crime analysis, restructuring organisations in the era of e-governance, and e-training in e-governance.

Year One	Semester I: 4 Courses			
Code	Name	LH	CH	CU
	3 Core Courses			
MCS 9100	Philosophy of Computing and Information Technology	45	45	3
MCS 9101	Research and Project Proposal	45	45	3
MCS 9102	Advanced Research Methods in Computing and IT	45	45	3
	1 Elective Course			
MCS 9103	Managerial Problems in Information Technology Research	45	45	3
MCS 9104	Research Project Management	45	45	3
MCS 9105	Gender and ICT	45	3	3
Year One	Semester II: 4 Courses			
	3 Core Courses			
MCS 9200	Philosophy of Science and Computing Research	45	45	3
MCS 9201	Presentations, Scientific Writing and Research Ethics	45	45	3
MCS 9203	Trends in Information Systems	45	45	3
	1 Elective Course			
MCS 9202	Trends in Computer Science	45	45	3
MCS 9204	Trends in Information Technology	45	45	3
MCS 9205	Trends in Software Engineering	45	45	3
Year Two	Semester One and Two			
	Independent Research and Dissertation Compilation			
Year Three	Semester One and Two			
	Independent Research, Dissertation Compilation and Defense			

A PhD in Information Systems will have a minimum of 24 credit units for the two semesters in Year One.

PhD (Software Engineering)

Development paradigms; requirements elicitation / specification; analysis and design (including architectural design and design patterns); system models; programming paradigms; prototyping and evolution; testing; verification and validation; assessment and evaluation; software reuse; software measurement and metrics; operation and maintenance; project management; quality assurance and management; configuration management; formal description techniques; software dependability; tools (including computer-aided software engineering (CASE) and environments; software process models; implementation; documentation.

Software has become the driving force behind most new technologies. But the engineering of software is becoming increasingly complicated. A pragmatic approach to problem-solving is the hallmark of a software engineer. A software engineer must balance a variety of competing factors, including functionality, quality, performance, safety, usability, time to market, and cost.

The software engineering research will pursue the discovery of principles and the development of technologies to support the engineering of large, complex software systems. The challenging targets for this work are organisations and software systems operating in the wide-area, heterogeneous, distributed, and decentralised contexts of wide-area networks such as the Internet. Research in scientific computing, including scientific modelling, will also be undertaken.

Year One	**Semester I: 4 Courses**			
Code	Name	LH	CH	CU
	3 Core Courses			
MCS 9100	Philosophy of Computing and Information Technology	45	45	3
MCS 9101	Research and Project Proposal	45	45	3
MCS 9102	Advanced Research Methods in Computing and IT	45	45	3
	1 Elective Course			
MCS 9103	Managerial Problems in Information Technology	45	45	3
MCS 9104	Research Project Management	45	45	3
MCS 9105	Gender and ICT	45	3	3
Year One	Semester II: 4 Courses			
	3 Core Courses			
MCS 9200	Philosophy of Science and Computing Research	45	45	3
MCS 9201	Presentations, Scientific Writing and Research Ethics	45	45	3
MCS 9205	Trends in Software Engineering	45	45	3
	1 Elective Course			
MCS 9202	Trends in Computer Science	45	45	3
MCS 9203	Trends in Information Systems	45	45	3
MCS 9204	Trends in Information Technology	45	45	3
Year Two	Semester One and Two			
	Independent Research and Dissertation Compilation			
Year Three	Semester One and Two			
	Independent Research, Dissertation Compilation and Defense			

A PhD in Software Engineering will have a minimum of 24 credit units for the two semesters in Year One.

PhD (Information Technology)

Most managers feel that the critical asset that separates their organisation from their competitors is the knowledge assets or intellectual capital of the employees of their organisation. With many organisations downsizing, rightsizing, outsourcing, and the like, the ability to capture, share, and apply the 'lessons learned' of the employees (especially those experts who retire or leave the firm) is critical to the success and growth of the organisation. Modern management requires an awareness of information technologies in order to remain competitive. Information systems influence the way in which the whole organisation operates dealing with work practices, products, tools for decision-support, marketing and sales, and many other areas of business, which are critical to the efficient running and operation of any enterprise.

Advances in Information Technology (IT) have dramatically transformed the way in which our entire society lives, works, learns, communicates, and does business. In particular, the conduct of science and engineering has been profoundly altered, so that it is possible today to work on problems in these areas at unprecedented levels of speed, precision, and detail. In education, IT has the potential to make available in the remotest corners of the earth the highest levels of learning, information, and analysis. To enhance the positive effects of these transformations, the research in IT will explore new scientific, engineering, and educational areas in IT that will enhance development.

A PhD in Information Technology will have a minimum of 24 credit units for the two semesters in Year One.

Year One	**Semester I: 4 Courses**			
Code	Name	LH	CH	CU
	3 Core Courses			
MCS 9100	Philosophy of Computing and Information Technology	45	45	3
MCS 9101	Research and Project Proposal	45	45	3
MCS 9102	Advanced Research Methods in Computing and IT	45	45	3
	1 Elective Course			
MCS 9103	Managerial Problems in Information Technology	45	45	3
MCS 9104	Research Project Management	45	45	3
MCS 9105	Gender and ICT	45	3	3
Year One	Semester II: 4 Courses			
	3 Core Courses			
MCS 9200	Philosophy of Science and Computing Research	45	45	3
MCS 9201	Presentations, Scientific Writing and Research Ethics	45	45	3
MCS 9204	Trends in Information Technology	45	45	3
	1 Elective Course			
MCS 9202	Trends in Computer Science	45	45	3
MCS 9203	Trends in Information Systems	45	45	3
MCS 9205	Trends in Software Engineering	45	45	3
Year Two	Semester One and Two			
	Independent Research and Dissertation Compilation			
Year Three	Semester One and Two			
	Independent Research, Dissertation Compilation and Defense			

The PhD programme by coursework and research enables students to major in the respective areas pointed out. There are also the subjects of the programme's qualifying examinations, which must be taken by all students right after completion of the core courses and before they fully engage in doctoral research. This amount of coursework is the minimum acceptable standard for doctoral programmes. Keeping coursework to a minimum reflects the explicit intentions of the programme's designers of devoting most of the student's time and academic credits to doctoral research. The doctoral dissertation is the most important outcome of the student's doctoral experience, and it may be a requirement that it be published in a recognised scientific journal are before graduation.

Research Excellence

It is not adequate to define computing research excellence by traditional criteria of scientific excellence, as the user community is trans-disciplinary (academic and non-academic) and have a broader set of interests. RAOE (2000) also contends that "these communities may have different requirements than simply academic excellence or wealth creation" (p.10). Computing research excellence may therefore be defined as the level of efficiency or usefulness on enhancement of wealth-creation and quality of life in society by producing knowledge and the understanding necessary to produce designs, implementations and improvements of computer systems or solutions. These computer systems or solutions must lead to an improvement in the quality of life, capacity to generate wealth in the community and above all provide mechanisms for sustainability and vitality for these computing research artefacts.

The areas of specialty mentioned above conform to the core of the interdisciplinarity of the research environment, and foster the formation of new interdisciplinary groups and partnerships with industry, government, and universities in research projects of mutual interest.

Through this effort, the university is expected to further develop its current computing and engineering research capabilities involving students in greater numbers. It is hoped that through this effort, the nation might find a successful model that will help in building high academic standards and technological enterprise for the benefit of its present and future generations.

Projections, Conclusions and Recommendations

The PhD programme in computing of Makerere University is attracting many students from within the East African region. The first lot of students enrolled in the programme are due to complete by 2006, with the current enrolment shooting an alarming twenty plus (20+). By the end of two years, the average enrolment is projected at forty students per year, and it will be the best in East and Central Africa. This output will boost the demand for the labour force within the region and other programmes, such the regional master's programmes in computing.

Recommendations

- Formulation of a sustainability strategy
- Designing appropriate structures, programs and developing plans

However, there have been lots of problems in the area of research because of lack of guidelines to the students and content development. It was therefore suggested that the PhD programmes should be appropriately handled by introduction of a two-semester examinable coursework and two years' dissertation writing and presentation.

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4

Inter-departmental Staff Transfers in a Multidisciplinaty Research Environment

Venansius Baryamureeba and *Ddembe Williams*

This chapter explores the benefits of interdepartmental staff transfers in a multidisciplinary research environment. Some academic staff usually transfer their service to departments not related to their area of graduate (master's and PhD) training. In most cases this is attributed to a change in research interest or emergence of a new discipline. For instance in most universities, most Senior Professors of Computer Science hold PhDs in areas such as electrical engineering, physics, mathematics and chemistry. In developing countries some interdepartmental staff transfers are motivated by good working conditions and imbalanced remuneration for staff at the same rank in the same university. The committees or boards responsible for promoting, appointing and transferring staff in departments are always faced with the challenge of benchmarks in terms of realistic criteria. Baryamureeba and Williams propose a criteria for guiding university organs when transferring or appointing staff whose highest qualification is not related to the department the member of staff wishes to join.

Introduction

Computer Science, Information Systems, Software Engineering, and Information Technology, to mention but a few, are relatively new disciplines. Even today most of the Senior Professors in the above disciplines hold PhD degrees from other disciplines such as electrical engineering, physics, mathematics and chemistry. This tends to suggest that computing is a multidisciplinary discipline. For example, the following answers have been given by different authors to the question. What is computer science?

- It is a science of computers and surrounding phenomena (such as algorithms, etc) (Newell et al., 1967);
- It is a study (not science) of algorithms and surrounding phenomena (such as computers they run on, etc.) (Knuth, 1974);
- It is the empirical study ('artificial science') of the phenomena surrounding computers (Newell and Simon, 1976; cf. Simon 1996);
- It is not a science but a branch of engineering (Brooks, 1996);
- It is the body of knowledge dealing with information-transforming processes (Denning, 1985);
- It is the study of information itself (Hartmanis and Lin, 1992);
- It is the study of virtual phenomena (Crowcroft, 2005);

- It is a new kind of engineering (applied science) that studies the theory, design, analysis, and implementation of information-processing algorithms (Loui, 1987,1995).

Theory has its origins in mathematics, design in engineering and modelling in physical and biological sciences. This could easily explain why, for instance, in some universities, most Senior Professors of Computer Science hold PhDs in areas such as electrical engineering, physics, mathematics and chemistry.

Background

Appointments and promotions are based on academic qualifications, research, service to university, community service and secured donations or research funds, among others. In most universities appointments at the rank of lecturer require academic qualifications only and most universities require a PhD or its equivalent. Usually its staff that are already in university service that apply for promotions either on the basis of additional academic qualifications obtained or in recognition of exceptional contributions in both teaching and research.

Teaching, course preparation and examining

Satisfactory teaching performance, which involves an appropriate range of teaching methods, is judged by such evaluation methods as course reviews, external examiners, peer observation and student questionnaires. Satisfactory teaching can be assessed on the basis of:

- a capacity to teach at the different levels appropriate to the post - for example undergraduate and postgraduate.
- efficient setting, marking and assessment of coursework and examinations.
- a willingness to adopt fresh teaching or assessment approaches.
- a contribution to the planning and development of modules within the relevant subject area.
- evidence of the impact of research and scholarship on teaching.
- average teaching load over the past n years (as measured against the university norm for this period) where n is the required number of calendar years.

Research, scholarship and professional standing

Research, scholarship and professional standing can be measured by considering:

- a record of regular publication of original or other forms of externally recognised professional or creative output of a similar standing
- successful research supervision of graduate students, especially masters, doctoral and postdoctoral fellows
- PhD student turnover

- organising/ participating in international conferences
- journal reviews
- whether one is a member of professional bodies
- championing new ideas

Promotion

Promotion of academic staff is designed to recognise and reward sustained excellence. Judgements are made by committees through a process designed to enable fair and consistent application of standards. Applicants are expected to have made sustained and exceptional contributions in both teaching and research. Service to the university, the discipline and the profession are taken into account. Applicants for promotion to higher ranks such as Professor must be eminent scholars in a particular field of knowledge. They must have achieved, maintained and demonstrated deep understanding of a discipline, a capacity to extend knowledge in that discipline, and the ability to communicate scholarly endeavour in the discipline to students, peers and others. These contributions must be thoroughly documented in the application.

For each academic level, Minimum Standards for Academic Levels (MSALS) have been drawn up. To be promoted, staff members must, on objective evidence, reach a level of performance consistent with the level to be attained through promotions. Many of the tasks are common to each rank, but as staff members advance in their careers, they are expected to perform at a higher level, which may be characterised by:

- an increase in the quality of performance and expectation of recognition in teaching;
- a greater contribution to the advancement of the discipline;
- more complex and responsible duties;
- greater independence of action;
- a greater contribution to academic, institutional and public life;
- an expanded range of responsibilities in service to the university and increased quality of service;
- increasing leadership.

There are six broad areas used in assessments for promotion, namely:

- Educational development and practice (experience and achievement in teaching);
- Advancement of the discipline (achievement in research and/or scholarship and/or artistic or professional practice);
- Service to the university leadership (contribution to institutional planning, governance and operations);
- Qualifications and experience;

- Service to the discipline (service to the relevant profession and/or academic discipline and/or relevant contributions to the wider community);
- Secured donations/ research funds.

Grounds for Promotion

Evidence presented in support of a claim for scholarly eminence in a discipline may include:

- publication of books and monographs through publishing houses of high national/international reputation.
- publication of the results of original research and other scholarly endeavour in refereed journals of high international repute.
- publication through exhibition of the results of executant art research, in galleries and museums of high national and international repute.
- publication of the results of original research and other scholarly endeavour in conference proceedings that are subject to peer review and published through publishing houses of high national/international reputation.
- publication of reports commissioned by government agencies and international organisations.
- publication of peer reviews and critiques, in nationally and internationally recognised forums, of the outcomes of original executant art or design activity.
- representation of original works of art in major national and international publications.
- successful application for patents and licences based on original research and development.
- original designs and executed structures or instruments which result in high professional standing.
- acquisition of original works of art by significant public and private collections.
- experience in leading research teams.
- ability to attract funds from external peer adjudicated grants agencies.
- award of prizes/honours.
- demonstrated record of editorial leadership in the dissemination of knowledge.
- ability to attract funds for contract research from government agencies, industry and commerce.
- record of achievement in the transfer and application of the results of research and development to industry and commerce, the professions and wider community.

- leadership in the generation of collaborative research and development programmes with other institutions including universities, government agencies, industry and commerce.
- record of effective contribution to the development of a discipline in the wider community.
- publication of advanced textbooks in the candidate's field of expertise through publishing houses of high national/international repute.
- reports on high-level consultancies carried out for industrial and commercial firms.
- record of provision of academic guidance to junior colleagues.
- evidence of having obtained more academic qualification (s) since last appointment or promotion.

Other evidence which reflects a candidate's standing both in the profession and in the scholarly community, and which will be taken into account includes:

- experience in the management and administration of academic units and programmes.
- high category of membership of professional societies and associations.
- leadership in professional societies and associations as demonstrated by the holding of executive office.
- membership of nationally and internationally recognised honorific societies.
- membership of government advisory bodies, committees of inquiry and boards of management.
- membership of international delegations in the candidate's area of expertise.
- invitations to serve as a referee or adjudicator by major national and competitive grant awarding or award-granting schemes or organisations.
- invitations to serve as external examiner in other higher education institutions.
- invitations to speak at major (international) conferences.
- invitations to serve as visiting Professor in other higher education institutions or as visiting academic in government departments and agencies.
- offers to take up chairs in other universities of high national/international repute.
- evidence of having been short-listed among the top 3 applicants for a Chair.
- invitations to edit special issues journals, books.
- opinion sought by other institutions for their reviews.

- Chair of a major (international) conference.
- invitation to serve as external member on high-level selection committees.
- appointment to international journal Editorial Boards.

Case Study

A case study was conducted among selected staff from computing departments within East African universities, London South Bank University and the University of Groningen.

It was reported that academic staff who transfer to units where they lack expertise often have problems with the structure, do not want to acquire new skills/ knowledge, and do not engage with students and staff. This is worse when the member of staff transferred is at a senior level.

The results of the case study strongly suggest that the candidate applying to transfer to another academic unit must demonstrate that he/she has the capacity to perform tasks commensurate with those expected of staff at the level sought in the unit where the person wishes to transfer and the quality of his/her current performance is appropriate to the level sought.

Vetting of Publications

In most universities within the East African region the vetting process was not clear. For example, at Makerere University it is the Academic Registrar that selects an independent expert to vet the publications of the person seeking to be appointed either Professor or Associate Professor. It is recommended that the academic unit (faculty/ institute/ department) be the one to search for at least three experts in the discipline and forward their CVs to the Appointments and Promotions Committees/ Boards so that the committee/board can select one expert to vet the publications. It is also recommended that this applies to all new appointments, promotions and transfers at the rank of Associate Professor and Professor.

Recommendations and Concluding Remarks

Recommendations

a. The candidates applying to transfer to another academic unit must demonstrate that:

   (i) they have the capacity to perform tasks commensurate with those expected of staff at the level sought in the unit where the person wishes to transfer; and

   (ii) the quality of their current performance is appropriate to the level sought.

b. The candidate's past history should not be relied on but the candidate must demonstrate ability to undertake academic activities (teaching and research) in the new discipline before being appointed. For staff seeking to transfer at the rank of Senior Lecturer and above, an external expert must review the publications and ability to teach and supervise/ advise graduate students.

c. When applying for appointment the applicant must clearly indicate the discipline or his area of expertise and the department where it is based and the evaluation process should follow a fair and consistent assessment standard set by the relevant policy organ of the university.

d. Staff should only apply for promotion in the discipline where they have already been appointed on merit.

e. Staff seeking to transfer from one unit to another should go through the appointment process in the same way like new entrants into university service and be required to meet the minimum requirements for the position applied for.

f. Staff should be appointed and/ or promoted in more than one discipline if their academic qualifications and publications allow. For example a member of staff can be Professor of Applied Mathematics and a Senior Lecturer in Computer Science or (Associate) Professor of Computer Science subject to meeting the minimum requirements for the position (s) in either unit.

Concluding Remarks

Any application of any member of academic staff wishing to transfer from one department (discipline) to another should go through the formal process of appointing new staff and such members only be appointed to the position applied for if he/she meets the requirements for the post. The candidate must demonstrate that he/she has the capacity to perform tasks commensurate with those expected of staff at the level sought in the unit where the person wishes to transfer and the quality of his/her current performance is appropriate to the level sought.

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5

Strengthening Research and Capacity Building in Computer Science

Peter Wagacha, Katherine Getao and *Bernard Manderick*

This chapter discusses strengthening of research and capacity-building in Computer Science at the School of Computing and Informatics, University of Nairobi over the last few years. Research is one of the school's primary missions. The vision of the School is to be a leading centre of excellence in research, research and development (R&D) and advanced education in Computer Science. We further elaborate on some significant changes and experiences that this department has gone through in its development. To harness synergies within individual members of staff, the school formulated research groups. These research groups have been responsible for research in their own areas, curricula development, and student research, project supervision and direction. As a way to foster growth, the school has been in strategic academic and research collaboration with development partners from various parts of the world. Links with researchers from different parts of the world have also been established. To harness synergies, specific areas of research are being pursued.

Introduction

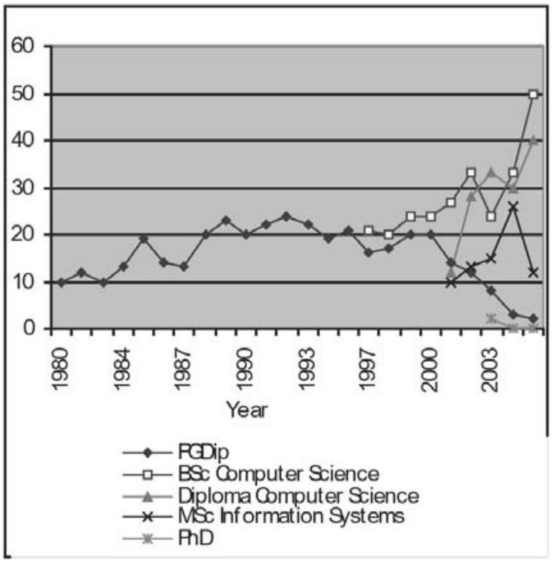
The School of Computing and Informatics (SCI) is the department of the University of Nairobi charged with teaching and research in Computer Science. Since its inception (formerly as the Institute of Computer Science) in 1977, it has established itself as a regional leader in computer science and informatics with regard to teaching, research and consultancy. Its main areas are Information Systems, Distributed Systems and Artificial Intelligence.

It has several approved programmes, some of which are very competitive: Diploma in Computer Science, BSc Computer Science, Postgraduate Diploma in Information Systems, Postgraduate Diploma in Computer, MSc in Computer Science, MSc in Information Systems, MSc in Applied Computing and PhD. See Figure 1 for graduands.

The current mission of the school includes (SCI2003a,SCI2005):

Research: This is the primary activity of the school, upon which the success and quality of all other activities hinge. The School aims at instituting a dynamic programme of aggressive research in its core areas of competence: information systems, distributed systems and artificial intelligence, in line with national and regional priorities. This is to be achieved through the harnessing of local, national and regional resources and skills.

Figure 5.1: Graduands 1980-2005 in various programmes (2005 figures are projected)



Teaching and Learning: To produce high-quality, well-rounded graduates who are productive, innovative, work effectively with academic and industrial partners and capable of lifelong learning. The school's courses will be developed and delivered to a high standard of educational and technological competence.

Consultancy: To engage productively with the public and private sectors to solve problems of national or organisational economic importance in order to foster progress in computer science.

Active research is the cornerstone of any academic department and is closely related to capacity-building (UoN2005). For several years the school's research output and interest amongst staff was been fairly low, (compare Figure 5.2 and 5.3). In 2003, the school instituted a process to address this problem. The main goal was to strengthen research.

This paper describes the process that the school has taken towards achieving this goal. Some of the challenges are enumerated in the sections below.

This paper is organised as follows: First, in section 2, we give an overview of the strengths, weaknesses, opportunities and threats (SWOT) that SCI identified during a strategic planning process. On the basis of the SWOT analysis, SCI developed a strategic plan for research. This plan has subsequently been used as a road map for current research activities and capacity-building. Sections 3 and 4 discuss the research and development (R&D), and consultancy and extension activities respectively. These are part of the school's mission. Academic research and capacity-building are discussed in section 5. Finally we provide a conclusion in section 6.

The SWOT Analysis

By carrying out a strengths, weaknesses, opportunities and threats (SWOT) analysis the school was able to uniquely evaluate and re-define itself. This is illustrated in Table 5.1. This culminated into the SCI Strategic Research Plan document (SCI2003b).

Below we highlight a few of the issues brought to the fore. Some of the strengths were: a significant group of trained academic staff in a wide spectrum of computer science disciplines, and a good quality student intake that could serve as the basis for research activity and staff development. Some of the weaknesses were high staff turnover due to poor university remuneration in a market with a healthy demand for ICT skills, lack of adequate research funds, and staff exhaustion due to moonlighting (extensive participation in other academic or non-related areas outside the university). Some of the opportunities were: research opportunities in the contextual application of rapidly developing ICTs, and a pool of human resource (academic staff) that can engage in research activities. One major threat that was highlighted was the poaching of staff in an environment where there are a rapidly growing number of learning institutions combined with a scarce pool of appropriately qualified human resources.

To address these important issues some strategic objectives were developed (see Table 5.2). These objectives include motivation of staff through better terms and the provision of high-quality staff training opportunities; facilitation of staff to carry out productive research; and to collaborate with qualified institutions in offering comprehensive academic programmes.

Research and Development Activities

The School of Computing and Informatics has an extensive portfolio of research and development activities in diverse areas such as Mobile Communications, Electronic Learning, Management Information Systems, Web-based applications and Hardware projects. For example, the development of an e-learning software platform, WeduSoft[1], which was designed and developed in-house. Several university departments in East and Central Africa are actively producing electronic courses using WeduSoft.

The school is currently preparing an extensive demonstration and database of these projects that have been developed by staff and students over the years with the hope of attracting opportunities for commercial development. The school is in conversation with a number of interested parties from industry as well as actively participating in the Chiromo Science Park Project to be based at the University of Nairobi.

Consultancy and Extension Activities

The School of Computing and Informatics takes its role as a leading Computer Science Department in the region seriously. Members of staff serve as external examiners to regional universities in South Africa, Zimbabwe and Uganda as well as nearly all local public and private universities.

The school participates in local initiatives such as the development of an Information and Communication Technology policy, and a variety of conferences and symposia. In recent years the school has worked hard in selling itself to industry and government in an advisory capacity. As a department, the school has the highest concentration of computer science expertise in the country, by the virtual of the number of PhDs, P.hD students and master's degree holders. SCI is currently assisting the Ministry of Lands, the Ministry of Health, Kenya Bureau of Standards, Kenya Revenue Authority and the Commission for Higher Education, among others.

Table 5.1: Research and Research & Development SWOT Analysis (SCI2003a)

Mission Area	Summary	Research & Development
Strengths	▪ A well-established department of over 28 years' standing ▪ A significant kernel of trained academic staff in a wide spectrum of computer science disciplines ▪ Excellent students intake serving as a basis for staff development ▪ Good networking and computing infrastructure ▪ Strategic location of the school	▪ Strong portfolio of student projects with potential for further development ▪ Some staff members with research degrees ▪ Several project proposals for research funding in process
Weaknesses	▪ High staff turnovers due to inadequate remuneration in a competitive sector ▪ Inadequate funding for maintenance and communication costs ▪ Inadequate provision to sustain future capital development ▪ Lack of funds for further training ▪ Moonlighting leading to academic fatigue	▪ Lack of active research activities (inactive research groups) ▪ Lack of funds dedicated to research ▪ Staff morale to carry out research is low ▪ Limited portfolio of research projects and publications
Opportunities	▪ Ability to acquire specialised computing resources for teaching and research ▪ Fast pace of international developments in ICT research (since this allows room for new researchers) ▪ Potential of collaborating with other institutions	▪ Increasing participation in relevant contextual research
Threats	▪ Decreasing funding from the Exchequer ▪ Poaching of human resources	▪ Fast pace of international developments in ICT research (since it requires resources to keep pace) ▪ High cost of equipment and training

Research and Capacity-Building

The school realises that research is the pillar of academic work. The School of Computing and Informatics is the first Computer Science department in Kenya to train computer scientists to the level of PhD by research. The world over, research activities are closely linked to capacity-building. These are both discussed below.

Research Activities

Research at the School of Computing and Informatics is guided by the Research Strategic Plan 2003-2007 (SCI2003b). This plan was developed in line with the overall school's Strategic Plan (SCI2003a). This research strategic plan describes the mission, vision, SWOT analysis and research strategic objectives defined by the school (see section 2).

All researchers in the school are currently organised into three research groups, namely:

1. Artificial Intelligence Research Group (AI);
2. Distributed Systems Research Group (DS);
3. Information Systems Research Group (IS).

These research groups were created through a broad clustering of computer science disciplines, with research leadership in mind. Each group also has an action plan that describes the specific activities of that group which may include seminars, preparation of technical reports, specific research projects and so on.

Currently, some of the research activities within these three groups includes:

- Grid computing: This involves the use of intelligent agents, scheduling, issues of quality of service etc. (AI & DS groups)
- Natural language processing (NLP): Research in Swahili and other local Kenyan languages, development of text-to-speech systems etc. (AI group)
- ICT policy and e-governance, e-strategies (IS group)
- Geographical Information Systems (GIS): Modelling and decision support (IS group)
- Electronic learning technologies (IS group)
- Electronic learner modelling (AI & IS group)
- ICT for development and technology forecasting (IS group)
- Mobile phone telephony (AI & DS group)

Table 5.2: Strategic Objectives (SCI2003a)

Objective	Strategies
To recruit, motivate and retain qualified staff	• To cultivate a reputation for academic excellence and improve the school's visibility internationally • To offer attractive terms and conditions of service • To facilitate or create and maintain high-quality staff development programmes • To develop and maintain a well-defined structure that provides opportunities for promotion and professional growth • To develop and maintain systems of staff evaluation, reward and correction.
To facilitate staff to carry out productive research	• To restructure the school to provide strong specialised research leadership (through creation of specialised departments) • To provide adequate remuneration to allow concentration on research activities • To provide adequate teaching and research assistance • To simplify teaching and assessment activities without lowering standards • To complement classroom teaching with at least 40% online learning • To measure both teaching and research load when allocating duties to staff
To carry out research in ICT policy, and key areas of Computing and Informatics in line with national needs	• To create and sustain research groups in the areas of research interest • To obtain adequate funding to support relevant research • To create a structure that facilitates and rewards research
To offer advanced bachelor's, master's and doctoral degrees	• To develop and regularly update curricula
To produce high-quality graduates	• To provide an environment that encourages students to explore, discover, innovate and learn • To provide flexible learning opportunities that use innovative technologies and methodologies • To provide learning experiences and inculcate values and attitudes to develop a holistic person • To provide opportunities for learners to gain practical & industrial experience. • To purchase and or develop and maintain robust, modern hardware, software and communications infrastructure and learning materials that support high-quality academic programmes and maintain a student computer ratio of 2:1
To collaborate with qualified institutions in offering comprehensive academic programmes.	• To create and sustain links with institutions of excellence in information and communication technology in order to achieve the school's objectives • To accredit qualified institutions to teach the school's programmes at the basic, secondary and tertiary education levels

To be a model in the application of ICT in the implementation of our research, teaching and learning, management and extension roles	• To acquire, initiate or develop management information systems to support the major teaching and learning, research and management functions of the school • To regularly evaluate and update information and communication technology hardware, links and software • To use e-learning as a major delivery method for teaching and learning
To facilitate the formulation of productive and relevant national and regional policy for ICT	• To engage in ICT policy research and development • To disseminate ICT policy through a series of technical reports, workshops, seminars and other fora
To create an infrastructure for developing ICT products, in collaboration with relevant partners, that address regional needs	• To utilize the Master of Science in Applied Computing Science to fund and develop novel and relevant ICT products • To create and sustain links with partners in order to develop ICT products that address regional needs
To facilitate professional networking in ICT (including its interface with other disciplines)	• To encourage staff to represent ICT interests in all relevant national and regional fora • To disseminate ICT knowledge through a series of technical reports, workshops, seminars and other fora • To build strong links with industry through networking and collaboration
To strengthen consultancy and other income generation activities	• To carry out training for specified target groups at various levels of expertise • To undertake contracted research and consultancy • To carry out research and development leading to marketable products
To extend our reach into all areas of national ICT need	• To develop technological products that bridge our national digital divide

- Telemedicine (AI group)
- Application of ICT in organisational change management (IS group)

The school actively nurtures links with internationally renowned researchers and institutions. Some of these researchers include: Prof. Barry Levine from the University of San Francisco; Prof. Thierry Duval from the University of Rennes in France; Prof. Laurence Duval from INRIA research institute in France; Prof. Luc Steels of the Free University of Brussels; Dr Gerald Kotonya from the University of Lancaster; Prof. Peter Flach from the University of Bristol, U.K.; Dr Guy DePauw from the University of Antwerp, among many others. These links have played a key role in building international research networks.

Short courses conducted and visits by these renowned scholars have been invaluable in developing interest and capacity in research among staff and students at the school.

Capacity-Building

Staff development is a key strategy of the School of Computing and Informatics. At the moment, all staff are recruited with a master's degree in a Computer Science-related discipline and three years' teaching experience in higher education. Staff are expected to prepare a PhD proposal and commence on doctoral research. A PhD degree is a mandatory requirement for senior academic appointments. This has proved a very challenging requirement for the Computer Science discipline since there is strong competition from industry for these professionals.

The current staff stautus is depicted in Table 5.3. It should be noted that most staff are in the lecturer grade. Five out of the fifteen members of staff are on leave from the school. There are few women members of staff, their number currently standing at 20%.

There are two avenues for developing staff at SCI. Most staff have sought scholarships to pursue their doctoral studies outside Kenya. However, this has proved difficult as the number of scholarships has shrunk as the competition for the few scholarships become much stiffer. In addition potential applicants often find it difficult to leave their families for three or four years, and very few scholarships fund families. It is more common nowadays for staff to follow sandwich programmes that involve collaborating with an institution in the developed world to manage a degree in both environments. The school's plan envisioned the development of adequate capacity to manage the PhD programme locally at lower cost. This is also meant to enable the school to sustain its programmes.

Both sandwich and local programmes have their own challenges. These include availability of adequate concentrated research airtime, in an environment that may require them to continue supporting their departments in terms of teaching and other related duties.

Table 5.3: Staff status SCI (71% of establishment filled; 52% on the ground 20% of staff are women)

Post	Establishment		Academic Staff in Position
	Old (ICS)	New (SCI)	
Professor	2	3	1
Associate Professor	4	3	1
Senior Lecturer	6	6	3
Lecturer	9	9	10
TOTAL	**21**	**21**	**15**

Table 5.4: Capacity-building at SCI (SCI2005)

Donor	Programme	Period	No. of Scholarships	Successful Completion	Retention
UoN/DAAD	PG Diploma Computer Science	1980-1994	2-3 annually	All	**3**
UNESCO	PG Diploma Computer Science	1985-1989	1 annually (regional)	Most	**0**
ODA/TCT (UK)	PhD (UK) MSc (UK)	1984- 1984- 1985	7 3	6 3	**1** **3**
IDA/World Bank	PhD (UK) HND	1992 1992	1 1	1 1	**0** **0**
Other	PhD (UK) PhD (Finland) PhD (USA)	1983-86 2001-05 2001-05	1 1 1	1 pending 1	**1** **1** **0**
Commonwealth Secretariat	MSc PhD (split)	1995 2004- 2006	1 1	1 pending	**1** **1**
VLIR	PhD (split) PhD (split) MSc (Belgium) MSc (UoN)	1998- 2002 2003- 2007 1998- 2002 1998- 2002	3 2 8 2	2 pending 6 1	**2** **2** **1** **0**
TOTAL (excl. PG Diploma)			32	23	**13**

At the moment the school has three staff members with PhD that were pursued overseas, and two staff members who have recently acquired their PhD through sandwich programmes. Currently, two members of staff are pursuing their PhD abroad, two others have recently enrolled on sandwich PhD programmes, and another two have enrolled on local PhD programmes. SCI believes that it now has more than adequate teaching and supervision capacity for its PhD programme. Two recently recruited tutorial fellows are enrolled in our MSc programme on staff development.

Staff recruitment, development and retention have been a big challenge. For example, of the seven PhD candidates who have been trained through international scholarships between 1985 and 2000 only one is still at the school (see Table 5.4). Note that retention of staff was very low in the period when PhD graduates returned to an institution which had no Research Strategic Plan, where little active research was taking place. Since most of these graduates were returning from active research centres, the lack of research combined with poor pay packages was highly demotivating. This led to serious problems with staff retention. With the revival of research activities, it has been possible to create a more motivating environment for PhD graduates. It is also expected that recent improvements in terms of service for academic staff will have a positive impact on recruitment and retention.

The fast pace at which technology evolves makes it paramount for SCI to continuously evaluate and upgrade its infrastructure. Both students and staff require better tools, better access, better labs etc. This is an expensive exercise and remains a big challenge owing to its financial requirements. In the recent past the school has been able to fund these from the little departmental funds and through partnerships with collaborating research institutions in the developed world such as The Flemish Inter-University Council (VLIR), which for the duration 2003-2007 will provide support to the tune of Euro 334,000.

The government's support to public universities has over the years reduced, constrained by demands in other sectors of the economy. This in turn has led to reduction in funding from the university. Research funding is, and remains, a big challenge.

The school's Strategic Plan was presented to the University Council and approved for implementation. It included a comprehensive budget for infrastructure, human resources and operations to be funded through university development budgets, increased productivity through the school's income-generating activities and development partners (e.g. VLIR). This strategy is already on course. Resources are in the process of being provided such as: recruitment of highly qualified technical staff to support research activities; extension of laboratories through building works and acceptance of paid study leave and lighter duties for staff pursuing PhD studies. Part of this support is funded through the university's income-generating "development" budget as well as the Kenya government treasury allocation for staff salaries.

6. Conclusion

The research vision of the school is to be the premier research and research and development school in the areas of artificial intelligence, distributed systems, and information systems. The school has already met, or is poised to soon meet, many of its strategic research objectives such as increased research activity as indicated by the number of peer reviewed publications and human capacity-building at PhD level. (See Table 5.3 and Figures 5.2 and 5.3.) It is now very evident that a culture of research activity and excellence is being institutionalised.

Figure 5.2. Number of peer reviewed publications over the last 5 years (figure for 2005 is projected)

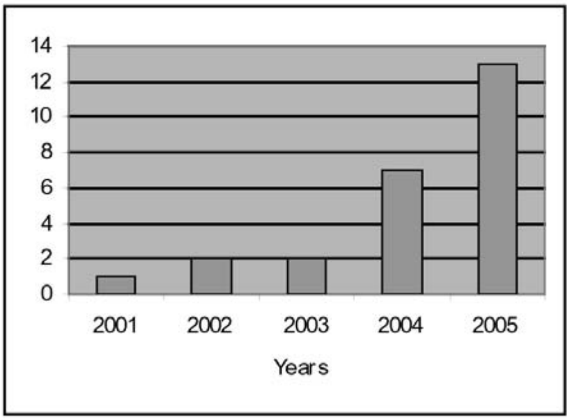
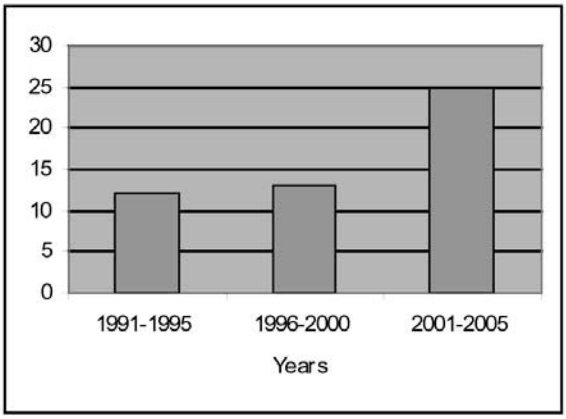


Figure 5.3. A comparison on the number of peer reviewed publications over the last 15 years



One of the motivations of research in computer science is the numerous opportunities that continuously present themselves for research due to the nature of this discipline and the related technologies. For instance, research into local African languages, GIS modelling, grid computing and mobile telephony all have the potential to impact many facets of life in Africa, as well as other parts of the world. Moreover, in a domain such as Natural Language Processing which is particular to the African situation African researchers can make valuable contributions that can be recognised.

Another source of motivation is the fact that generally for computer science research, investment is fairly low compared to other disciplines such as medical science, biotechnology, high energy physics and many others.

Finally, vibrant research motivates staff and makes them proud members of the global community of researchers. This assists the school in retaining high-quality staff who would otherwise drift into the private sector. Research raises the profile of the department and improves the quality of teaching and therefore makes the department more attractive to potential students.

The successful implementation of the SCI research strategic plan has made research groups more vibrant than before. Most of the research activity that is ongoing can be attributed to the current PhD and MSc students and academic staff. The research culture has been fostered through workshops and lunch-hour seminars given by staff, students and visitors to the school. Student research projects are designed by the research groups with the aim of encouraging both undergraduate and postgraduate students to engage in more challenging, research-oriented projects. One way that SCI is able to achieve its objective of strengthening research and research excellence is through collaboration with local and international researchers, and other quality institutions. We have fostered closer ties with regional universities such as Makerere and Dar-es-Salaam universities by actively participating in regional workshops. We have a two-pronged South-South (regional) and North-South (international) strategy for research excellence. Publications have been achieved at both levels. This has been made possible through links developed and nurtured over the years and the school's increased international visibility.

Recently, researchers at the Massachusetts Institute of Technology (MIT) have approached the school for collaborative research in mobile phone data mining. Also, we and researchers from the University of Antwerp are in the process of writing a research proposal on developing tools for our local languages.

The school is commited to continuously evaluating its research and capacity dvelopment, a means of checking its progress. However, there remain many serious challenges such as staff retention, sources of research funding, continuous improvement in infrastructure and thus sustainability of active research.

We acknowledge the fact that these gains have been made through the school's wisdom in, firstly, self-evaluation through SWOT analysis, and thereafter developing and implementing a strategic plan.

References

[SCI2003a] School of Computing & Informatics, Strategic Plan, 2003

[SCI2003b] School of Computing & Informatics, Strategic Research Plan, July 2003

[SCI2005] School of Computing & Informatics, Strategic Research Plan, 2005

[UoN2005] University of Nairobi Strategic Plan, June 2005

6

Optimising the Potential of Educational Computing Research in Emmerging Countries

Ronald Bisaso

This chapter explains the possibility of merging approaches to educational computing research for the benefit of developing regions. It is on the premise that educational researchers, policymakers, and practitioners agree that educational research is often divorced from the problems and issues of everyday practice (The Design-Based Research Collective, 2003). Moreover, educational effectiveness and efficiency is a factor of Information and Communication Technology (ICT) especially the computer – a 'tool of our time'. Developing countries have seen the potential of educational computing as a catalyst in the enhancement of knowledge acquisition and management, but approaches to educational ICT research in these settings have not been explored. It is noteworthy that software developers have either developed materials on the basis that they are conversant with all the contextual factors, or have remained oblivious of the advantages accruing from understanding the change process. Consequently, in this chapter, Bisaso proposes a blended approach where two strands, namely (rapid) prototyping and basic research ought to sit side by side if the exceeding relevance of educational computing research is to be sustainable and its returns fully exploited in the developing regions.

Introduction

Interest in developing educational technology solutions to curriculum and instruction problems has been ever increasing. Czerniewicz, L. and Carr, T. (2005) report that there is evidence of diverse emerging practices in the use of educational technologies across Southern Africa, in both the school and higher education sectors, hence suggesting that institutions at all levels in the developing regions have seen the benefits that this field of study offers that each is considering installation of new educational computing hardware and software. Governments at all levels have expressed support for educational technology initiatives, for example the Uganda Ministry of Education SchoolNet project, and the CurriculumNet project at the National Curriculum Development Centre (NCDC), the latter tasked to develop content online or computer-based curriculum instructional materials (National Curriculum Development Centre, 2004). It is thus not difficult to find environments in which to evaluate educational computing research and development owing to the prevalent support for educational technology and the anticipated prospects it renders to effective schooling in the developing regions. Rath and Hsu (1999) argue that it is the existence of this potential that motivates the necessity for progress in productivity and quality in educational computing research and development. Yet Nieveen and Gustafson (1999) note that data documenting the advantages accruing to the practicality and effectiveness of educational computer support systems are still insufficient. Rath A. (1999) acknowledges that, in education, we are struggling to link research with development in a practical and productive manner.

Reeves (2000) recounts that some instructional technologists appear to have immense dedication to basic research, irrespective of whether it has any practical value, perhaps because basic research seems more scientific or they believe that it is someone else's role to figure out how to apply the findings of basic research. Others seem to believe that the value of basic research in a design field such as IT is limited and that ICT research should therefore have direct and clear implications for practice. Basic research is characteristically work that emphasises fundamental processes. Development is typically work that emphasises the design and development of curriculum materials (Rath and Hsu, 1999). Tyler (1978, in Rath and Hsu, 1999), for example, stated that "Research is an activity seeking to gain greater understanding of a phenomenon, while development is an effort to design a system that will achieve the desired ends under specified conditions or constraints" (p. 94). In this vein, the two approaches to investigation are amalgamated into research and development, and consequently globally defined as a "process that links basic research on curriculum, instruction, and learning with the design and development of educational products and processes for specific teaching and learning situations" (Rath and Hsu, 1999). According to Revees (2000), Stokes (1997) called for more "use-inspired basic research" rather than either pure basic or applied research. "Use-inspired basic research" for instructional technologists is what is labelled "development research" (Akker, 1999).

Notwithstanding the inventiveness in educational computing, we ought to uncover ways to qualitatively and quantitatively enhance the current state of invention and inquiry. It should be borne in mind that educators are limited in choice when it comes to selection of tested and proven educational computing systems in the developing regions. This explains the need for guaranteeing sustainability of research and development to the advantage of both the theorists and designers, remaining keen on their interdependence (International Federation for Information Processing, 2005). Development researchers are also committed to constructing design principles and producing explanations that can be widely shared. Instructional technologists engaged in development research are above all reflective and humble, cognisant that their designs and conclusions are tentative in even the best of situations (Reeves, 2000). Moreover, educational computing research and development is both a process and a tool. It thus remains questionable how one is either a theorist or a designer and successfully develops well-situated products. Although it may seem to work, this naivety explains why educational computing products and processes developed in faculties or Schools of Education hardly trek past the development phase (Rath and Hsu, 1999). The subsequent sections of this paper discuss the invention and innovation approaches in detail.

Invention (prototyping) research

Nieven (1999) argues that to reach product quality, the suitability of the prototyping approach is beyond question. Nieveen (1999) quotes Smith (1991, p.42) who defines a prototype as "a preliminary version or a model of all or a part of a system before full commitment is made to develop it." Prototypes are all interim products that are incrementally designed before the final product is constructed and fully implemented in practice (Moonen, 1996). Nieveen (1999) notes that based on several such cycles, the computer system evolves towards a high quality final product.

De Hoog, de Jong and de Vries (1994, in Nieveen, 1999) are reported to propose a non-linear approach to development in which several parts of the product are developed independently of each other. Nieveen (1999) notes that this approach envisages an improvement in the product under construction with its parts showing a correspondence with the set quality criteria, and remaining consistent with the other components undergoing development. The output of this method is in all probability regarded exemplary and consequently very useful as innovations unfold in educational settings. These software materials can, for instance, illustrate the basic meaning of change at hand, provide the would-be users with a (probable) chance to interface with these materials or better still elicit interaction among the users on their relevance or irrelevance. Nieven (1999) recounts that only when these materials are of "good quality" can we predict with certainty that they will fulfil the obligation mentioned already.

Even then, the aspect of quality remains hazy because of its varied interpretations (Nieven, 1999). Some often imply robustness (working well) while others effectiveness (better results). Either way, a robust or effective product is cherished and valued but this ought to be grounded on the tenets below:

a) Validity: This refers to the extent to which materials developed are congruent with the state of the art knowledge (content validity) and consistent in linkage between the diverse sections of the materials (construct validity). Educational software can only be valid on meeting this standard.

b) Practicality: Software for learning or educational computing products will be regarded to be of quality when there is compatibility between software utilisation among the intended audience (teachers or other experts) and the software developers' intent.

c) Effectiveness: Users' experience with the products developed is such that it adds value to their current way of doing things in a way that is in agreement with the intentions of the developer.

However, in an educational context, it must be remembered that ICTs are basically tools for facilitating learning and teaching. Their success does not depend on the technology itself, but on the correctness of its application. High expectations for ICT applications may cause disappointment among their users, if they do not take full account of the actual educational contexts, hence the importance of understanding innovations.

Innovation (basic research)

Fullan (1999) attempts to discuss the interactive factors affecting implementation in educational settings, and he posits that the characteristics of the change, namely Need, Clarity, and Complexity, are vital ingredients in the implementation of innovations. Educational computing innovations are no exception. Need refers to how much scrutiny is made in relation to the software 'addressing' the most imperative demands. Equally important is the establishment of the edge of the software product under development over other similarly essential issues; otherwise, the beneficiaries of the status quo may reject it as sson as it is rolled out. On clarity, Fullan notes that "people often become clearer about their needs only when they start doing things, that is, during implementation itself". The question, have software developers taken the trouble to deal with making their clients "clear" before they get "clearer"? The level of difficulty, relevant skills needed to grapple with the change, and alteration in beliefs, instructional strategies, and application of technologies constitute the complexity attribute. A software developer who has distanced himself from these characteristics thrives on relativism rather than objectivism during his research in educational computing.

Rogers (2003) recounts that it is not uncommon for societies to adopt relevant practices external to their environments, and adapt them to meet their own needs, and discard the rest; and according to Constant (1984), and Rath and Hsu (1999), "Community and tradition are the locus of what is called technological change" (p. 29). It is impeccably acknowledged that practitioners are the major determinants of the change process (Rath and Hsu, 1999). Dourish (1995) argues that "the design process does not end with the delivery of a system to some community of users. Instead, it continues as they use and adapt the system" (p.44). This serves to concretise the view that the software development process is a never-ending journey which undergoes several refinements as the context may dictate. Even in web technologies, an area common in educational computing, Powell (1998) notes that the value of software depreciates over time unless it is altered in response to changing needs.

Development research (a blended approach)

Development research refers to the successive approximation of interventions in interaction with practitioners (Akker, 1999). Its aim is both practical and scientific contributions but the innovation challenge is usually quite substantial. Moreover, it involves an iterative process of 'successive approximation' of the ideal intervention is desirable. The argument is that direct application of theoretical underpinnings is a necessary but not a sufficient method to solve these rather complicated problems. Hake (2004) argues that proponents of design-based research are willing to attempt to address, simultaneously and iteratively, the scientific processes of discovery, exploration, confirmation, and dissemination, resulting in an active innovation and intervention in the classrooms (Kelly, 2003). Moonen (1999) reported on the rational and relational approaches; the former entailing problem-disintegration into sub-problems and eventually tackling these in a micro manner. On the whole, problems are well defined and consensus is obtained with regard to the solution.

Moonen (1999) on the contrary recounts that design methods that are only lop-sided to this strand are inappropriate. This, he argues, is a result of the growing influence of the stakeholders. Shön (1993, in Moonen, 1999) is reported to have suggested an extension in the execution of this process to embrace "reflection-in-action" in which means and ends are dealt with iteratively. Kessels (1993) refers to this as the relational approach – "gradually evolving correspondence between the product and the intended user".

Moonen (1999) further questions the way to go – either 'rational' (invention) or 'relational' (innovation). His argument is that it all depends on the situation. He further argues that once there is clarity of purpose then a rational approach is more appropriate. However, when the contrary is the case, a relational inclination serves better. Moonen concludes that "it is a wise choice to combine in a global design strategy, the strengths of both approaches". This is represented in the model in Figure 1. Fusion of these two methods should bear in mind that a) there is often uncertainty about how to proceed, b) the context has considerable influence, and c) many design activities have to do with adaptation (Moonen, 1998). Kessels (1993) in his study on curriculum consistency in corporate education labels this as internal and external consistency respectively

, implying rational (invention) and relational (innovation) approaches.

Discussion and conclusion

The preceding discussion and the model suggest that educational computing research and development should focus on the product through the lenses of basic research hence producing educational software that has been thoroughly tested on both fronts. Much as it is costly to develop a software product, to solve some of the educational and training challenges, an informed approach of involving the stakeholders through analysing the context (what hardware and software limitations), the task at hand and the users themselves is inevitable(Reeves, 2000). Muianga (2005) reports on an on-site study into the development and application of a course management system (CMS) for online learning in Mozambique, which clearly shows the application of development research. Teachers and students were involved in the use of the TeleTop environment, a CMS, which enriched both the design aspects and the innovation challenge, especially on the part of the teachers. Moreover, the Apple Advance Technology Group (Sphorer 1998, in Moonen, 1999) reported that users had to be involved in two perspectives, namely the cognitive fit (for usability) and social fit (for dissemination).

The authors acknowledge that the social fit is appreciably longer than the cognitive fit. Hence, educational technologists should establish the critical determinants for successful adoption and adaptation as they strive to evolve well-situated products for the developing regions. It is of paramount importance that educational technologists in emerging regions are duty-bound to develop models as frameworks for adoption and diffusion. Miller's model, a synthesis of a variety of technology-implementation models, has been successfully tried out in South Africa and Mozambique to study the introduction of computers in schools (Cossa and Cronje, 2004). These two southern countries have been mapped onto the stages in Miller's model. Emerging countries also ought to explore possibilities of at least designing software according to their local priorities; for example, in the Southern African region, South Africa is becoming a producer of software and ICT-related services within the global market (Hodge and Miller 1997; Otter 2005, in Czerniewicz and Carr, 2005).

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Part Three

Startegic Planning and Quality Assurance in Higher Education

7

Research Methods for Organisational Studies

Shushma Patel, Dilip Patel Huong Tang and *Geofrey Elliot*

This chapter examines organisational behaviour research by using the case study approach. The study of organisational behaviour is a broad subject area. The paper outlines our experiences of identifying a research topic, justification of the topic within the context of published literature and the selection of suitable research methodologies. Within this, we identify what the research questions are and how the research is undertaken to address these questions, ensuring that the legal and ethical issues are considered.

Introduction

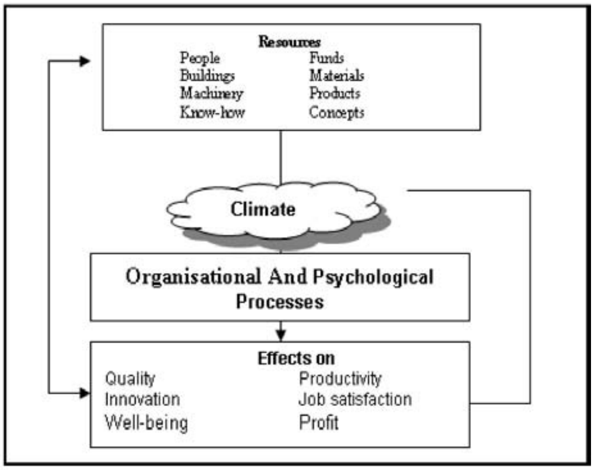
The operations of an organisation are dependent on its climate. The organisational climate is an intervening variable, which has a moderating power because it influences organisational processes such as communications, problem-solving, decision-making and the psychological processes of learning and motivation (Ekvall, 199, see Figure 7.1).

Every organisation has a number of different types of resources (people, money, machines, etc.), which are used in its processes and operations. These operations have different effects at different levels of abstraction:-

- High-quality or low-quality products or services
- Radically new products or only small improvements in the old ones
- High or low job satisfaction among employees
- Commercial profit or loss

Climate has an important influence on organisational outcomes, but the effects in turn influence both resources and the climate itself. However, the study of organisational climate is complex and is further complicated by attitudes, feelings and behaviours, which characterise life in an organisation. Communication, problem-solving, decision-making, learning and motivation can all be affected by the organisational climate. This in turn might affect the effectiveness and the productivity of the organisation as well as the working environment and the well-being at the workplace (Ekvall, 1985). Therefore, organisational climate has much to offer in terms of its ability to explain the behaviour of people in the workplace.

Figure 7.1: The relationship between climate & the organisation (Ekvall, 1991)



This paper describes how the research hypothesis – "An organisation can be nurtured through organisational climate awareness in terms of understanding the feelings, attitudes and behaviours that can be found at the different climate levels within the organisation in order to increase the effectiveness of team/group interactions" – is investigated. In order to evaluate the hypothesis, a number of social science research methodologies can be used. The aim of social science research varies significantly, depending on the theoretical orientation of the framework that guides the research. This work focused on action research, theory testing, sampling – quantitative and qualitative a– nd case study within the context of social science research, and integrated into the framework for investigating organisational climate. Each of these aspects is discussed in detail to justify the approach undertaken.

Research approach

Within the context of organisational climate there are two well-established and defined levels of climate – psychological climate that focuses on the day-to-day feelings, attitudes and behaviours of the employees within the organisation (Hellreigel and Slocum, 1974; Howe, 1977), and organisational climate, which also focuses on the day-to-day feelings, attitudes and behaviours, but at the organisational level (Ekvall, 1991; Schneider, 1968 and 1990; James and Jones, 1989). Review of published literature indicates there is evidence of a third climate level (Powell and Butterfield, 1978), which lies between the other two levels of climate, and refers to the day-to-day feelings, attitudes, and behaviours of the teams/groups found within an organisation. This climate level has been categorised or referred to as team climate, unit climate or group climate (Arvidsson and Johansson, 2003; Salas et al. 2003). This research examines how the two current organisational climate levels, originally proposed by other researchers, can be extended into three new refined levels of climate.

There are a number of examples referring to organic organisational metaphors, in the area of organisational theory, which can be explored further in terms of its potential in nurturing organisational climate awareness. In order to explore the possibilities and benefits climate levels have on nurturing the effectiveness of team/group interactions, the research proposed a new organic organisational metaphor, the 'Tomato Plant' organisational metaphor, where an organisation is viewed as a tomato plant.

The Tomato Plant organisational metaphor and the three levels of organisation climate formed the underlying theoretical framework, from which the organisational climate awareness toolkit was developed.

The toolkit has been developed from a combination of existing organisational analytical tools that are currently used separately to analyse a particular level of climate in an organisation. The toolkit comprises questionnaires developed by Carter and Russell (2001) (Personality Tests Type 1, 2 and 3, Are you Tactful or Undiplomatic?, Are You in the Right Job?); Belbin (1981) (The Team Skills Management-Personal Inventory); Bridges (1992) (The Organisational Character Index); and Goffee and Jones (2001) (The Corporate Character Questionnaire).

The toolkit was used in a three-part case study investigation: part 1 - toolkit pilot on small teams/groups; part 2 - toolkit used on a range of organisations in different industries; and part 3 - toolkit tested on a larger team/group. The organisations were from a judgement sample of twelve organisations ranging from large international organisations such as investment banks and universities to small local supermarkets. Each part of the case study investigation had a post-case study investigation questionnaire that was given to the participants a week after they were given the results of the organisational climate awareness toolkit. The results of the post-case study questionnaires were used to measure whether the toolkit had nurtured the organisational climate awareness levels and if there was any effect on the team/group interactions.

Research Methodology

There are a range of research methodologies that can be applied to study organisational theory and organisational climates. However, the aim of social research varies significantly, depending on the theoretical orientation of the framework that guides the research. The sections below conceptualise the research methodologies used in the paper within social research; explains the research methods of data collection used in the framework of investigation and the data analysis approach taken for the case study investigation; discusses the professional practices and ethics standards for the researcher respondent relationship, which has been taken into consideration.

Social Research

The driving force behind any type of social research is its philosophical framework. This dictates not only the general perception of reality and social relations, but also the types of methods and techniques available to researchers, and the motives and aims of social research. The aims of social research vary significantly, depending on the theoretical orientation of the framework that guides the research. According to Sarantakos (1998) writers usually refer to the following aims: -

1. to ***'explore'*** social reality for its own sake or in order to make further research possible,

   to ***'explain'*** social life by providing reliable, valid and well-documented information,

   to ***'evaluate'*** the status of social issues and their effects on society,

   to make ***'predictions'***,

   to ***'develop'*** and/or ***'test theories'***.
2. to ***'understand'*** human behaviour and action.
3. to offer a basis for a ***'critique'*** of social reality,

   to ***'emancipate'*** people,

   to ***'suggest possible solutions'*** to social problems,

   to ***'empower'*** and ***'liberate'*** people.

It is clear that the aims of social research presented are neither exhaustive nor mutually exclusive. Research projects may be undertaken for a number of reasons and may serve many and diverse aims. These aims depend primarily on the paradigm that guides the project. Positivist research strives to achieve the aims listed under 1, that is, to 'explore', 'explain', 'evaluate', 'predict' and 'develop/test' theories; while interpretive research is more interested in 'understanding' people (point 2). Critical research aims at 'criticising' social reality, 'emancipating' people, and 'empowering' them to change social reality by suggesting possible solutions and thus liberating them from oppressive and exploitative social structures (point 3). Still, the boundaries between these three perspectives seem to be rather flexible.

The research described in this paper is a combination of positivist (p), interpretive (i), and critical (c) research approaches. The hypothesis stated earlier was formulated to help 'explore' (p) the organisational climate framework, toolkit, and theories 'developed' (p) in order to help nurture the employees' awareness and their 'understanding' (i) of the organisational climate levels that exist in their organisation. Therefore, 'empowering' (c) them with knowledge of the ways in which each climate level affects the interactions within a team/group and 'suggesting possible solutions' (c) to any problems that arise.

Action Research

Action research has been traditionally defined as an approach to research that is based on a collaborative problem-solving relationship between researcher and client, which aims at both solving a problem and generating new knowledge. The organisational dynamics in action research (see figure 2) comprises the following (Coghlan and Brannick, 2001): -

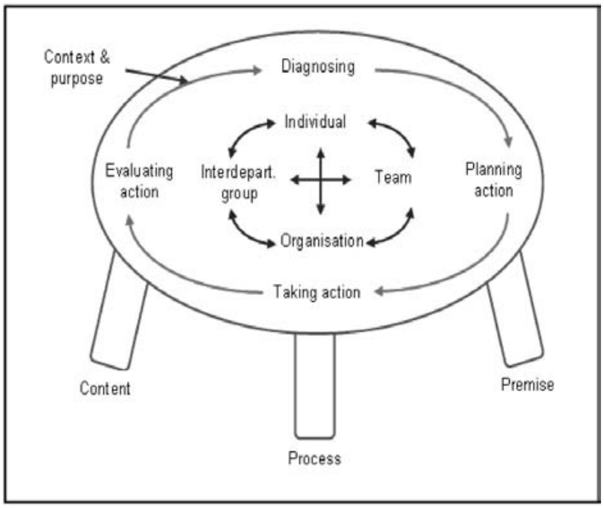
Pre-step: context and purpose

The process of defining the desired future state is critical as it sets the boundaries for the purpose of the project and helps provide focus.

Main steps

1. ***Diagnosing*** – involves naming what the issues are as a working theme, on the basis of which action will be planned and taken.
2. ***Planning action*** – follows from the analysis of the context and purpose of the project, the framing of the issue and the diagnosis, and is consistent with them. It may be that this action planning focuses on a first step or a series of first steps.
3. ***Taking action*** – the plans are implemented and interventions are made.
4. ***Evaluation action*** – the outcomes of the action, both intended and unintended, are examined.

Figure 7.2: Organisational dynamics of action research (Coghlan & Brannick, 2001)



Post-steps: re ective stage – there are three forms of reflection (Mezirow, 1991) and when applied to action research is known as the meta cycle of inquiry.

1. ***Content re ection*** – is where you think about the issues, what is happening, etc = the ***'content'*** of what is diagnosed, planned, acted on and evaluated is studied and evaluated.
2. ***Process re ection*** – is where you think about strategies, procedures and how things are being done = the ***'process'*** of how diagnosis is undertaken, how action planning flows from that diagnosis and is conducted, how actions follows and are an implementation of the stated plans and how evaluation is conducted are critical foci for inquiry.

3. ***Premise re ection*** – is where you critique underlying assumptions and perspectives = there is also ***'premise'*** reflection, which is inquiry into the unstated and often subconscious, underlying assumptions, which govern attitudes and behaviour.

The organisational dynamics of action research has been integrated and used as part of the framework of investigation.

Theory-Testing Research

The main purpose of conducting research is to generate knowledge and understanding of the phenomena that occur, and to build theories based on the research results. According to the Oxford dictionary (1996) the definition of a theory is as follow: -

> *a set of statements or principles devised to explain a group of facts or phenomena, especially one that has been repeatedly tested or is widely accepted and can be used to make predictions about natural phenomena*

Such theories subsequently become the foundation for further study of the phenomena (Sekaran, 1992). This process of building on existing knowledge is the genesis for theory building in the management area. Its aim is to test the validity of a theory (Sarantakos, 1998). Theory building and testing may employ other types of research to achieve its purpose, such as qualitative and quantitative research. The process of theory building in the context of qualitative and quantitative research is clearly different as shown in Table 1. Not only the theoretical framework that guides this process but also the research process itself varies in the two fields.

Table 7.1: Theory building in quantitative & qualitative research (Vlahos, 1984)

Differences	Quantitative research	Qualitative research
Logic of theory	Deductive	Inductive
Direction of theory building	Begins from theory	Begins from reality
Verification	Takes place after theory building is completed	Data generation, analysis and theory verification take place concurrently
Concepts	Firmly defined before research begins	Begins with orienting, sensitising or flexible concepts
Generalisations	Inductive, sample-to-population generalisations	Analytical or exemplar generalisations

Qualitative research has been used in this study in the context of theory building to develop theories to explore the proposed hypothesis. Qualitative research is set to produce theories that are grounded in empirical data from which they are generated, which is known as 'grounded theory' and are the result of social research that goes through a number of steps (Sarantakos, 1998).

Theories in this research are approached from the qualitative research aspect where the logic of those theories is 'inductive' in terms of increasing awareness and understanding the 'reality' of how different levels of climate within an organisation can affect us. The 'verification' process of the theories proposed is carried out with the use of the toolkit, framework and case study investigation.

Data Collection & Analysis

There are two types of data, primary and secondary. Leedy and Ormrod (2003) stated that data is said to be primary if it is collected first-hand by an inquirer for a determinable purpose. Whereas, secondary data refers to data that has been selected by an inquirer who is not one of the original data creators, for a purpose that may be different from that of the original purpose. Table 7.2 is a comparison of primary and secondary research approaches to data collection (Sekaran, 1992).

Table 7.2: Comparison of primary & secondary research approaches to data collection (Sekaran, 1992)

	Primary research	Secondary research
Data collected	• The investigator must design & implement the data collection process. This can be a controlled (laboratory) experiment or a sample survey.	• The investigator does a search for relevant data. • Investigators can use a variety of sources of data. These could be - statistics published by governments or other organisations, such as the UN - census data - scholarly articles published in journals - archived data (from surveys etc.)
Pros	• An experiment can isolate the factors of interest & eliminate or control for unwanted factors. • Randomised investigations can avoid bias.	• Data can be available for different times & places so that they apply to a wide range of circumstances & lead to more encompassing generalisations. • The use of many sources of data may make the research convincing because of its large sample size & representativeness. • Collection of data can be cheap & quick.
Cons	• Experiments can be contrived & artificial so that the scope to generalise them to the real world can be limited. • A large investigation can be expensive. • Investigations can take a long time to complete.	• The investigation is limited by the data available. • The available data may not exactly match what is required for the research. • The data that has been published might be a biased selection.

This research utilised a combination of primary and secondary data, whereby, the foundations for the underlining theoretical framework and theories proposed in this research were based on empirical secondary data. Primary data was generated from the case study investigation that was undertaken as part of the framework of investigation.

Sampling

The research approach undertaken in this research is mainly qualitative and, therefore, the qualitative sampling aspects have been taken into consideration when choosing the sample for the case study investigation. Table 7.3 shows that the qualitative sampling size is relatively small and there are positive outcomes in terms of time, cost and ease of use. Sarantakos (1998) states that many researchers use a minimum of 100 subjects to allow statistical inference, but this is not always correct. Published research literature has shown that many statistical measures are designed for samples smaller than 30 (Robson, 1993; Bryman and Bell, 2003; Leedy and Ormrod, 2005).

Judgement sampling is similar to convenience sampling, except that it is more refined. In convenience sampling, a researcher exerts no effort to obtain a representative sample. Such efforts are expended in judgement sampling. Judgement sampling (or purposive sampling) is thus a procedure in which a researcher exerts some efforts in selecting a sample that he or she believes is most appropriate for a study and therefore is more representative of the ideal population than a convenience sample. (Parasuraman et al., 2004).

Table 7.3: Quantitative & qualitative sampling - a brief summary (Sarantakos, 1998)

Quantitative sampling	Qualitative sampling
Is relatively large	Is relatively small
In most cases it employs statistics	In most cases it employs no statistics
Is often based on probability theory	Is often based on saturation
Allows no researcher bias in selection	Allows researcher influence in selection
Its size is statistically determined	Its size is not statistically determined
Occurs before data collection	Occurs during data collection Involves simple procedures
Involves complex procedures	Its parameters are flexible
Its parameters are fixed Involves high costs	Involves very low costs
Is time-consuming	Is not time-consuming
Is representative	Is not representative
Is laborious	Is easy
Treats respondents as units	Treats respondents as persons
Facilitates inductive generalisations	Facilitates analytical generalisations

Questionnaires

Questionnaires as a method of data collection have both strengths and weaknesses. These strengths and weaknesses are factors that have a significant impact on a researcher's decision about whether or not to use questionnaires in the study.

Questionnaire construction is a very demanding task, which requires not only methodological competence but also extensive experience with research in general and questioning techniques in particular (Leedy and Ormrod, 2005). This expertise provides the researchers with the necessary skills required to cope with the major issues of this process, which relate to how the format of the questionnaire should be moulded, what types of questions should be considered and what they should contain, how long the questionnaire should be, and in general how the questionnaire should be presented so that it is clear, easy to read and attractive to the respondent and, most importantly, so that it achieves its purpose.

The process of questionnaire construction is time-consuming and requires extensive experience to produce a questionnaire that is justifiable as a research tool. Therefore, this research proposes a toolkit made up of a combination of existing questionnaires that have been tested and widely accepted in organisational theory research in order to explore and test the proposed hypothesis.

Case Study

According to Leedy and Ormrod (2005) a case study is a type of qualitative research method in which in-depth data are gathered relative to an individual, group or organisation for the purpose of learning more about an unknown or poorly understood situation. There are four main aspects needed for case study design:-

1. A 'conceptual framework'
2. A set of 'research questions'
3. A 'sample strategy'
4. A decision on 'methods and instruments for data collection'

In case study research, the notion of combining qualitative and quantitative data offers the promise of getting closer to the 'whole' of a case in a way that a single method of study could not achieve (Brewerton and Millward, 2001). These aspects of the qualitative and quantitative combination approach of case study design are explored in relation to the design of the case study investigation. The organisations in Table 4 were chosen on the basis of the judgement sampling method where a range of organisations were chosen from large international organisations such as investment banks and universities to small local supermarket. The aim of this is to show that the toolkit is generic in use in any organisation. By looking at organisations in service-based industries to demonstrate the toolkit diversity in use.

Data Analysis Approach

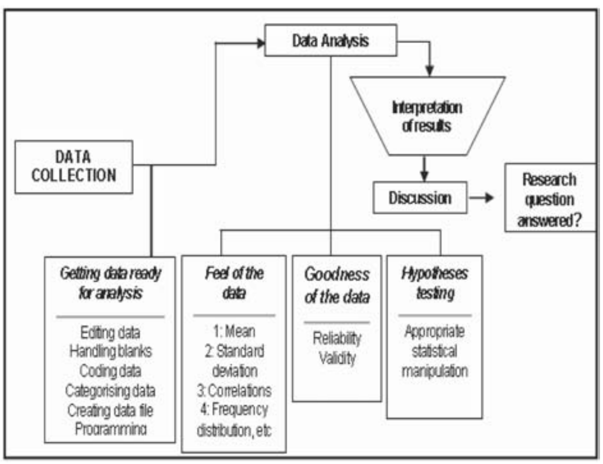
In qualitative research, data analysis often occurs simultaneously with data collection, data interpretation, and narrative report-writing. According to Denzin and Lincoln (1994) in qualitative analysis several simultaneous activities engage the attention of the researcher: collecting information from the field; sorting information into categories; formatting the information into a story or picture of the event; and actually writing the qualitative narrative report. In qualitative research, the researcher takes a voluminous amount of information and reduces it into meaningful categories, patterns, or themes and then interprets the information. Flexible rules govern how one goes about sorting through interview transcripts, observational notes, documents, and visual material (Creswell, 1994).

However, the researcher generally forms categories of information and attaches codes to these categories. These categories and codes form the basis of the emerging story to be told by the qualitative researcher (Kirk and Miller, 1986). Although the rules of this process are flexible, the process should be systematic and well articulated as part of the qualitative plan and final report. While much of the work of analysis entails taking apart and organising information, the final goal is the emergence of a larger, consolidated picture of some social reality.

Mason (1996) stated that the intent of qualitative research is not to generalise findings, but rather to form a unique interpretation of events for a given group of individuals or institutions, within a given context, at a particular point in time. Like the issue of generalisability, the uniqueness of the study within a particular context militates against replicating the research exactly in another context. After collecting data from a representative sample, the next step is to analyse the data so that the research hypothesis can be evaluated and tested.

However, according to Sekaran (1992) before this can be done some preliminary steps need to be completed. These steps help to prepare the data for analysis, ensuring that the data obtained is reasonably good, and allow the results to be meaningfully interpreted. Figure 3 shows these steps and identifies the four steps in data analysis as (1) getting data ready for analysis, (2) getting a feel for the data, (3) testing the goodness of data, and (4) testing the hypotheses.

Figure 7.3: Flow diagram of data analysis process (Sekaran, 1999)



These preliminary steps of preparing collected data for analysis have been integrated into the framework of investigation.

Ethics

Many organisations have a 'human subjects committee' to protect the rights of human subjects involved in any type of research activity involving people (Sekaran, 1992). The basic function of these committees is to discharge the moral and ethical responsibility of the organisation by studying the procedures outlined in the research proposals and giving their stamp of approval to the studies. There are professional practices and ethics standards for the researcher-respondent relationship, which this research follows as guidelines in the context of conducting research (see Table 7.4): -

Table 7.4: Ethics standards for researcher-respondent relationship (Sarantakos, 1998)

Practices/ethics standards	Description
Proper identification	Codes of ethics suggest that the researcher should identify herself or himself to the respondent and avoid giving false impressions of the researcher or the project sponsor.
Clear outset	Researchers should inform the respondent of the type of questions, the degree of question sensitivity or stress and the possible (true) consequences that the questioning and the research in general might have on the respondent.
Welfare of the respondent	The researcher should always be concerned with the welfare of the respondent, including mental and physical health and safety, and take all possible precautions to avoid incidental injury. The researcher should also avoid questions or issues that may cause embarrassment, guilt, discomfort, hazards or risks to the respondent (Vlahos, 1984). Where such conditions might occur, the researcher should inform the respondent accordingly at the outset of the study.
Free & informed consent	Respondents should participate in the research freely and not be pressured to do so or deceived in any way. They should also be fully informed about the nature and goals of the study before they are asked to take part in the project.
Right to privacy	Researchers should respect respondents' privacy when entering their private sphere and when asking questions, and should allow respondents to leave unanswered questions for which they do not wish to provide the information required.
Right to anonymity	Data collected by the researcher should be anonymous, that is, not related to names or other forms of identification.
Right to confidentiality	Information offered by the respondent should be used by the researcher only, and only, for the purpose of the study; it should not be made available to other people for any reason or purpose.

London South Bank University has an Ethics Committee, whose purpose is to approve all investigations involving human participants for which they are responsible. The Ethics Committee is primarily concerned with ensuring that the proper ethical standards are maintained in carrying out investigations. The Ethics Committee will consider and comment on whether a proposed investigation has a clear purpose or is productive (Research and Business Development Office, 2003). The research presented in this paper was approved.

Conclusion

The purpose of this paper was to outline the research methodologies used in this research to evaluate and explore the proposed hypothesis. A combination of positivist, interpretive and critical research approaches of social research aspects have been taken into consideration. This research utilises a combination of primary and secondary data. Hence, the foundations for the underlining theoretical framework and theories proposed in this research are based on empirical secondary data. Primary data was generated from the case study investigation that was undertaken as part of the framework of investigation. The research approach undertaken in this paper is mainly qualitative and, therefore, the qualitative sampling aspects have been taken into consideration when choosing the sample for the case study investigation. Also, the qualitative sampling size is relatively small and there are positive outcomes in terms of time, cost and ease of use.

The process of questionnaire construction is time-consuming and requires extensive experience to produce a questionnaire that is justifiable as a research tool. Therefore, this research proposed a toolkit made up of a combination of existing questionnaires that have been tested and widely accepted in organisational theory research in order to explore and test the proposed hypothesis. When carrying out research it is important to follow the professional practices and ethic standards.

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Part Four

Sustainable Information and Communication Technology Development

8

The Role of ICTs and their Sustainability In Developing Countries

Justine Kasigwa, Ddembe Williams and *Venansius Baryamureeba*

This chapter discusses how developing Countries (DCs) are increasingly aware that they have a major responsibility for rural ICTs development, but often lack the capacity and solutions to meet the challenge. Rural people constitute the greater part of the population in DCs and often lack access to basic ICT needs. These conditions, considered harsh by the majority of the rural population, result in immigration into urban areas, often in search of formal employment, as the only option for survival. This paper uses critical discourse analysis to demonstrate how ICTs have become deeply involved in the conception and practice of socioeconomic development within (LDCs) The challenges of creating sustainable ICT projects, initiatives and ultimately the community development in LDCs is explored and recommendations on the way forward are made.

Introduction

Information and communication technologies (ICTs) are often promoted as central to reviving and sustaining regional communities (Simpson and Hunter, 2001)[23]. The information revolution is another intervention with the potential to ensure that knowledge and information on important technologies, methods and practices are put in the right hands. The relevance of this revolution is supported by Balit (2003)[2]who pointed out that the least expensive input for rural development is knowledge. Knowledge and information are basic essentials for facilitating rural development and bringing about social and economic change. While many developed countries have high-profile computer industries that have become major export businesses, sub Saharan Africa has few ICT success stories to tell. The situation is rather that donor-funded Western experts are paid high salaries for doing quick consultancy tasks without contributing to the development of local resources. While available capital for private investments, technological infrastructure and political stability are crucial factors for developing ICT industry, no business will start without skilled specialists.

Traditional media and new ICTs have played a major role in diffusing information to rural communities, and have much more potential. Despite the emphasis placed on ICTs, many ICT initiatives have stalled in DCs. In short, the question of how community-based ICT initiatives can survive financially, that is be sustainable in the longer term, has grown in significance (Gurstein, 2001)[14]. In this paper, the role of ICTs in the sustainability of regional communities is initially considered and some of the reasons for the failure of ICT initiatives are then explored, finally the critique and way forward are discussed. This discussion leads us to ask whether there are more effective models of the implementation of ICTs and their role in regional development. Based on a review of the literature in this field and on action research conducted in Uganda, it is proposed that regional ICT initiatives need to:

(i) achieve clarity in specifying sustainability goals;

(ii) leverage micro-business enterprise development off government-funded technical and human infrastructure provision;

(iii) build on local industry strengths and learn from global experiences whilst building on local assets;

(iv) find innovative business models to capitalise on new ICT opportunities for content and applications;

(v) ensure community involvement in deciding, planning and evaluating projects; and

(vi) adopt a learning approach through cycles of evaluation based on action research.

Current State of ICTs in Developing Countries

The position that ICTs have a role to play in enhancing sustainability in regional communities has several threads and can be seen from three spheres – community, government and business. Here, community is understood as sustainability of what a group of people living in a geographically defined area consider important, how they want to achieve those goals and what they judge their success by (Simpson and Hunter, 2001 [23]; Stellar, 2002 [24]; Gurstein, 2001 [14]). Representatives of each sphere sometimes ascribe different meanings to sustainability. Briefly, from a community perspective, sustainable ICT projects are those that can pay their own way, generally without reliance on government funding. Those who adopt a business perspective view sustainability in terms of whether the project is commercially viable and profitable. Proponents of the government perspective focus on service provision and they recognise that governments have community service obligations and that market failure occurs, especially in rural, regional and remote areas where the costs of setting up and maintaining ICT services can be very high. These factors make government support of ICT initiatives necessary. Yet these advocates acknowledge that, in the current policy context, government funds are limited. Consequently, greater financial responsibilities are being foisted onto local communities (Alston, 2002)[1]. Expanding on the community perspective, Gurstein (2001) [14] argues that if an ICT facility is seen as providing a community service and the ongoing sustainability can be understood within the context of the ongoing sustainability of other community services such as schools, health facilities etc and can be drawn from whatever sources (taxes, grants-in- aid etc.) are supporting those services. However, if the ICT facility is seen as only providing a service to specific individual users, then the model of sustainability must necessarily be one of identifying individual revenue sources and immediately puts the facility into the context of market-driven mechanisms. If the ICT facility is a necessary component of capacity development for local citizenship, i.e. of maintaining local empowerment, then clearly the issue of sustainability must be looked at in the first context. The aim of the research then becomes identifying the manner in which the ICT facilities can become sufficiently and visibly embedded in the community so that it is recognised for what it is, a necessary component for community survival. To attain this, of course, requires the development of strategies and applications which link the facility directly into other and necessary community processes and involves determining how to use the technology as the basis for more effective and efficient organisational management. What Gurstein [14]makes clear is that not only does sustainability mean different things to different groups but also that these understandings can derive from the purpose from which the facility is seen to be used and from the ideological position(s) of those users.

A Critique: Reasons for the Failure of ICT Initiatives

Based on several analyses, it has been found that a variety of factors contribute to the stalling of many ICT projects in DCs. These factors are: many initiatives are largely ICT supply-driven and fail to specify and address local and cultural impediments and opportunities; they do not take account of the dynamics of the global ICT industry; they are overoptimistic about the productivity improvements that ICTs can bring in traditional industries; and they often overlook the importance of content per se. They are discussed briefly below:

ICT supply driven initiatives and failure to specify and address local and cultural impediments and opportunities

As many initiatives are largely ICT supply-driven, they result in inadequate consideration being given to the local context (Simpson and Hunter, 2001 [23]; DCITA, 2003, [9]). Local cultural impediments and opportunities can be overlooked as a result (Oakley and Campbell, 2002) [19]. Examples include: the length of time the community has been exposed to ICTs; community members' access to and experience with these technologies; the type of industry(ies) in, and the socioeconomic structure of, the area; and how businesses view the use of ICTs in relation to their operations. By overlooking such contextual considerations, the advocates of ICT projects can mis-specify and under-resource the social and human infrastructure required. It is necessary that citizens are able to not only access that technology but that they also possess the skills to use and the resources to access them. This endeavour might require governments and communities employing skilled specialists in regional areas (Simpson and Hunter, 2001) [23]. As a number of Ugandan and international initiatives have indicated, relying on volunteers to raise awareness and to provide training can be detrimental to the sustainability of a project in that, where there is only a small pool of volunteers to draw upon, these people may suffer from burnout (Colle, 2000) [7].

Initiatives that do not take account of the dynamics of the global ICT industry

Outcomes like those considered above highlight the digital divide. The digital divide refers to those who lack the ability or the capacity (including affordability, information literacy skills and location) to access and use basic ICT services. This divide exists between and among developed and developing countries, between rural and urban areas, within urban areas, between racial and ethnic groups, and between those that society considers able and thoseit deems disabled (Rooksby et al. 2003)[22]. These points regarding the nature of the digital divide are reinforced by the uptake of ICTs being slower in those regional areas where incomes (and educational levels) are lower than in some urban areas. As ICT uptake has been identified as related to gender, age, education, income and interest level (Simpson and Hunter, 2001, pp. 59; Rooksby et al., 2003), then it may also be a socioeconomic divide. Thus supply-side policies could be insufficient to address it adequately (Simpson and Hunter, 2001 [23]; Rooksby et al., 2003 [22]).

The digital divide has magnified existing socioeconomic disparities (Krouk et al. 2000 [17]; Rooksby et al., 2003 [22]) by further marginalising those who are already disadvantaged while extending the power and reach of groups such as those who are information literate or who own and manage capital (Gurstein, 2001)[14]. Where ICTs are considered a driving force behind globalisation, it is possible that globalization hollows out local communities, making whole regions expendable in relation to these overwhelming global forces (Gurstein, 2001)[14]. By considering the digital divide it is evident those who have been implementing some ICT projects in regional communities might have been ignoring the local context and been giving insufficient attention to the structure of the global ICT industry. Some approaches might provide access to another tool of information, without questioning its forms and content, thus consolidating social and economic inequalities (Fortier, 2000)[11] as a consequence.

Over-optimism about the productivity improvements that ICTs can bring to traditional industries and overlooking the importance of content per se.

Another reason why some ICT projects fail is that their drivers can be over-optimistic about the productivity improvement ICTs can bring in traditional industries. This enthusiasm might lead governments and communities to focus on traditional industries rather than to foster diversification such as through the development of new industries. This situation can contribute to people neglecting innovative and creative content that is relevant to the needs of a local community. ICTs are changing the way all sectors operate (Hearn and Manderville, 2004). Yet research indicates that productivity growth arises from a complex set of factors, not just ICTs (Castells, 1996a [5], 1996b [6]; Parham, 2003 [21]).

In general, over several decades, productivity growth has not paralleled investment in ICTs (Castells, 1996a [5], 1996b [6]). As an analysis of Uganda's productivity upsurge during the 1990s reveals, the link between ICTs and productivity growth is complex and might not be even across all firms and industry sectors. A set of multiple and interacting factors might have been responsible for the productivity gains that Uganda is experiencing. One of these is the catch-up phenomenon. This characteristic is evident in Uganda's productivity surge predating that in the USA. The greater access to, and better use of, ICTs in many industry sectors in Uganda is facilitated by the policy reforms introduced progressively from the early 1980s. These reforms were aided by organisational restructuring, and upskilled workers and managers (Gretton et al., 2003 [13]; Parham, 2003 [21]).

The multiplicity of factors in the productivity of ICT is apparent when examining specific cases. These examples indicate that there is significant variation in mechanisms of how ICTs might yield productivity gains (Lennie et al., (2002 [18]). The use of ICTs within an enterprise could either enhance or reduce productivity through their effect on at least five functions and processes.

First, they might reduce the informational component of an enterprise's transaction costs. Alternatively, ICTs may increase transaction costs by adding additional steps in the production process through increases in the level of technology and/or staff needed to process logistical information. ICTs might also expand the amount of information that has to be collected. There are also significant hidden human resource costs in terms of training and recruitment (Hearn and Manderville, 2004 [15]).

Second, distributed systems, intranets and web band services all change the logic of space and time that connects enterprises to their stakeholders. However, the opposite is also true. For example, where banks have replaced branches with ATMs in Uganda, their managers appear to have failed to understand their customers' attachment to real rather than virtual branches (Hearn and Manderville, 2004 [15]). New markets and users can clearly be reached.

Third, adding information to an existing product or service can make it smarter and more attractive to clients. ICTs are used widely in agriculture, for instance (Hearn and Manderville, 2004 [15]; Goggin, 2000 [12]). Yet increased information intensity can add significant costs to an enterprise without improving quality or lowering cost.

Potential of new ICTs for rural development

While the term ICTs can be interpreted as including a wide range of media, new ICTs is used to denote "the use of computers and communication systems between computers" (CTA 1999:4)[8]. These new ICTs are becoming more accessible, and users can obtain information from various sources, and one computer could meet the needs of a large rural community. Electronic mail is the most commonly used new ICT and has caused a cultural revolution in the way individuals and organisations interact, in terms of time, cost and distance. The second most significant use of new ICTs is the World Wide Web, which enables people to access information on millions of other computers.

Although the Internet is not a panacea for rural development problems, it can open new communication channels that bring new knowledge and information resources to rural communities (Bie, 1996)[4]. Traditional communication channels have been used successfully but these have been monologic and have not allowed for much interaction with users. Radio, for example, has been very effective in disseminating information to all types of audiences, but broadcasting times are sometimes not appropriate for most people. But radio could be linked to the Internet, and a few initiatives have been started on this concept. This enables users to access programmes on the Web at a convenient time, and send feedback through email or chat. Broadcasters could then disseminate the latest information promptly.

Some examples of areas where ICTs could play a catalytic role in developing rural areas include:

(i) ***Decision-making process:*** Sound decision-making is dependent upon availability of comprehensive, timely and up-to-date information. ICT problems facing developing countries demonstrate the need for informed researchers, planners, policy-makers, and development workers. Information is also needed to facilitate the development and implementation of ICT policies. Email and the Internet could be used to transmit information to and from inaccessible rural areas.

(ii) ***Market outlook:*** People in LDCs could promote their products and handle simple transactions such as orders over the Web while payment transactions for the goods can then be handled offline (OFarrell et. al., 1999:4) [20]. It has been shown to be cheaper and faster to trade online than on a paper-based medium, telephone or fax. Electronic commerce could, therefore, enable entrepreneurs to access global market information and open up new regional and global markets that fetch better prices and increase peoples earnings.

(iii) ***Empowering rural communities:*** ICTs can empower rural communities and give them "a voice" that permits them to contribute to the development process. With new ICTs, rural communities can acquire the capacity to improve their living conditions and become motivated through training and dialogue with others to a level where they make decisions for their own development (Balit, 2004) [3] . Giving rural people a voice means giving them a seat at the table to express their views and opinions and becoming part of the decision-making process. The approach should be participatory and could lead to improved policy formation and execution. Improved policy formulation and strategies, however, require "an educated and informed populace to reduce poverty, excessive population growth, environmental degradation and other factors that are most often the direct causes of hunger" (FAO, 1998)[10]. New ICTs have the potential to penetrate under-serviced areas and enhance education through distance learning, facilitate development of relevant local content and faster delivery of information on technical assistance and basic human needs such as food, agriculture, health and water. The Internet can also enable the remotest village to access regular and reliable information from a global library (the Web). Different media combinations may, however, be best in different cases through radio, television, video cassettes, audio cassettes, video conferencing, computer programs, print, or the Internet. Rural areas also get greater visibility by having the opportunity to disseminate information about their community to the whole world.

(iv) ***Targeting marginalised groups:*** Most poor rural people lack the power to access information. ICTs could benefit all stakeholders including civil society, in particular youth and women (UNDP, 2000)[25]. Other disadvantaged groups that could be targeted include the disabled and subsistence peasants.

(v) ***Creating employment:*** Through the establishment of rural information centres, ICTs can create employment opportunities in rural areas by engaging telecentre managers, subject matter specialists, information managers, translators and information technology technicians. Such centres can help bridge the gap between urban and rural communities and reduce the rural-urban migration problem.

5. Way forward: Key factors for ICTs sustainability in DCs

A number of other insights about the sustainability of regional ICT projects can be gained from these cases. In feedback on the initiatives, participants in both communities understood sustainability as community sustainability. They stressed the growing importance of financial viability in a time of diminishing government assistance. Yet perhaps more significant than, and a precursor to, this financial viability is the requirement that the ICT initiative is relevant to the community. As one participant stated, sustainability means that the project is ongoing and can sustain itself financially and continue to provide a service to the community. Another participant argued that the initiative must be of benefit to the community and continually grow and change with the community. To meet the shifting needs of individuals and groups they must be relevant and useful. The project needs to not only [be] able to keep itself going but to be a growing entity as well.

(i) ***In uencing ICT policy in rural development context:*** Weak and inadequate policies have led to lack of development (social, economic, political) and to problems of ICTs in many developing countries. This underlines the need to address policy constraints (Jensen, 1997). Developing countries could play a much greater role in facilitating ICT policy formulation and implementation. Its status makes it much easier for it to seek audience with key decision - and policy-makers within the government sector and the international community. There are a number of success stories in the ICT sector, and these could be shared and discussed with policy-makers and be considered as best practice guidelines for formulating ICT policies. There is also a need to advocate the institutionalisation of communication as a vital component of rural development policies of developing countries.

(ii) ***Telecentres:*** There is evidence that telecentres have played a major role in mobilising communities to address their development problems. Telecentres can be used as information hubs that capture, repackage and disseminate information to rural communities (FAO,1998). Bie (1996) recommends "an Internet and development strategy focused on rural and agricultural communities and the intermediary agencies that serve those communities with advice, project support, research, extension, and training". Governments could take the lead and work with like-minded partners to further develop the concept of multipurpose community information telecentres into information and knowledge systems, aimed at meeting ICT and rural development goals.

(iii) ***Capacity-building and training:*** One major constraint to the delivery of ICTs initiatives in rural areas is weak institutional capacity and insufficient coordination. NGOs and the private sector in particular possess a vast but often untapped potential. DCs could seek partners to fund capacity-building activities. The partnership could also assist with building the required human and institutional capacities at national and regional levels to provide training and education to rural communities on how to manage local knowledge and information, using ICTs. The training materials produced could be availed as an electronic archive of training resources, and could be repackaged in preferred media such as the successful video-based model used in LDCs. The resources could then be translated into major languages to ensure that most developing countries benefit.

(iv) ***Harmonisation of standards:*** As Simpson and Hunter (2001) [23] argue, common standards are a prerequisite for sharing information. Developing countries could work with relevant producers and disseminators of knowledge and information to develop standards for managing information and knowledge targeted at rural communities. Some tools and methodologies such as Participatory Rural Communication Appraisal (PRCA) have already been developed and have been used to "uncover local skills and knowledge" (Anderson et al., 1999:2) and to fully understand the information and knowledge needs of rural communities. These could be promoted for adoption by other actors in rural areas.

(v) ***Repackaging and local content development:*** The African Development Forum (ADF99) underscored the need to harness indigenous knowledge for development. This is further supported by One World, who have stated that "a country's knowledge base needs to be developed and fostered to both improve its competitive position and to contribute to human and sustainable development goals" (One World, 2000). Developing countries have to play a major role in managing local scientific and technical agricultural information and could, in the same vein, provide technical assistance to national and regional institutions managing rural knowledge and information systems. Special emphasis could be placed on developing and disseminating local content, "improving the relevance of the information to local development" (FAO 1998:3), as well as capturing and auditing all relevant local resources using ICTs. The resources produced should involve the participation of local communities and be packaged in local languages, to make the services offered more valuable and accessible.

(vi) ***Promoting use of traditional and new ICTs:*** Developing countries and partners could play a key role in raising awareness of the power of appropriate traditional and new ICTs in facilitating rural development and ICTs. This could be done through workshops, visits to telecentre models, radio, video, television and print. LDCs may also produce and disseminate documentation on development and use of ICTs and electronic information management systems.

(vii) ***Sustainability of ICT projects:*** Most projects established with external funding face major challenges after the project period has ended. Sustainability of these projects should be considered right from the outset and, where possible, should have government, private-sector and community support (Lennie and Hearn, 2003 [18]). Users should also pay for services but the cost will depend on how much they can afford. There are as yet few examples of success in attaining such sustainability, and there is urgent need for viable models to be developed and tested.

Conclusion

This research, combined with several other Ugandan and international studies, suggests that there are several factors that can assist in the sustainability of ICT projects, and can promote economic and community development. They cover and ensure the community's sustainability goals that are specified clearly through measures including community involvement in deciding, planning and evaluating projects; and adopting a learning approach through cycles of evaluation based on action research. These features also include leveraging micro-business enterprise development of government-funded technical and human infrastructure provision, building on local industry strengths, learning from global experiences whilst building on local assets; and finding innovative business models to capitalise on new opportunities for content and applications.

These characteristics are evident in successful Ugandan and international initiatives. They were missing from projects that stalled, especially through their drivers' failure to consider the local context and the dynamics of the global ICT industry. In ignoring these features, the strengths and impediments unique to a particular community were sometimes overlooked and the assumption that the use of ICTs translates into greater productivity was not questioned.

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9

Income Generation at Public Universities: A Case of the University Of Nairobi Enterprises and Services Limited

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In this chapter, we look at income generation at public universities. Over the years, public universities in the region have had to innovate in order to cope with increased competition and diminishing capitation, particularly from the Treasury. The University of Nairobi is no exception. In 1995, under the strain of outstanding debts to suppliers, utilities, Kenya Revenue Authority and pension schemes, it decided to set up the University of Nairobi Enterprises and Services Ltd. (UNES), a limited company wholly owned by the university. Amongst other objectives, UNES was to facilitate the running of the parallel programmes for full fee-paying students at both undergraduate and postgraduate levels. It also facilitated revenue collection for various income-generation activities (IGA) from various non-academic income generating units, such as mortuary services. The income generated was classified by the nature of the activities: teaching, consultancy, short courses and special production units with clearly defined schedules for disbursement of the said generated income. It was in this way that the University of Nairobi was slowly able to get itself off the ground and move towards partial solvency. The diversification of income-generation activities, improvement of internal processes, better customer/client services and managing the tenuous relationship between the university and UNES , a company wholly owned by the university, through a judicious balance between autonomy and co-operation, is advised for the sustainable development of both parties.

Introduction

Global context. Revenues raised from industry and commerce are becoming an increasingly important source of income for universities. These sources are gradually accounting for a larger proportion of the total income. The generation of this income, along with certain other activities, has sometimes been referred to as 'academic entrepreneurship'.

The perception of universities as merely institutions of higher learning is gradually giving way to the view that universities are important engines of economic growth and development (Chrisman et al., 1995). The knowdege society is having an important impact on economic life and universities are increasingly adopting a more outgoing, market-led commercial attitude, plugging into and supporting economic development.

Smilor et al. (1993) argue that a new paradigm is emerging of the 'entrepreneurial university' which encompasses a more direct involvement in the commercialisation of research activities, and a more proactive approach to the role of academic research in the market place. This paradigm emphasises that the environmental forces of a hyper-competitive global environment are alterting the university's research, teaching and service misssions.

Local background. Over the past one decade or so the University of Nairobi (UoN) has continued to receive less financial allocations from the Kenyan government than the estimated expenditure. This trend has resulted in the accumulation of a debt now totalling about 2.3 billion (2005 Ministerial Public Expenditure Review, Table 2.16, page 39).

There are strong indications that the government will no longer be able to fully finance public universities.

The Sessional Paper No. 1 of 2005 on Policy Framework for Education, Training and Research has clearly brought out this fact by stating that "university education is particularly expensive to Government and is not sustainable within current resources. Universities will, therefore, have to reduce their dependence on the Government and diversify their sources of income as well as ensure more efficient and cost-effective use of institutional resources. They will also be required to establish comprehensive financial management systems that ensure efficiency in the application of resources (p.74)".

In an attempt to bridge the gap between the budgetary allocations and actual expenditures, the university established University of Nairobi Enterprises and Services Ltd. (UNES)in 1996 as its commercial arm and charged it with the responsibility of promoting and coordinating income-generating activities in the university. In order to respond fully to this challenge it was deemed necessary to separate the management of income-generating activities from the mainstream teaching and research functions of the university, while ensuring that the income from these activities serves the core functions of the university. To successfully pursue this goal, the UNES Board of Directors realised right from the beginning that the company needed a clear roadmap to guide its operations. It, therefore, sanctioned formulation and implementation of the first corporate Strategic Plan (1998-2001).

The main thrusts of the first Strategic Plan were stakeholder education on the need to intensify income-generating activities, and the strategic value of mounting module II degree programmes. In general, UNES successfully achieved these two strategic objectives.

History has shown that the higher the success, the tougher the demands that are placed on institutions as well as on individual players. It was, therefore, not surprising that UNES identified new and perhaps more challenging issues as it formulated its second Strategic Plan (2001-2005). Among these issues were the need for diversification of business areas; consolidation and expansion of existing programmes; relationships with various university organs, corporate governance and image, and human resource-related issues. Despite its success, UNES has encountered serious challenges, mainly from key internal stakeholders.

An implementable Strategic Plan must incorporate both the assessment of the internal operating environment and the potential impact of external (contextual) factors. In this regard, since UNES is wholly owned by the university, which is a state corporation, the impact of any government regulations and directives must be evaluated when formulating the UNES Strategic Plan for the 2005 – 2010 period. At present one principal government directive is that all state corporations must embark on result/performance-based management systems.

Results-based management is currently being instilled into the Public Service through performance contracts. A performance contract is an agreement between two parties that clearly specifies their mutual performance obligations, intentions and responsibilities. Simply stated, a performance contract comprises the two major components of determination of mutually agreed performance targets and review and evaluation of periodical and terminal performance. The two components also constitute the hub of an implementable strategic plan.

The third UNES Strategic Plan (2005-2010) has been formulated in such a way that it reflects the key elements of results-(performance-) based management, namely the mission, objectives, performance criteria and indicators, and targets. It should, however, be noted that the UNES performance contract predicated upon this Strategic Plan will be signed with the University Council since, as stated above, UNES is a wholly owned subsidiary of the university. Therefore, the substance and spirit of this plan are consistent with those of the university.

The company derives its mandate from the Memorandum of Association, which states that the company was formed, inter alia, to:

- harness the resources of the university with a view to enhancing the university's teaching and research capabilities;
- promote, co-ordinate, and provide managerial services for income-generating activities within the university;
- undertake consultancy work, research, production and other income-generating activities and promote and facilitate such activities undertaken by departments and other organs of the university;
- provide managerial services for consultancies, research, production and other income-generating activities to the departments, faculties and other units of the university; and,
- register patents of any inventions and innovations to which the company will have made a contribution.

Data Collection Instruments and Administration

Approach and methodology. In the preparation and development of the UNES Strategic Plan for the period 2005 to 2010, 15 formal meetings and a three-day retreat were held. Both secondary and primary data were used to develop the strategic plan. For the secondary data, the team reviewed a number of relevant documents, which included the two previous UNES strategic plans, the 2001 – 2005 university Strategic Plan, other university documents, the report of University Academic Staff Union on module II programmes, public sector reform programme documents, the State Corporations Act and MoES&T documents.

For the primary data, the team adopted the survey approach. The team organised face-to-face interviews, talks and discussions with UNES stakeholders that included the Vice Chancellor, members of the College Academic Boards of the six colleges and senior administrative staff. In addition, the team interviewed the Managing Director, Business Development Manager and other staff at UNES.

In order to have wider university coverage, a structured questionnaire was distributed both by hand and electronically to a number of stakeholders. The Technical Team visited all the six UoN colleges and administered the questionnaires. Among other analyses, the attitude analysis of the structured questionnaire enabled the team to determine the attitude that the various stakeholders hold towards UNES.

Data Organization

Three different questionnaires were administered, each one to one of the following groups:

1. UoN staff members comprising:
   a) College Academic Board (CAB) members for all six colleges;
   b) Senior staff in central administration including the librarian and internal auditor; and
   c) Miscellaneous staff.
2. UoN students from both Module I and II.
3. All UNES staff members.

Not all the data that was collected using the above instruments was analysed. This is because some of the questions in these questionnaires required a continuous prose answer. The data that was extracted for analysis was essentially the structured data, i.e. tabular data or multiple choice questions.

For the purpose of analysis, the responses were given ordinal values.

Analysis

The data that was entered was analysed using SPSS. Three measures were obtained from the analysis.

1. ***Frequency tables:*** These tables show the percentage who chose each response.
2. ***Average response:*** This value was obtained by averaging the responses from one respondent, thus obtaining one response for that respondent for a table. This was then calculated per cohort by obtaining an average of the average responses of individuals in the same cohort.
3. ***Attitude index:*** This is a measure that shows the orientation of the attitude of a group of people. It is computed using the following formula: Percentage frequency of positive responses – Percentage frequency of negative responses = Attitude Index. Responses like 'don't know', 'neutral', 'fair' and

'not applicable' were omitted since these responses are neither negatively nor positively oriented. The more positive the attitude index the more positive the attitude for a given group of people, and vice versa.

The following tables summarize the findings for the various cohorts identified using the measures explained above.

UON Staff Members

Frequency tables

Table 9.1: Overall satisfaction with the quality of service being offered by UNES from UoN staff members

College	Respondents	Very Satisfied	Somewhat Satisfied	Neutral	Somewhat Dissatisfied	Very Dissatisfied
College of Biological and Physical Sciences	13	0%	15.38%	0%	53.85%	23.08%
College of Health Sciences	23	0%	17.39%	4.35%	43.48%	13.04%
College of Agriculture and Veterinary Sciences	33	9.09%	45.46%	0%	24.24%	18.18%
College of Education and External Studies	16	5.88%	47.06%	0%	41.18%	5.88%
College of Humanities and Social Sciences	13	7.69%	53.85%	0%	23.08%	15.38%
College of Architecture and Engineering	2	0%	100%	0%	0%	0%
Senior administrative staff	7	14.30%	71.40%	0%	14.30%	0%
Miscellaneous staff	7	0%	42.90%	0%	14.20%	42.90%
Overall satisfaction	114	5.26%	39.47%	0.88%	32.46%	15.79%

Attitude index

Table 9.2: Attitude Index for 'Service delivery within UNES' from UoN staff members

Respondents = 114	Reliability	Responsiveness	Competence	Access	Courtesy	Communication	Credibility	Security	Understanding the stakeholder	Tangibles
Bad	32.7%	26.1%	35.7%	32.4%	18.1%	79.1%	43.1%	28.3%	69.8%	46.6%
Good	67.3%	73.9%	64.3%	67.6%	81.9%	20.9%	56.9%	71.7%	30.2%	53.4%
Attitude Index	**34.5%**	**47.8%**	**28.6%**	**35.2%**	**63.9%**	**-58.2%**	**13.8%**	**43.4%**	**-39.7%**	**6.9%**

Table 9.3: Attitude Index for 'Strategic Directions for UNES' from UoN staff members

Respondents = 114	Mission of UNES is consistent with that of UoN	We understand the objectives of UNES	Goals and objectives of UNES are clearly stated	We understand well priorities of UNES	UNES has a visionary capable leadership	Strategies used by UNES are consistent with its objectives	UNES keeps its policies and procedures relevant and up-to-date
Disagree	13.6%	33.0%	35.6%	53.2%	48.6%	48.6%	61.3%
Agree	86.4%	67.0%	64.4%	46.8%	51.4%	51.4%	38.7%
Attitude Index	**72.7%**	**34.1%**	**28.9%**	**-6.3%**	**2.7%**	**2.8%**	**-22.6%**
Respondents = 114	Decision making in UNES is flexible	UNES has a capacity to both initiate and accommodate change	UNES considers stakeholders input in strategy formulation	UNES is highly innovative	Opportunities exist for increased responsibilities in our IGUs	UNES and IGUs work well to produce good performance	IGUs regularly achieve their predetermined objectives
Disagree	56.9%	34.2%	56.9%	74.2%	10.6%	67.1%	52.8%
Agree	43.1%	65.8%	43.1%	25.8%	89.4%	32.9%	47.2%
Attitude Index	**-13.8%**	**31.6%**	**-13.9%**	**-48.3%**	**78.7%**	**-34.1%**	**-5.6%**

Average Response

Table 9.4: Average response values for 'Service delivery within UNES' from UoN staff members

	College of Biological and Physical Sciences (CBPS)	College of Health Sciences (CHS)	College of Agriculture and Veterinary Sciences (CAVS)	College of Education and External Studies (CEES)	College of Humanities and Social Sciences (CHSS)	College of Architecture and Engineering (CAE)	Senior administrative staff	Miscellaneous staff	Overall
Respondents	13	23	33	16	13	2	7	7	114
Average Response	5.39	4.96	5.99	6.37	6.04	6.75	5.75	5.72	5.87
Response	**Bad - Fair**	**Very Bad - Bad**	**Bad - Fair**	**Fair - Good**	**Fair - Good**	**Fair - Good**	**Bad - Fair**	**Bad - Fair**	**Bad - Fair**

Table 9.5: Average response values for 'Strategic directions for UNES' from UoN staff members

	College of Biological and Physical Sciences (CBPS)	College of Health Sciences (CHS)	College of Agriculture and Veterinary Sciences (CAVS)	College of Education and External Studies (CEES)	College of Humanities and Social Sciences (CHSS)	College of Architecture and Engineering (CAE)	Senior administrative staff	Miscellaneous staff	Overall
Respondents	13	23	33	16	13	2	7	7	114
Average Response	5.71	4.87	6.33	6.23	5.59	7.11	6.41	5.55	5.98
Response	**Slightly Disagree - Neutral**	**Disagree - Slightly Disagree**	**Neutral - Slightly Agree**	**Neutral - Slightly Agree**	**Slightly Disagree - Neutral**	**Slightly Agree - Agree**	**Neutral - Slightly Agree**	**Slightly Disagree - Neutral**	**Slightly Disagree - Neutral**

UNES Staff Members

The questionnaire that was administered to all 17 UNES staff members was very lengthy, with many tables and many criteria per table. For the purpose of analysis the data was summarised. Since each table was looking into one issue, one criterion encompassing all the criteria in the original table was used to form a table with only that criterion. The original responses were averaged for each respondent for each table, thus obtaining one response per respondent per table.

Attitude Index

Table 9.6: Attitude index for UNES staff members

Criteria	Disagree	Agree	Attitude Index
UNES has a clear mission that drives members' behaviours.	42.1%	57.9%	**15.7%**
The culture in UNES helps it fulfil its mission	37.0%	63.0%	**26.0%**
The Incentive system in UNES encourages performance	75.3%	24.7%	**-50.6%**
Strategic leadership positively affects UNES Performance	32.8%	67.2%	**34.5%**
UNES governance impacts positively on its on performance	36.1%	63.9%	**27.9%**
Organisational structure facilitates UNES in achieving its mission or goals	45.6%	54.4%	**8.9%**
UNES has the ability to plan for its human resource, thus positively influencing its performance	42.7%	57.3%	**14.6%**
UNES has adequate staff to ensure its performance	25.3%	74.7%	**49.3%**
UNES has appropriate human resource development systems and approaches to ensure its performance	85.1%	14.9%	**-70.1%**
UNES has an appropriate system for assessment and reward that is fair and motivating	86.7%	13.3%	**-73.4%**
UNES has an effective human resource relation	77.1%	22.9%	**-54.2%**
There is adequate financial planning to support UNES performance.	19.4%	80.6%	**61.3%**
Financial statements and systems in UNES are appropriate to support its performance	22.2%	77.8%	**55.6%**
UNES facilities are adequate to support UNES performance.	61.2%	38.8%	**-22.4%**
UNES technology resources help improve UNES performance	81.9%	18.1%	**-63.8%**
UNES appropriately plans its programmes	66.7%	33.3%	**-33.5%**

UNES appropriately implements its programmes	42.4%	57.6%	**15.2%**
UNES appropriately monitors and evaluates it programmes	62.2%	37.8%	**-24.4%**
UNES has a planning process that improves its performance	73.5%	26.5%	**-47.1%**
Problem-solving and decision-making processes at UNES support it in carrying out its functions	55.7%	44.3%	**-11.5%**
UNES performance is effectively supported by its communication system	61.6%	38.4%	**-23.3%**
UNES monitoring and evaluation is adequate to improve performance	71.1%	28.9%	**-42.2%**
UNES has established and pursued external linkages adequate to support its performance	69.3%	30.7%	**-38.6%**
UNES has established and pursued electronic linkages adequate to support its performance	74.0%	26.0%	**-48.0%**

Average response

Table 9.7: Average response for UNES staff members

Criteria	Average Response	**Response**
UNES has a clear mission that drives members' behaviours.	4.51	**Disagree - Neutral**
The culture in UNES helps it fulfil its mission.	5.29	**Neutral - Agree**
The Incentive system in UNES encourages performance	4.15	**Disagree - Neutral**
Strategic leadership positively affects UNES performance	5.1	**Neutral - Agree**
UNES governance impacts positively on its on performance	4.19	**Disagree - Neutral**
Organisational structure facilitates UNES in achieving its mission or goals	4.91	**Disagree - Neutral**
UNES has the ability to plan for its human resource, thus positively influencing its performance	4.91	**Disagree - Neutral**
UNES has adequate staff to ensure its performance	5.13	**Neutral - Agree**
UNES has appropriate human resource development systems and approaches to ensure its performance	3.9	**Strongly Disagree - Disagree**
UNES has an appropriate system for assessment and reward that is fair and motivating	3.95	**Strongly Disagree - Disagree**
UNES has an effective human resource relation	3.98	**Strongly Disagree - Disagree**
There is adequate financial planning to support UNES performance	4.81	**Disagree - Neutral**
Financial statements and systems in UNES are appropriate to support its performance	5.42	**Neutral - Agree**

UNES facilities are adequate to support UNES performance	4.29	**Disagree - Neutral**
UNES technology resources help improve UNES performance	4.08	**Disagree - Neutral**
UNES appropriately plans its programmes	5.05	**Neutral - Agree**
UNES appropriately implements its programmes	4.09	**Disagree - Neutral**
UNES appropriately monitors and evaluates it programmes	4.95	**Disagree - Neutral**
UNES has a planning process that improves its performance	4.95	**Disagree - Neutral**
Problem-solving and decision-making processes at UNES support it in carrying out its functions	4.43	**Disagree - Neutral**
UNES performance is effectively supported by its communication system	4.17	**Disagree - Neutral**
UNES monitoring and evaluation is adequate to improve performance	3.97	**Strongly Disagree - Disagree**
UNES has established and pursued external linkages adequate to support its performance	3.99	**Strongly Disagree - Disagree**
UNES has established and pursued electronic linkages adequate to support its performance	4.9	**Disagree - Neutral**
Overall Response	4.55	**Disagree - Neutral**

Analysis Results

The following can be deduced from the tables above:

1. In general, UoN staff members are 'Somewhat Satisfied' with the quality of service being offered by UNES (see Table 9.1).
2. The 'Communication' and 'Understanding the stakeholder' criteria were rated most negatively in the service delivery within the UNES table. 'Courtesy' however, had the most positive attitude index (see Table 9.2).
3. In the strategic directions for the UNES table, 'UNES is highly innovative' was the worst voted criterion. This was closely followed by 'UNES and IGUs work well to produce good performance', which was also given a strongly negative attitude index. On the other hand, 'Opportunities exist for increased responsibilities in our IGUs' and 'Mission of UNES is consistent with that of UoN' were the two best voted criteria (see Table 9.3).
4. The overall average response to the criteria in service delivery within the UNES table was between 'Bad' and 'Fair' while it was between 'Slightly Disagree' and 'Neutral' for strategic directions for UNES (see Table 9.4 and Table 9.5).
5. For the UNES staff members' table, 'UNES has an appropriate system for assessment and reward that is fair and motivating' had the most negative attitude index, whereas 'UNES has appropriate human resource development systems and approaches to ensure its performance' had the most positive attitude index. It is worth noting that most of the criteria in this table had a negative attitude index (see Table 9.6).

6. The overall average response for the criteria in the UNES staff members' table was between 'Disagree' and 'Neutral' (see table 9.7).

Strategic Analysis

Introduction. In addition to the findings from the data analysis summarised in the aforesaid tables, the strategic analysis of UNES involved evaluating the questions of 'where has UNES come from, where it is now and where it will be in five 'years time'. To address these questions, the following tasks were undertaken:

- a review of the past performance of the company;
- an analysis of the internal environment in order to identify key strengths (S) and weaknesses (W);
- an analysis of the external environment in order to identify opportunities (O) and threats (T);
- a scenario analysis of where UNES is likely to be in future and identification and prioritisation of strategic issues.

Review of Past Performance (2001-2005 Plan Period). The review of past performance compares the objectives of the 2001-2005 Strategic Plan with the actual performance. This is followed by the identification and analysis of possible causes of any significant differences between the targets and actual achievements.

Internal and External Environment Analysis. Besides the review of past performance, an internal and external environment assessment of UNES was undertaken in order to identify key resources and competencies of the company on one hand and opportunities and challenges that face the company on the other. These are summarised as Strengthens, Weaknesses, Opportunities and Threats (SWOT).

Strengths

- Diverse and highly resourceful human resource within the university.
- An intelligent, vibrant, energetic and resourceful student body.
- Vast physical asset base of the university.
- Valuable intangible assets such as strategic location, knowledge, innovations and research and development.
- Corporate image of the University.
- Established institutional framework.
- Strategic partnerships, networks and linkages.
- Diverse products and services of high quality such as the postgraduate programmes, publications and software for e-learning.
- Open and distance learning facilities.

Weaknesses

- Inadequate marketing strategies.
- Limited entrepreneurial culture.
- Partial strategy implementation and inadequate monitoring and evaluation practices.
- Inadequate capacity at UNES level.
- Conflicting legal framework.
- Lack of a comprehensive human resources policy.
- Inadequate partnerships with industry.
- Tenuous relationships among key internal stakeholders.
- Ineffective interpersonal communication.
- Narrow product portfolio.
- Ineffective organisational processes, systems and infrastructure, including inadequate managerial and financial accounting systems, inadequate Information and Communication Technology (ICT) infrastructure, poor credit management, lack of an integrated Management Information System (MIS).
- Unsatisfactory service delivery to internal and external customers.
- Inadequate funding due to limited ability to access external financing.
- Limited internal financial resources due to the deteriorating university debt burden.

Opportunities

- Increased demand for higher education in Kenya and the requirement by the economy for highly skilled manpower for development purposes. The latter is in turn supported by official development policies, that is, the Economic Recovery Strategy (ERS) Paper and the Millennium Development Goals (MDGs).
- Wider markets following regional integration and potential economic prospects in Southern Sudan and Somalia.
- Emphasis by the Government, non-governmental organisations (NGOs) and development partners for utilisation of local expertise.
- Increasing transparency and competitiveness in the political, socio-economic and legal environment for doing business.
- Strong alumni in key positions and an established corporate name of the university.
- Strong and diverse human resource base within the country.

- Recognition by the government of the need for a knowledge-based economy driven mainly by ICT and biotechnology.

Threats

- Decreasing (in real terms) capitation from the exchequer.
- Intensifying competition from other institutions offering higher education in Kenya.
- Operating in an environment where research and development, especially within the private sector, is done by parent companies.
- Sluggish growth of the economy.
- Political uncertainty due to the Constitutional Review stalemate and the forthcoming 2007 elections.
- Weak enforcement of laws related to intellectual property rights.
- High cost of borrowing capital both locally and offshore.
- Categorisation of UNES as a state corporation reporting to MoES&T as opposed to the university.
- Potential interference from outside.
- Negative word-of-mouth communication.
- Inability to liquidate the current debts.

Strategic Issues

Introduction. A strategic issue is anything that must be addressed if the organisation is to succeed. It is therefore a fundamental challenge affecting an organisation's mandates, mission, product or service level and mix, clients or users, and management.

Consolidating the Gains and Growth. Revenue from academic programmes, particularly module II, has continued to grow but at a slower rate than in the previous years, indicating a maturing product and market. The strategic plan proposes a number of initiatives that, while drawing from past experience, will sustain the current programmes and drive growth over the plan period.

The initiatives seek to broaden the product portfolio by entering new business areas while consolidating the gains made in the last seven years. As a consequence, the current plan is growth-focused through consolidation and new products.

Strategic Issues

- Students
- Human Resources
- Assets and their Utilization
- Underutilised Real Estate and Other Physical Assets
- Investment Policy

- Intellectual Property Rights Policy
- Corporate Image
- Governance and Organisational Structure
- Partnerships
- Product and Service Portfolio and Markets
- Strategy Implementation
- Organisational Processes, Service Delivery and Infrastructure
- Financial Resources

Balanced Scorecard

From the results of the survey and the review of the 2001-2005 Strategic Plan, it was evident that whereas the company had achieved commendable financial results, it faced challenges in the implementation of strategies affecting students, employees and service providers. It was also unable to implement many of the actions intended to deliver new products and to improve the product portfolio. In order to improve on the implementation performance in these areas during the 2005/2010 plan period, it is important to give prominence to the balanced scorecard as a tool of planning, implementation and evaluation of performance.

The balanced scorecard framework is a modern tool that integrates and balances various dimensions of planning and control by combining the measurements of :

- customer service,
- internal processes,
- the organization's capacity for learning and growth, and
- the traditional financial measures of performance.

This ensures that the interests of all stakeholders and underlying critical business processes are addressed, monitored and evaluated as an integral part of managing the business.

The 2005-2010 Strategic Plan contains strategies and activities that reflect the balanced scorecard position and key performance metrics to be undertaken by UNES during the plan period as shown in the third UNES Strategic Plan (2005-2010).

Table 9.8 Balanced scorecard table

Balanced Scorecard	Strategic Issues	Strategic Objectives
Financial	Assets and their Utilisation	To increase UoN revenue facilitated through UNES by 20% per annum
	Financial Resources	To increase the net surplus of UNES by 30% per annum
Customer	Students	To establish and maintain a positive relationship between UNES and the students
	Corporate Image	To cultivate, position and maintain an improved UNES corporate image
	Partnership	To establish, promote and enhance partnerships and collaboration with strategic partners
	Products Portfolio, Services and Markets	To increase UoN revenue facilitated through UNES by 20% per annum
Internal Processes	Governance and Organisational Structure	To strengthen the corporate governance of the company
	Strategy Implementation	To adopt results-oriented management approach
	Organisational Processes Service Delivery and Infrastructure	To provide world-class service to internal and external customers at competitive cost
Human Capital	Human Resources	To attract, develop, retain highly motivated and competent staff in UNES. To establish and maintain strong linkages with consultants within and outside the University of Nairobi.

Strategies, Activities and Desired Outcomes

Summary. The table below summarises the Strategies, Activities and the desired Outcomes for each Strategic Objective, highlighting the one pertaining to research, research and development, and commercialisation.

Table 9.9: Objective 1 - To increase UoN revenue facilitated through UNES by 20% per annum

Strategies	Activities	Desired Outcomes
1.1 Enhance investment in agribusiness	1.1.1 Provide working capital, management and marketing support for dairy, coffee, tissue culture, vegetable farming and food processing 1.1.2 Develop new plant varieties 1.1.3 Work out operational agreements between UNES and farm enterprises	Significant contribution from agribusiness to overall revenue base
1.2 Strengthen business environment in human and animal health	1.2.1 Revamp the small and large animal clinics 1.2.2 Provide equipment and means of transport for small and large animal clinics 1.2.3 Invest in diagnostic services by purchasing and installing a scanner 1.2.4 Implement the dental clinic project 1.2.5 Establish a university medical centre	Significant contribution from human and animal health to overall revenue base
1.3 Expand involvement of UNES in consultancy	1.3.1 Lobby the government, development partners, NGOs and private sector 1.3.2 Create relationships with potential local and foreign consulting firms 1.3.3 Establish a data bank of consultants 1.3.4 Identify key consultants and develop working relationships 1.3.5 Develop support mechanisms during proposal writing 1.3.6 Set-up, equip and facilitate a unit to promote initiatives and ventures	Consultancies make up a significant proportion of the UNES product portfolio and income
1.5 Expand involvement of UNES in the provision and use of ICT particularly in e-learning and ODL	1.5.1 Provide capital for the translation of the academic programmes into ODL, develop ODL and ICT infrastructure, training of staff in ODL and e-learning.	E-learning and ODL becomes a major source of revenue growth in the coming years
1.6 Broaden the product and service portfolio to achieve a ratio of 30:70 of non-teaching programmes	1.6.1 Develop new products in consultancy and non-academic areas	Consultancies and non-teaching projects make up a significant proportion of the UNES income
1.7 Increase rate of return on UoN tangible and intangible assets	1.7.1 Identify and clarify underutilised and new assets to be exploited 1.7.2 Prioritise investment projects 1.7.3 Source financing for the selected projects through borrowing 1.7.4 Initiate review of legislation to facilitate access to UoN assets for business or act as collateral	UNES/UoN obtain financing to commercialize under-utilised assets/facilities

Table 9.10: Objective 2 - To increase the net surplus of UNES by 30% per annum

Strategies	Activities	Desired Outcomes
2.1 Increase UNES revenue by 28% per year	2.1.1 Carry out activities 1.1.1 to 1.7.4 above 2.1.2 Seek investment to support projects 2.1.3 Lobby for implementation for differentiated unit costs	Revenue growing at least 28% per year
2.2 Increase operating efficiency	2.2.1 Improve and invest in the client service delivery 2.2.2 Improve on internal processes	Low ratio of cost to revenue compared to other universities? Significant reduction in clients complains

Table 9.11: Objective 3 - To Strengthen the corporate governance of the company

Strategies	Activities	Desired Outcome
3.1 Support the UoN to lobby for the declassification of UNES as a state corporation	3.1.1 Appraise the implications the categorisation of UNES as a state corporation 3.1.2 Develop a concept paper for the board on legal implications of exemption from the SCA versus declassification	UNES is declassified as a state corporation to restore legal responsibilities for its management to the university.
3.3 Streamline relationship between UoN and UNES	3.3.1 Establish a functional IGU forum	The relationship between UNES and UoN is well understood and accepted in order to enhance an enterprise culture that will turn UoN resources into the much-needed revenue
3.4 Ensure harmony between UNES and IGUs	3.4.1 Hold meetings with IGUs at least quarterly 3.4.2 Regularly share financial performance and other business information with IGUs 3.4.3 Management of business in an efficient, accountable and transparent manner	UNES works harmoniously with all IGUs
3.5 Prepare and roll out a communication and public relations improvement programme	3.5.1 Publish a quarterly UNES newsletter 3.5.2 Revitalise and regularly update UNES website 3.5.3 Synchronise the front office function of UNES and UoN	Better perception by internal and external clients

Table 9.12: Objective 4 - To provide world-class service to internal and external customers at competitive cost

Strategies	Activities	Desired Outcomes
4.1 Reengineer the service delivery system	4.1.1 Invest in/install/institute effective managerial and financial accounting systems 4.1.2 Invest in/install/institute effective ICT infrastructure 4.1.3 Improve credit management systems 4.1.4 Include treasury management in the finance function 4.1.5 Develop and institute an integrated and customer-oriented MIS 4.1.6 Streamline financial, procurement and audit processes and controls 4.1.7 Train front-line staff 4.1.8 Present a single face to the external customer by harmonising the students' admissions and enquiries desk	The service delivery system is efficient and attracts clients to deal with the institution

Table 9.13: Objective 5 - To cultivate, position, and maintain an improved UNES corporate image

Strategies	Activities	Desired Outcomes
5.1 Establish a public relations office	5.1.1 Identify and recruit a PR officer 5.1.2 Equip and facilitate the PR office	An efficient and effective public relations office staffed by properly qualified staff is in place
5.2 Establish a mechanism for effective communication	5.2.1 Publish quarterly newsletter on UNES 5.2.2 Develop corporate profile and a brochure 5.2.3 Re-design, regularly update and popularise UNES website	An easily accessible and neutral source of news and information about UNES is available
5.3 Sensitise UNES and UoN staff	5.3.1 Hold a seminar to create common understanding between UNES, IGUs and other organs of UoN 5.3.2 Hold regular meetings with IGUs and other organs of UoN 5.3.3 Attend and update college and faculty boards quarterly	A university community awareness and interest in the activities of UNES

Table 9.14: Objective 6 - To establish, promote and enhance partnerships and collaborations with strategic partners

Strategies	Activities	Desired Outcomes
6.1 Lobby the government	6.1.1 Develop a concept paper with other public universities 6.1.2 Develop with MOES&T a cabinet paper	Acceptance by the government to make the university, through UNES, the first port of call for consultancy engagements
6.2 Lobby the development partners, NGOs and private sector	6.2.1 Identify areas for collaboration 6.2.2 Develop MOUs with the various partners	UNES becomes a key source of consultancy services by development partners, the private sector and NGOs
6.3 Create relationships with potential local and foreign consulting firms	6.3.1 Identify areas for collaboration 6.3.2 Develop MOUs with the various consulting firms	Strong bonds exist between UNES and local and foreign consulting firms

Table 9.15: Objective 7 - To attract, develop and retain competent highly motivated staff in UNES

Strategies	Activities	Desired Outcomes
7.1 Develop HR policy of UNES including undertaking job evaluation and analysis	7.1.1 Undertake a skills audit 7.1.2 Develop an efficient and effective recruitment selection and placement policy 7.1.3 Review the organisational structure of UNES 7.1.4 Undertake periodical reviews and terms and conditions of service for UNES staff 7.1.5 Conduct annual employee performance appraisal	An HR policy that becomes the framework for participation of employees in continuous improvement of company performance
7.2 Enhance the staff development programme	7.2.1 Identify staff for training based on UNES needs 7.2.2 Undertake staff training programmes.	An active staff development programme is in place

Table 9.16: Objective 8 - To establish and maintain strong linkages with consultants within and outside UoN

Strategies	Activities	Desired Outcomes
8.1 Lobby the consultants	8.1.1 Establish a data bank of consultants 8.1.2 Identify key consultants and develop working relationships	A strong network of consultants within the University of Nairobi is in place
8.2 Identify potential ideas for intellectual property protection and commercialisation.	8.2.1 Develop support mechanisms during proposal writing 8.2.2 Set up a unit to promote initiatives and ventures 8.2.3 Equip and facilitate the unit 8.2.4 Develop an intellectual property rights policy	A priority list of ideas for protection and commercialisation is developed and regularly updated

Table 9.17: Objective 9 - To establish and maintain a positive relationship between the students and UNES

Strategies	Activities	Desired Outcomes
9.1 Engage students in research and consultancy work	9.1.1 Establish mechanisms for engaging students 9.1.2 Involve students in consultancy as research assistants 9.1.3 Encourage students to do dissertations and projects that are related to the consultancy they are engaged in	Student community benefits from the Company's enterprise initiatives either in form of cash or work experience
9.2 Promote viable innovations from students.	9.2.1 Establish a unit to promote students' initiatives and ventures 9.2.2 Equip and facilitate the unit	Viable innovations from students are supported by UNES

Table 9.10: Objective 10 - To adopt results-oriented management systems

Strategies	Activities	Desired Outcomes
10.1 Develop specific objectives and tasks for individual staff	10.1.1 Develop, using participatory approach, specific work plans for individual staff 10.1.2 Develop operational procedures	Work definition within UNES is more clearly and responsibilities assigned
10.2 Adopt standard operating procedures	10.2.1 Set up quality assurance mechanisms 10.2.2 Incorporate M&E as an integral function of UNES	A standard operating procedures manual exists

Conclusion

As is apparent from the above, our university is now paying increasing attention to the value of more applied research, innovative and relevant teaching and service to the local, regional, national and global public and private sectors. Such developments are usually facilitated through innovative linkages between the university and its external constituencies.

The paradigm shift to a more entrepreneurial university appears to be still elusive, particularly with regard to mechanisms for increasing technology transfer between universities and industry. These mechanisms could include the introduction or expansion of university offices involved in licensing and patenting (seeking commercial applications for university research); small business development (providing technical or managerial assistance to entrepreneurs or small businesses); research and technology centres (operating or participaing in facilities for the development of new technology); incubators (managing facilities in support of new technology-based businesses); and investment/endowment offices (utilising the university's financial resources for equity in start-up businesses) (as indicated in Dill, 1995). For example, in the case of the University of Nairobi, the establishment of a Science Park has only recently (June 2005) been approved by the University Management Board. This indicates that we still have a long way to go in the entrepreneur performance benchmark.

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10

Computing Research Challenges and Opportunities with Grid Computing

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Grid computers are integrated environments in which software and hardware resources are pooled in ways that give any user the impression of working with a single fast computer. This paper examines the current advances in grid computers from the point of view of their structures, global attention and support. We particularly relate these matters with a section of the East African region and highlight the research opportunities that arise out of the research challenges. We show the relevance and options for adopting grid computing by developing countries. We concretise our ideas by presenting a conceptual framework for a campus grid computing scenario at the University of Nairobi, Kenya. Our contributions in this paper include a review of current trends in grid computing and available options; creation of awareness of the importance of grid computers; and relating research opportunities in grid computing to regional circumstances.

Introduction

Defining research

According to Cambridge Dictionaries Online, research is a "detailed study of a subject, especially in order to discover (new) information or reach a (new) understanding". Research is also defined by Dictonary.com as a "scholarly or scientific investigation or inquiry". or a "close, careful study". Again according to Mugenda and Mugenda (1999, p.1), research is "... carrying out diligent enquiry or a critical examination of a given phenomenon … implying exhaustive investigation or experimentation following some logical sequence".

It is therefore expected that computing-related research would also involve a detailed study of aspects of computing such as software, hardware and communication networks, especially in order to discover new information/ knowledge or reach a new understanding such as in aspects of utilisation". It also entails studying these computing subjects thoroughly so as to make detailed, accurate presentations.

When we consider ways of attaining research excellence in computing-related work we would expect to give attention to activities that would enable realization of the positive impact of the results of research in society. One way to do this is to encourage participation in promoting detailed studies in areas that are relevant to needs of the society. A second way is to promote discovery of new information, hence knowledge in related areas. A third way is to promote attainment of new levels of understanding such as in aspects of efficient utilisation of relevant research results. Furthermore, there should be positive attitudes in encouraging attempts to find out in a systematic and scientific manner. Efforts would be necessary in ensuring that the benefits of research are realised such as those highlighted by Mugenda and Muganda (1999) that include discovery of new knowledge, accurate description of phenomena, prediction of phenomena, control of phenomena, explaining phenomena, and generating theories about phenomena. We now highlight the main computer science areas so that it will be possible to visualise how grid computing fits into the picture.

Grid computing in context

We first note that there will normally be a wide variation on the way institutions of higher learning select the many possible combinations of course items in computing, information and communication programmes that they offer. We, however, highlight some courses that commonly appear in such programs. The areas that are likely to be encountered include: artificial intelligence, artificial life, computer graphics, database theory and applications, distributed computing, operating systems, parallel computing, computer networks, information security, internet-and web-related areas, computer systems organisation and architecture, computer engineering, software engineering, systems analysis and design, computer programming, data and information systems; management information systems, human-computer interaction, computer applications, algorithm design and analysis. This list is by no means exhaustive but only indicative. Grid computing emerged out of experiments with high-performance computing such as parallel and supercomputing. Currently several subject areas contribute to it including distributed systems, computer networks, artificial intelligence and other areas such as economics and game theory. We now consider the trends related to computing, communication and information technology.

General trends

Advances in computing hardware and networking technology have enabled access to computing facilities at much-reduced costs. This has made availability of computing facilities widespread and possible in many places around the world. Computer network speeds have also increased, which has made it possible to exchange information around the world in a much more feasible manner. We now hear and read about globalisation where the world is tending to become one global village. This is a view advanced to underscore the increasing ability of people to communicate and transact real time irrespective of their location on the face of the planet earth. We also note the impact of the Internet that has enabled e-commerce. In e-commerce transactions are possible over the Internet. Many organisations these days want to be present on the Internet through maintaining an Internet site. Many governments are also now considering increased use of computing and communication facilities to enhance the provision of services to their citizens. We can view this trend as a tendency to encourage or move towards e-governance. Most of these governments also support promotion of the use of improved access to computing and communication facilities to stimulate scientific activities, a move sometimes referred to as e-science. In the same way initiatives exist that are set to encourage the use of computing and communication technology to enhance educational resources. These initiatives fall under the umbrella of e-learning. We note the same trends of use in the banking industry referred to as e-banking. At software development level, the trend is to simplify the development process as much as possible with attention to paradigms that promote automated programming. While at application level we note the trend to service oriented packages and outsourcing. This is a trend where some organisations offer a range of flexible services that can be configured to offer solutions to clients. We also note the trend to incorporate intelligence into hardware and software, a feature that has been the realm of researchers but now has matured into useful applications that are deployed in several industries. In this case we have in mind expert systems, robotics or multi-agent-based systems. We note that these trends will eventually put higher-level demands on technology for deliveries that are acceptable. Some of these high-level demands will include high-performance computing support. We will not only need faster communication backbones but also very fast processing elements. In this sense we point out that the quest for more computing power will remain. This need for increased computing power has been in the past addressed as a domain of supercomputing but in the last decade alternatives have emerged that have included grid computing. In grid computing, computing resources are combined to produce enhanced performance. We now, therefore, outline the trends in high-performance computing.

High performance computing trends

High-performance computing has been dominated by supercomputing. Supercomputers are very fast expensive computers with centralised architectures. They have been traditionally used to tackle grand challenge problems. These are fundamental problems in science and engineering that generate very many complex data. They demand simulations and intricate visualisations (Lumb, 2004). Supercomputers can also form part of computing resources that are part of a grid computer. The grand challenge equations will still be investigated by the use of supercomputers and also grid computers. Another trend in high-performance computing is the use of clusters. Clusters are whole computers that are interconnected in a parallel or distributed systems settings that deliver services of a single computing resource. Some people consider cluster computing as grid computing (Lumb, 2004b). Clusters can also be seen as a logical arrangement of independent entities that collectively provide a service. Another trend in high-performance computing is peer-to-peer (P2P) computing. P2P computing involves linking several personal computers via the Internet with the aim of sharing computing resources such as files, but in the process accumulate much computing power. An example of such computing power pooling can be associated to SETI@home project. In this project researchers hope to gain as much insight as possible into the existence of extra-terrestrial intelligence (Minoli, 2005). Another trend associated with high-performance computing is Internet computing where Web services can be provided to address the needs of clients. Another high performance computing trend is virtualisation. In this trend computer servers, storage facilities and networking capabilities are combined into an infrastructure without hard boundaries or fixed constraints (Minoli, 2005). Virtualisation enables moving of resources from one application to another dynamically. The server, storage and network resources are aggregated into a single pool of resources. Virtualisation can therefore span servers for optimal utilisation, networks via intelligent routers and other elements like switches, storage for improved utilisation and reduced costs. Virtualisation can also span applications for increased throughput, and data centres for flexible provision to meet dynamic demands. We also point out the tendency to give data specialised attention as many applications are now complex and require the use of data in a much more specialised manner. This tendency has resulted indata grids. Data grids are regarded to be part of grid computers. Data grids enable users to collaborate securely by sharing processing, applications and data. Data, applications and shared and other computing resources can be found and shared. Remote access and secure provision of data resources are enabled. These data resources include flat-file data, relational data and streaming data (Grimshaw, 2004). We now highlight the focal trend in high-performance computing which is about grid computing. This trend is regarded to be about a decade old and can be traced in focused attempts and application experimentations to pool computing resources and develop core grid protocols. Consequently toolkits such as Globus Toolkit and data grids have emerged. Grid computing may be viewed as virtualised distributed environments where dynamic runtime selection, sharing and aggregation of geographically distributed autonomous resources are enabled. Access to grid computing resources depends on availability, capability, performance, costs, specific baseline requirements and processing requirements (Minoli, 2005). We note that attention and demands for high-performance computing will tend to sustain highlights to resources that can provide services that need fast computer processing and data communications. We now consider general trends associated with software and applications to enable us to examine if we may still identify the importance of high performance computing from the software point of view.

Trends in software and applications

Software and application development trends indicate that there is a moving away from stand-alone applications, documents, and isolated users. The move is towards universally accepted file formats, shared documents, and real-time collaboration. We note the database proliferation in which databases form the backbone of today's software for accounting, project management, CAD work and e-commerce. There is a Webcentricity trend that involves infrastructure, database-driven Web applications, and increasing Web-dependency. This tendency may be exemplified by imagining that yesterday clients may have wanted phone numbers from a Web site. Today, however, the clients may want to interact with a Web site. By tomorrow, the clients, maybe, will want to conduct almost any business online (Lamendola, 2000). On the outsourced software front we note that there are now many companies involved. These companies maintain software on their servers, so that their clients can use it over the Internet. Note, however that in such cases application service providers (ASP) limit access efficiency only to the speed of the Internet connection, regardless of how fast the local machine (PC, PDA, laptop, handheld) runs (Lamendola, 2000).

Considering the information integration dimension, the tendency is for the client database to talk to the vendor's database. This eliminates the cost of handling paper invoices. One fills out a Web-based form or one's program interacts directly with the vendor's programs. This integrates one's information system with the vendor's information system. The trend will be characterised by the need to move beyond stand-alone applications designed to produce paper reports and to applications that integrate with enterprise software (Lamendola, 2000). On the software development level the trend is to make the case for a learning and knowledge-driven view of software development in a way that accounts for the long-term survival, growth and evolution of software-intensive systems (Dalcher, 2003). In these application and software development trends we identify the main activities as exchange of information and data and incorporation of learning models into software. The accompanying real-time responses and quality of service demands point to the need for high-performance computing services. This is so because we will want realistic responses from linking systems which will only be possible if the communication facility is fast and processing elements complete their tasks in moments within expectations. We have so far argued that there is need for high-performance computing by outlining various trends. We will now make some general observations on the potential for our participation in research work that may affect us, or enable us to assimilate grid computing-related research outcomes faster.

First we note that if there is anything to learn from the Internet evolution, it is that there are many consumers of the product. The Eastern African region is no exception. The next issue is whether they like the consumption or not. It may also be noted that like any other technology, it will have its good points and bad points and the usage is driven by the fact that the good points outweigh its negative impact. What we note is that the Internet is being used in the Eastern African region, like in many other parts of the world. We are caught up in it. We also note that while it may be admissible that the Internet has affected many people, grid computing also has potentially the same effect. Others may argue that it has already started to affect many people. It may be pointed out that with this potential to affect many people some research focus needs to be given to it early enough. Only a decade has elapsed and the products are just coming out. A possibility of participation in grid-related research work at such a time exists in the room for opening collaboration with other researchers globally and making contributions. This will also lead to early understanding of the scope of grid computing technology for adoption of its products for the benefit of society. With these observations we now turn briefly to the technical aspects and define terms that are or have been encountered that are related to grid computing. We particularly consider more terms that will surface in later discussions. We highlight the meaning of the terms artificial intelligence, agent, grid computing, multi-agent systems and scheduling.

Defining relevant terms

Artificial intelligence may be described as a field of computer science in which studies focus on finding ways of replicating mental faculties using computational models. This can be summarised as attempts to make computers that think and act like human beings (Russel, Novig, 1995). Areas such as expert systems, machine learning, machine vision, and natural language understanding are some of the subfields of artificial intelligence. There are many real- and world applications that have been deployed that are based on artificial intelligence.

An agent is an entity such as software or a software-hardware combination that accomplishes tasks on behalf of its user as it exhibits autonomy, mobility, reactivenes, proactiveness and intelligence. It can perceive and react to its environment. Examples of agents include Internet search engines, robots, humans, animals, ants (Brenner et al., 1998; Nwana, 1996; Russel, Novig, 1995); Ferber Jacques, 1999, p.9).

Grid computing involves networked heterogeneous computing elements such as processors, storage facilities and other computing peripherals that present themselves as single computing resources to users (Forster et. al., 2001). With grid computing, organisations transparently integrate, streamline and share dispersed, heterogeneous pools of hosts, servers, storage systems, data and networks so that they form one synergistic system. It may be viewed as a type of distributed computing in which several locations, organisations, machine architectures, collaboration, information access and software boundaries are involved (Minoli, 2005).

Multi-agent systems are those systems consisting of several agents. Agents are autonomous entities in the environment that can sense and react to the environment. Multi-agent systems are seen to be potential in solving distributed systems problems as they can handle decision-making in delayed circumstances, such as in real-time decision making that is required in many complex systems (Wooldridge, 2002), like in a grid computing environment.

We may take a schedule to be a list of times of departures and arrivals; a timetable such as bus schedules or schedules of guided tours. A schedule may also be seen as a plan for performing work or achieving an objective, specifying the order and allotted time for each part. We may refer to "finished project on schedule". A schedule may also be a printed or written list of items in tabular form. An example of such a schedule is the list of postal rates. A programme of events or appointments expected in a given time is also a schedule as we can ask "Can you fit me into your schedule Tuesday afternoon?" (Houghton, 2000). In our case we will use the term schedule to mean a list of events in which temporal details are included. We then see scheduling as the process of constructing or producing schedules. Scheduling is used in many places. These places can benefit from automated scheduling solutions. They include factory shift schedules, educational institutional lesson schedules, agricultural crop management schedules, project management control schedules, production/ manufacturing schedules, job-shop operations, institutional operations, operating systems resources management, parallel processor utilities or in grid computing resource utilities (Sycara et al., 1991).

Basic research challenges in grid computing

After the definitions of the main terms, we now consider the basic research challenges in grid computing. According to Forster et al. (2001), the real and specific problem in grid concept is coordinated resource sharing and problem-solving in dynamic, multi-institutional virtual organisations. In this case sharing refers to direct access to computers, software, data and other resources that may be needed for collaborative problem-solving and resource-brokering strategies needed in industry, science and engineering. Such sharing must be controlled such that resource providers and consumers clearly specify their terms. The individuals or institutions that assemble in terms of sharing resources may be referred to as virtual organizations. Virtual organisations could be computer cycle providers, application service providers, storage service providers or consultants in car manufacture, amongst others. Buyya (2002) also points out some outstanding problems associated with grid computing that include: the need to support different application models that can cope well with tasks that communicate frequently and are interdependent; the need to support different economic models such as auctions, contract net, bid-based proportional resource allocation, that are not supported by Nimrod-G; the need to build an accounting infrastructure, a type of Grid Bank, perhaps similar to debit/credit card companies; the need to enhance GridSim to support various network types with different static and dynamic configurations and cost-based quality of service(QoS); the need to have a wide area data intensive programming and scheduling framework, where Nimrod-G may possibly be extended to support adaptive mechanisms for selecting the best service based on access, speed and cost. Uwe (2001) when considering evaluation of scheduling algorithms for grid computing, such as back-filling and round table, pointed out some problems such as the difficulty in theoretical evaluation since objective functions are too complex, the difficulty with experimental evaluation due to unavailability of grid computers. He advocated the use of simulation models and workloads, and the search for suitable models.

Overview of grid computers, multi-agent systems and scheduling

In this section, we revisit the concepts of grid computers, multi-agent sytems and scheduling and highlight how they are related to each other.

Grid computers

As has been pointeed out earlier, a grid computer is a computing infrastructure in which software and hardware resources are interconnected to provide dependable, consistent, pervasive and inexpensive access to high-performance computational capabilities (Joseph, Fellenstein, 2004). This kind of computing device is only possible when the resource-sharing is possible in a coordinated way during problem solving that spans over many virtual organisations. Structurally, therefore, a grid computer will need coordinated resource-sharing. This will require deviation from the centralised controls since there are many resources, individual policies, users and service-level agreements in a grid computing context. A grid computer also contains components that deal with compliance with open standards and frameworks. These components enable interoperability and integration of facilities. Grid computers also consist of components that enable enforcement of quality of service(QoS) demands for the end user. The quality of service demands may manifest as desired response time, performance, security assurance, resource scalability and availability. The basic grid computer architecture may be viewed as a layered architecture consisting of: APPLICATION LAYER; COLLECTIVE SERVICES LAYER; RESOURCE AND CONNECTIVITY PROTOCOLS LAYER, and FABRIC LAYER (Forster, 2002). The fabric layer is the lowest layer and it consists of physical devices or resources required by grid users that share resources. They include computers, storage systems, catalogs, networks and sensors. The next layer is the resource and connectivity protocols layer. This is the layer that contains core communication and authentication protocols. It must be implemented everywhere. The communication protocols make it possible to exchange data between resources, while authentication protocols enable verification of identity of users and resources. The resources layer consists of protocols that use communication and authentication protocols to effect secure initiation, monitoring and control of resource-sharing. An example of such a layer is Globus Toolkit. Globus Toolkit is a community-based open architecture, open-source set of services and software libraries that supports grids and grid applications. The collective layer consists of protocols that effect interactions between collections of resources. Collective services include directory and brokering services for resource discovery and allocation, monitoring and diagnostic services, data replication services and membership and policy services. The top layer is the application layer. This is where user applications call the services of other layers (Forster, 2002).

Ways in which grid computers are used

Grid computers are being used for a wide range of applications that fall in categories such as life sciences, engineering, data-intensive, and physical science applications (Berman et al., 2003b). In life sciences applications include computational biology, bioinformatics, genomics and computational neuroscience. They are mainly concerned with data access, collection and mining. Engineering applications include areas like design tasks such as of aircraft and resource-sharing for distantly located participants. Such applications may include satellite control, data acquisition and analysis, visualisations and simulations. Data-oriented applications involve collection and processing of massive amounts of data for specific needs. An example is the distributed aircraft maintenance environment (DAME) application. In this application gigabytes of in-flight data are gathered from operational aircraft engines to integrate maintenance, manufacture and analysis centers. The physical science applications are dominated by research support in particle physics. Several data grids are dedicated to physics that include GridPhyN, Particle Physics data grid, iVDGL, EU DataGrid and UK GridPP (Berman et al., 2003b). Grid applications have also included financial analysis and services, research collaboration and collaborative games (Joseph, Fellenstein, 2004). There are, however, some common needs for applications to run on a grid computing platform. First they need to be partitioned from overall problem versions to discrete pieces. Secondly, they need discovery and scheduling of tasks and workflow. Thirdly, they need communication support to enable distribution of data where it is needed. Fourthly, they need provisions for distribution of applications to specific processing nodes. The fifth requirement is the need for managing results. The last set of needs are related to autonomic features where self-configuration, self-optimisation, self-discovery and self-management are possible (Joseph, Fellenstein, 2004). We have so far considered the grid concept, architecture and application areas. We briefly shift attention to multi-agent systems and then scheduling.

Mulit-agent systems and grid computers

A multi-agent system may be simply viewed as a system of agents. As pointed out earlier, agents are entities that can perceive and act in their environments in an intelligent and autonomous way usually in pursuit of their goals (Russel, Novig, 1995; Wooldridge, 2002). When agents find themselves in some common environment they may interact and do things so as to form communities with joint aims. Software agents have opportunities in electronic business that is done over the Internet (Muller et al., 2001). Electronic business is the complex integration/transformation of existing infrastructures, business processes, enterprise applications, and organisational structures into high-performance business model using information technology based on electronic media such as the Internet, other computer networks and wireless transmission to facilitate the business. Electronic business is intended to increase the speed of service, improve customer satisfaction, integrate solutions, converge sales and service chains, leverage legacy systems, connect the entire corporate, contract manufacturing, information security and protect intellectual property (Muller et al., 2001). One aspect of electronic business is the electronic marketplace where the Internet is used as a meeting place for buyers and sellers. Agent technology can be used to combine heterogeneous electronic business solutions by adding advanced functionality and automating standard processes. Agents have been used for human resource matching and matchmaking. They can be used to play the role of device agents in which they represent owners of smaller devices such as palm-size devices. They can also play the role of user agents where they represent human users. They can also play the role of travel agents where they assist in booking facilities. They may also be brokers where they access service agents or other resource owners and negotiate on behalf of clients. Many other instances may be cited. Since agent applications on the Internet are already real, we are interested in their relationships with grid computers that may be seen as an extension of the Internet. We are particularly keen to investigate ways of using agents are mediators between users and resource owners in an agent-based grid computing architecture. In this case we find multi-agent systems relevant to grid computing. We are particularly keen to formulate multi-agent systems-based resource utility coordination and accounting in grid computing context. We therefore see multi-agent based systems as relevant to a grid computing. So far we have outlined the concept and relevance of multi-agent systems to the Internet and hence to grid computing. The coordination of resource use involves allocation strategies that are related to scheduling.

We now turn highlight scheduling and relate it to grid computing.

Scheduling in grid computing

The concept of scheduling has been outlined earlier. We saw scheduling as a process in which schedules are produced. Schedules may be seen as plans for performing work or achieving objectives, specifying the order and allotted time for each part. Schedules may normally contain items, activities and time slots when they should be performed. In the context of grid computing we have resources, resource owners and applications or users looking for resources. Owing to potential conflicts, availability conditions and demand constraints, scheduling is a major activity in grid computing. In grid computing those making service requests and those providing services can be paired through resource brokers. Usually the best available resources are selected for task execution. Brokers collect information such as resource availability, usage models, capabilities and pricing data. Related to brokers are schedulers. This time we look at the actual jobs and their allocation of resources. It is schedulers that manage jobs, their allocation of needed resources, partitioning for parallel execution, data management, event correlation and service-level handling. Usually jobs submitted to schedulers are allocated resources based on their service-level requirements. Schedulers therefore require components that include advanced resource reservation, service-level agreement validation and enforcement, job and resource allocation policy management and enforcement for best turnaround times within budget constraints, monitoring job executions and status, and re-scheduling and corrective actions of partial failover situations (Joseph, Fellenstein, 2004). Scheduling functions may be hierarchical where there is a global level and local-level schedulers. We are particularly interested in the investigation of cases where scheduling and brokerage functions are delegated to agents. This means that we are looking into grid computing architectures in which most mediation is done at multi-agent systems level. Already we have grid-computing platforms in which agent-based technologies are utilised. Examples of grid computing platforms/toolkits where agents are used include systems such as 2K, AppLeS, Bond, Globus and NetSolve (Buyya et al., 2002b). In our case we are interested in agent usage where market-based mechanisms are predominant. In other words, the agent interactions and agreements are controlled by auction-based mechanisms. It is these interactions that also determine the operational scheduling decisions. So far we have outlined the scheduling concept and indicated how scheduling and resource brokering arise in grid computing scenario. We have also indicated our interest in the scheduling functions and how we are looking at those options where multi-agent systems are relevant. We now turn to other aspects of grid computing that point to the fact that there is a notable trend worldwide by several governments to support grid-computing initiatives.

Global grid computing initiatives

We will now examine countries and corporations that are involved in supporting grid initiatives worldwide. We begin by examining participants in the worldwide grid testbed discussed in (Buyya, 2002, p. 75). This was a collaboration that involved setting up a global experimental grid computer. The regions linked were Asia, Australia, Europe, North America, and South America. In this regard we note that Africa was not in the picture. In Asia there were two locations (Japan, Thailand), and in Australia there was one location. In Europe there were thirteen locations spanning across several countries, while in North America there were seven locations. In South America there was one location. In this experiment heterogeneous hardware was used including personal computers, workstations, SMPs, clusters, and vector supercomputers. Operating systems included Linux, Sun Solaris, IBM AIX, SGI IRIX and Compaq Tru64. Grid computing services and fabric included Globus/Condor, Globus/Fork, Globus/LL and Globus/Condor G. We now associate major grid computing resources with their areas, regions or countries of origin based on Buyya (2002, pp. 32-37). Again we note that Africa will not feature. We start with AppLes (application-level scheduling) which is used for developing scheduling agents and which was developed at the University of California, San Diego, United States. Condor is a high-throughput computing environment developed at the University of Winconsin, USA. International Data Grid is established at CERN for high-energy physics research in Switzerland. Globus Toolkit is a software for grid infrastructure that was developed in the United States. Legion is an object-based grid operating system that was developed at the University of Virginia, United States. The EUROGRID project is a collaboration of 11 countries, six of which are European (Joseph, Fellenstein, 2004). TeraGrid is a project aimed at launching a world grid computer and it has its major sites in the United States. These facts point to the fact that Africa was never involved in grid computing initiatives. We now highlight national-level involvements in grid computing. Usually this takes the form of allocating resources for the construction of a fast computing network backbone.

National support for grid computing initiatives can be seen from the implementations of national-level grid computers or fast network backbone to support grid-computing establishments. In the United States there are a number of collaborations and linkages between universities and industry. In Europe some of the countries where we find dedicated grid-computing initiatives include the United Kingdom, Belgium, France, Netherlands, Germany, Switzerland, and Poland. In Asia there have been national moves to set up grid-computing backbone support in China, Japan and Korea. Australia has active universities such as Monash University. The advantage of having a national backbone is the jumpstart accorded to interested participants. Institutions can link faster than would otherwise have been possible. So far we note that there are countries that have considered grid-computing enablement of their academic and research institutions a priority and allocated resources for fast speed-computing network backbones. We now outline tangible claims to the benefits of adopting grid computing.

Benefits of adopting grid computing

Estimates for a country's tangible benefits may be compared with those of North Carolina in the United States of America (Minoli, 2005). Adopting grid computing in North Carolina would make the economy grow by the year 2010 to the extent that there would be an additional US$10.1 billion in output; an additional US$7.2 billion in personal income; growth in additional jobs by 31,700, and additional expenditure for communication services by US$1.2 billion on the purchase of broadband access. The main essence of these figures is the claim that the adoption of grid computing would result in additional output, additional jobs and some minimal additional telecommunication expenses. Such an optimistic economic forecast will draw attention to the adoption of grid computing technology. There are also other reasons that we highlight below that point to the advantages of adopting grid-computing technology.

Advantages of adopting grid computing may also be considered from its basic architecture and philosophy. In general, grid computing has the potential of creating some savings, it is also a technology that is moving rapidly and in which people are already involved (Minoli, 2005). Grid-computing environments can enable integration of instruments, displays, computational and information resources across many organisations in different locations. Organisations can share computing power, databases, and other tools securely across corporate, institutional and geographical boundaries without compromising local autonomy. Grid computing will also make it possible for people in different organisations and locations to work jointly on a common problem such as collaborative design. Grid-computing software allows resources-recovery, resourcesharing and collaboration on a distributed network. Grid computing is now feasible owing to available grid standards, grid toolkits, grid products and enabling technologies such as broadband networking. An industry adopting grid computing stands to gain greater productivity. This is due to more flexibility, faster deployment, access to massive computing power and cost savings. Virtualisation itself increases infrastructure efficiency that results in efficiency, flexibility and reduced costs. Benefits of grid computing may also be seen to accrue from the fact that a given amount of computing resources can be more cost effectively used due to sharing. It results in a significant amount of computing power that is useful in solving problems. Furthermore, its resources of many computers can be cooperatively and synergistically harnessed and managed in collaboration towards some common goal (Minoli, 2005). This point is particularly relevant to places where idle computing resources exist. Abbas (Abbas, 2004b) points out that average daytime utilisation of Windows servers is less than 5%, of UNIX servers is between 15 and 20% and desktops are utilised for less than 5%. This makes a case for tapping the unused power through some grid computing facility. We have so far considered the benefits of adopting grid computing. These benefits are expected to interest organisations irrespective of their geographical or economic standing. So grid computing can arguably be said to be relevant to operations in organisations located in developing countries. We now consider whether developing countries should adopt grid-computing technology.

Grid-computing and developing countries

We now consider whether institutions and organisations in the Eastern African region should also adopt grid computing. We note, as before, that there was no participation by Eastern African members in the initiation of grid-computing technology. We also note that even after a decade of development of grid-computing technology there are no centres in the Eastern African region that participate in global grid-computing research efforts, nor utilisation initiatives. Any regional information communication technology policy initiatives needs to be aware of other emerging technologies with far-reaching implications such as grid computing. The basic situation is that hard evidence for or against grid computing in the Eastern African region is still unavailable. This is a researchable question. This may be regarded as the first research opportunity for grid computing in the Eastern African region. Let us take a case where institutions and organisations in the Eastern African region want to adopt grid-computing technology purely on the basis of agreeing with arguments that speculate about its potential benefits and testimonials from initial success stories. A new issue that may need consideration is whether they can afford to implement and sustain versions of grid-computing technology. This question is less complicated compared to the first one. The cost element can be handled by taking stock of requirements then comparing these with the resources available. We briefly shift attention to grid-computing options to show that possibilities exist in adopting grid-computing technology, depending on the approaches that are taken.

Grid-computing technology options

We begin by recalling the generic grid-computing architecture. A grid computer will consist of networked computer processing elements that present resources as a single powerful computer. This happens even though the computer processing elements or fabric may be located in places far apart. Grid computers will need some good communication network as a basic resource. This is why in an earlier discussion we noted that countries that have identified the grid computing as a priority invest in a national high-speed computer network backbone. Some of grid-computing software is on open source, open standards platforms. An example is Globus Toolkit that is also leading in terms of support. Others include the Sun grid engine and Condor. Grid-computing configurations can take the form of data grids, cluster computing grids, enterprise grids, partner grids, and Web services (Minoli, 2005, p.50). A data grid connects databases in various locations. It enables savings in locating information and needs investment in broadband links. An example is AstraZeneca that links research and development centres in Sweden, the United States of America and the United Kingdom. Setting up a data grid is one option. Cluster computing – also called computational grid links – completes computers that harness computer power to achieve high-level computing speeds. It results in large savings in processing time and efficiency gains in throughput. It may evolve to enterprise grid. An example is its use at Oxford University in anthrax drug research. Cluster computing is one option. Enterprise grid involves setting up a grid computer with processing power and transport capability within one organisation. It usually links the research and development centres of the organisation that are situated in different places. It results in savings in research and development time and increased efficiency in processing power. It needs investment in broadband links. An example is the General Motors, Daimler Chrysler, and the Ford links to engineering groups at partner firms for design in Europe. Enterprise grid is an option.

Partner grid harnesses computing power and data transfer for several organisations. It results in savings in design time, research and development time, and marketing time. It increases collaboration between partners such as in supply chains. Web services are also an option. Web services involve provision of secure Internet access for consumers and business usually with cluster computing or data grid support. It results in productivity gains and reduced operational costs. It needs investment in broadband links and on software and integration services. An example is Bank of America' Internet services. We also note Internet computing (Abbas, 2004c). In Web services vast processing power of personal computers are used by scientists and engineers over the Internet. Computing tasks are broken down and distributed over personal computers. There are several examples of Internet computing in science (e.g. SETI@home, eON), life sciences (e.g. Genome@home, Drug design optimisation lab), cryptography(eg. Distributed.net, ECCp-109) and mathematics(Great Internet mersenne prime search, factorisations of cyclotomic numbers). Internet computing requires having computers linked to the Internet. Internet computing is also an option. There are also desktop grids(Johnson, 2004). Desktop computing involves sharing a collection of named machines, usually running specific operating system such as Windows. Each machine participates in a grid. Their architecture approximates client-server architectures as mechanisms must be put in place for distribution, execution and solution assembly using some central server. They require participation policies, dedicated high-speed networks (100mbps - 1 Gbps), administration and security and resources to share. Desktop grid can be used for data mining, engineering design, financial modelling, geographical modelling, graphic design, life science simulations, physical sciences or supply chain management. So far we have outlined possible grid-computing options that organisations or institutions in Eastern Africa region can adopt. The grid-computing options highlighted include data grids, cluster computing grids, enterprise grids, partner grids, and Web services, Internet computing and desktop grids. It is therefore possible for such organisations to use implementation strategies that are feasible to them. We now briefly revisit the questions of gaining from grid-computing technology or losing when we ignore the technology.

Towards cost-benefit analysis for grid computing

In this section we mention items that may be used to assess grid-computing undertakings. Owing to the scope of this paper a detailed quantification of the benefit and cost items is not possible. We particularly have in mind an East African University as a case.

A university on adopting grid computing will benefit in several ways. First, it will be possible to conduct research work that requires high-performance computing in areas such as life sciences or physical sciences. Without grid-computing resources such work can only be undertaken when expensive supercomputers or dedicated high-performance clusters are acquired. The existing network infrastructure and computing elements can be used with minimal financial inputs when grid computers are used. Secondly, since grid computing is based on integration and sharing of resources, gains in reduced costs and increased efficiency can be realised. Resources are better utilised and wastage due to ideless of computers is minimised. Thirdly, with grid computing collaboration among researchers is possible.

Adopting grid computing will also result in incurring some costs. The cost items include communication infrastructure, grid-computing software, and conversion of existing applications into forms that can run on the grid computers. We note that the communication infrastructure can be the same local area network or wide area networks that are already in place. Since most universities are on the Internet and regularly offer services such as e-mails, the costs on communication infrastructure can be reduced to nothing or just the costs of a few fast switches. Software costs can also be minimised, by depending on open source software resources. The conversion costs are harder to assess as strategic options will affect the costs. One method to handle this problem is to link up to a large grid-computing platform with many participants so that applications can find resources that require less problem decomposition and solution synthesis.

Research challenges in grid-computing

In earlier sections we have presented grid computing from the conceptual to the utility levels. We considered the meanings of associated terms such as grid computing, multi-agent systems and scheduling. We have considered the evolution of grid-computing technology and highlighted aspects of global concerns in its development and uses. We also considered the options available if we want to develop the technology as a region and the implications. In this section we shall consider the problems associated with building grid computers as conceptual models and artifacts. We specify the research agenda related to grid computing in this section. These may be categorised in two groups: those problems associated with grid-computing development, and those associated with technology adoption in the Eastern African region.

At the beginning we pointed out the research problems and issues in grid computing (Forster et al., 2001; and Buyya, 2002). These problems included finding ways to coordinate and share resources while solving problems in dynamic, multi-institutional virtual organizations; finding ways to support different application models that can cope well with tasks that communicate frequently and are interdependent; finding ways to support different economic models such as auctions, contract net, bid-based proportional resource allocation, that are not supported by Nimrod-G; finding ways to build an accounting infrastructure, a type of Grid Bank, perhaps similar to debit/credit card companies; finding ways to enhance GridSim to support various network types with different static and dynamic configurations and cost-based quality of service(QoS); finding ways to create a wide area data intensive programming and scheduling framework, where Nimrod-G may possibly be extended to support adaptive mechanisms for selecting the best service based on access speed and cost; finding ways to evaluate scheduling algorithms for grid-computing. These problems are related to modeling grid computers along original specifications. There is an ongoing global effort to build grid computers and the number of grid-computing platforms and middleware point to the existing need for solving these problems. The common plug-and-play status of many software resources is still rare in grid-computing software. There is still need to build user-friendly grid-computing software. Although the problems mentioned above deal with actual hardware and software configurations, the standards issues are still under development. So far the Global Grid Forum is the main standards body. One of the standards under consideration is the Open Grid Services Architecture (OGSA). Globus Toolkit is based on this standard. The other set of problems are concerned with ways of writing software to run on grid-computing platforms. These problems involve finding how a given problem can be decomposed and distributed to processing elements, and then assembling solutions. The challenges facing grid computing become more complex from such issues as heterogeneity in processing elements, the dynamism of the environment and various different administrative domains. In our case we are looking at construction of grid-computing schedulers that that are driven by multi-agent systems and quality of service assurance. Most of these problems are of the primary or basic research type.

We now consider problems associated with using grid computers. Adoption of any technology can pose real challenges. This applies to grid computing as well. Grid-computing users may be faced with a number of problems, some of which are pointed out in Manoli, (2005). These include unclear business cases where grid business cases can be made more specific; how to define grid-based processes for effective management; how to ensure security across grids; how to eliminate proprietary approaches (Hewlett-Packard, IBM, Microsoft, Platform Computing, Sun Microsystems, Oracle, VMWare/ EMC); how to overcome constraints to specific vendor computing products (e.g. IBM products); how to find ways of maintaining performance even if resources are shared. These problems will face any user of grid-computing technology.

We now briefly highlight some problems that regions intending to adopt grid-computing technology may face. These problems will be relevant to Eastern African participants in the adoption of grid-computing technology. Grid computing requires a fast networking backbone. There must be ways of putting in place computer network infrastructures that can sustain high-speed communications. Grid computing requires computing elements and interested organisations must find ways of acquiring these hardware/software resources. They also must find ways of experimenting and evaluating available grid-computing technology. As mentioned earlier, there should be an objective assessment of the opportunity cost of being cautious about the technology. They should find out how to avoid losing out by adopting both developmental and utility approaches or purely utility approaches. Development and utility approaches require that organisations participate in the development of the technology and at the same time be users of the technology. The purely utility approaches require that organisations only concern themselves with using the technology. In this case they only concern themselves with resolving implementation and management issues related to grid-computing technology.

Research opportunities in grid-computing

In the immediate earlier section we highlighted the problems associated with grid computing at the basic research level and the applied research level. We particularly pointed out that even if the approach is purely utilitarian there will be some problems to deal with. We recall the meaning of research given when we started. We noted that research is a detailed study of a subject, especially in order to discover (new) information or reach a (new) understanding. This makes us suggest that we make what we considered problems or challenges our subjects of enquiry. We then take steps to understand the problems and discover new information that we assemble into solutions. We therefore use research to address the problems related to grid computing.

The research challenges are used as a basis for discerning research opportunities. At basic research level it is possible to follow lines of enquiry that can lead to construction or improvement of grid computers. This requires examining communication issues (Internet, wireless links); constructing dynamic allocation models; constructing resource-sharing models, or exploring problem decomposition, distribution and solution synthesis. Software issues related to these items should be areas of enquiry. Grid-computing specific items of enquiry include the creation of plug-and-play grid-computing solutions; the creation of transparent easy-to-use interfaces; managing coordination of multiple resources for distributed applications; formulating effective models for resource-sharing, access negotiation, execution monitoring and control, communication protocols, resource usage accounting and pricing. New schedulers and brokers should be constructed that will cope with heterogeneity, environment dynamism allowing free entry and exit of participants. Some of these areas of enquiry can be complex and involving. The applied research options include appraisal of available grid-computing solutions; localisation of the solutions; setting up basic infrastructure; and monitoring the use of the technology. Having pointed out these research directions, we consider the feasibility and sustainability of such research pursuits.

The institutions that may adopt grid computing at the earliest opportunity are institutions of higher learning and research organizations. These institutions can form collaborative networks in which resources are shared. At the same time tertiary educational institutions can take the lead in grid-computing experiments and generation of knowledge. A number of Eastern African universities have computer science programmes at departmental or faculty level. Those universities in which computer science programmes include courses such as operating systems, distributed systems, computer networks, parallel computing and at the same time maintain local area networks can start grid-computing research with just about no additional investments. They can go the open source software route. They will, however, need to allocate a few computers to host setup and administrative software. Those universities with computer science programmes whose courses exclude the ones indicated above may need to start them if they are interested in making a local or global impact on grid-computing technology. Polytechnics and other higher level institutions are not excluded. We view the participation in grid-computing research as feasible owing the fact that there are options that can be scaled down virtually to any entry level as long as there are local area networks that are maintained. Those institutions that regard themselves as under-funded but are interested can set up desktop grids and harness idle personal computing power that is underutilised to create a supercomputer kind of computing resource. Those institutions that identify grid-computing as a potentially beneficial researchable proposition may work towards including some cluster computers in their grid-computing nodes to speed up high-performance computing. So far we have argued that there are research opportunities in grid-computing technology. We have also pointed out that institutions in the Eastern African region can participate in grid-computing research or utilisation.

We now narrate our experiences at the School of Computing and Informatics, University of Nairobi. We will then propose possible grid-computing layout models.

Local grid-computing efforts at the School of Computing and Informatics of the University of Nairobi, Kenya

In this section, we narrate our experiences, which are still humble, with grid-computing experiments. Later we will give grid-computing layout options that may be adopted in the Eastern African region. We begin by stating our grand vision for grid computing in the region. We are looking forward to being active participants in a collaboration that sets up a grid computer network that links up African universities and research organisations and other world-wide institutions. Our strategy is to begin with sections, departments, faculties, university campuses, universities, national grid computers, regional grid computers, continental grid computers and then link up to worldwide grid computers. Apart from establishing grid-computing facilities we look forward to modifying some grid-computing components that perform scheduling and quality of service assurance. So far we are at the sectional level. Last year (2003/2004), we shared three low end(200MHz, 64 MB RAM, 4GB disk) personal computer units with distributed systems group. We set up the Globus Toolkit Version 3 grid-computing middleware on two of them. The operating system was Linux Red Hat Version 7. We eventually ran some simple computer applications. The system stability and reliability was, however, low. We also noted that Globus Toolkit takes a long time to set up and needs specialist support to do so, especially on configurations. The user interfaces still leave much room for improvement. We also set up an application on the Microsoft. NET platform using C# which ran over several computers. This year (2004/2005) our investigations cover Globus Toolkit and Condor. We now have two dedicated fast personal computers (3.0 GHz, 512 MB RAM, 80GB Hard Disk). We are still experiencing problems with system stability with Globus Toolkit Version 3 and we are now looking at the Globus Toolkit Version 4 on Fedora-Linux operating system. This time we will perform analysis and visualisation experiments with Brain wave data (Neuroscience). We are also working on software models for grid-computing problem decomposition, distribution and solution synthesis. We expected that the visibility of our grid-computing effort would extend beyond the School of Computing and Informatics, but we are still stuck at sectional level. Though still at this humble level, we are inspired to press on. We have outlined our current grid-computing research involvements. We now present our grid-computing model for Chiromo Campus of the University of Nairobi.

A model for setting up a campus grid

In this section, we consider how a campus grid-computing facility can be built using the University of Nairobi as a case. Currently, there are no grid computing resources available at the University of Nairobi, which reflects the same situation in other Kenyan universities. Most of the benefits of a grid computer arise from its ability to locate appropriate resources that are needed well outside the jurisdiction of the users even if they do not own those resources.

The computing resources at the University of Nairobi reside in its campuses in which various computing devices are used. These devices are found in laboratories or offices used for academic, technical or administrative functions. The university has an independent information communication technology services unit with technical staff and a director. The university also has a School of Computing and Informatics that offers undergraduate and postgraduate programmes in informatics. The campuses include Parklands, Main, Kabete, Medical, Chiromo and Kikuyu. Chiromo and the main campuses are on a fast optic fibre network backbone.

Most of the computers on this network are personal computers that may not independently undertake high-performance computer-intensive jobs. When some or all of these computers are shared by a grid-computing infrastructure, it will be possible to attain levels of computational capacity that are not possible without such sharing infrastructure.

With the grid-computing researchers being members of the School of Computing and Informatics, the school becomes an initial point of departure. The grid-computing experiments will result in the visibility of grid-computing facilities at the school to begin with. After these experiments, this visibility will be extended to the departments of mathematics, physics, chemistry, geology, biochemistry, meteorology, human anatomy, biology and zoology. The experiments that will follow this extended visibility will be result in the visibility of the grid-computing facility to all the campuses.

The School of Computing and Informatics will initiate the grid computing set-up. This will be made accessible to computers within its own local network domain. This access will be extended to various departments at the Chiromo campus and then eventually to the whole university. After some time, the university can make access to its grid-computing facilities avaialable to external research institutions.

Various departments at the University of Nairobi can use grid-computing facilities for different applications that require high computing capacities. We only point out some possible uses. At the School of Computing and Informatics the grid-computing research may include the following areas: developing grid-computing applications, developing grid-computing middleware, and offering grid-computing user support in research areas such as linguistic analysis. In the department of Chemistry grid computing can be used for such tasks as simulations of chemical processes or studies related to material structures and properties. In the department of Physics grid-computing facilities can assist in simulations, experiments related to particle acceleration and visualisation. In the department of Mathematics grid computers can be used for simulations, investigating some problems such as the Quadratic Assignment Problem (locating facilities for minimum total cost) and the Steinberg wiring problem(finding the shortest total circuit length configuration). In the department of Human Anatomy grid-computing can be used in research work related to brain activity analysis and visualisation.

The user of the campus grid

We now look closely at a typical user of the grid-computing facility in a campus such as Chiromo. Structurally a grid computer consists of three main components, the user interface or grid application portal, the grid broker layer where we will build a multi-agent based scheduler, and the fabric layer or the grid-computing resources such as computers and storage devices. Consider a user located in one of the departments. Let us say the department is that of Mathematics and the user is investigating some Quadratic Assignment-related problem. Note that a grid computer has solved the Quadratic Assignment Problem for N=30 (Anstreicher, Brixius,2000). The user will submit her application program at the grid-computing interface or application portal. This layer will transfer the application to the grid broker layer or our multi-agent-based scheduling layer. The required data will be obtained, and it may be residing in a computer located at the department of Biology. The processing computer will also be selected and it may be residing in the department of Chemistry. The computations will be accomplished and results sent back to the user at her department of Mathematics. Some part of her results that is stored may be saved in a computer residing at the department of Geography. All the time this user only sees a single high-performance computer.

Grid-computing architectural options

In an earlier section on the overview of grid computers, we outlined the generic layered architecture of a grid computer. We noted that the basic grid computer architecture may be viewed as a layered architecture consisting of: the application layer; the collective services layer; the resource and connectivity protocols layer, and the fabric layer (Forster, 2002). In this section we outline how organisations or collaborating institutions can adopt grid computing.

We briefly describe a model for the grid-computing layout for an organisation (enterprise model). The organisation should have its computers and peripherals linked by a local or wide area network. The grid-computing environment is set up in which participating computing elements have identities and their resources are pooled together. One or more enterprises can be linked up. The jobs can be submitted at any participating node. Next we outline a model for national grid computing.

National grid-computing networks need some form of national high-speed computer network backbone. This network then allows any participating organisation to connect its computing elements. Universities and research organisations are the usual earlier participants. For Eastern African countries, Kenya, Uganda, Tanzania, Rwanda and Burundi may have their own national grid-computing initiatives.

Next we outline a model for regional grid-computing initiatives.

Regional grid computer networks can evolve in many different ways. Two possible ways are through the linking up of national grid networks and through linking organisations that span across the region on mutual agreements or purpose. Forming a regional grid network through linking up national grids depends on the existence of grid-computing networks in the countries that are participating. This is a slightly distant proposition for the Eastern African region since we need a number of countries to have their own national grid-computing technologies in place before they inter-link. Another option for a regional grid-computing network is one in which organisations team up and agree on how to share their computing resources. These organisations can span across national boundaries. A group of organisations that can start this kind of linkage is the universities. The universities in various regional countries can link together, set up and utilise some grid-computing facilities.

Conclusion

We began on the theme around computing research challenges and opportunities with grid computers. We have outlined the research problems with grid computers that we noted are of a primary and applied nature. We argued that it is these problems that we turn into opportunities since the purpose of research is to gain new understanding and discover new knowledge in a subject. We argued that we should make the problem areas in grid-computing our subject thereby generating many research directions. We also highlighted the fact that there are nations and corporations with grid-computing initiatives. We also highlighted the implications of adopting or ignoring grid-computing technology. We also gave models that may form bases of grid-computing options for organisations and East African countries. We therefore conclude that Grid-computing presents research challenges and opportunities for researchers in East Africa. We are therefore suggesting that grid computing be made part of the research agenda, especially in pursuit of research excellence.

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PART FIVE

Research Approaches In Information Technology Projects

11

Foundations and Research Trends In Object-oriented Information Systems

Shushma Patel

This chapter focuses on information systems and in particular research trends in Object-oriented Information Systems and Business Information Technology. The paper outlines the foundations of Object-oriented Information Systems and Business Information Technology. The domain of Object Oriented Information Systems is analysed and a generic structure of OOIS as a branch of computer science is derived. The domain of Business Information Technology is analysed and presented within the context of the Business and Information Systems. It defines both information and information systems from computing and business perspectives and shows how current information systems fit into this area. This paper looks at the foundations and research trends in these multi-disciplinary areas.

Introduction

It is an accepted fact that the term software engineering has been around since the advent of the first computer. Over the past three decades there has been a large body of knowledge that contributes towards the discipline of software engineering. The early definition of software engineering was first proposed in the late sixties by Bauer (Naur and Randell,1969) at a NATO-sponsored conference. The definition takes a developer's view of producing and managing the software production process, with scant regard for the impact of the software on the environment.

In the late 1980s the application of computing shifted from the scientific domain to the business domain as a result of the improvement of the hardware and software technologies. This shift resulted in applying the technology to solve routine business problems. The building of business software entailed developing new conceptual tools to enable business analysts to capture the essential information requirements of an organisation. Since the 1980s a large amount of knowledge has been accumulated within the discipline of information systems. In the following sections, we discuss the evolution of Business Information Technology and the problems of delivering robust systems.

What is an Information System?

Wang et al. (1998) clearly trace the history and the philosophical foundations underpinning the discipline of information systems for a computing perspective.

Outlined below is a summary of the findings.

The original work in the area of information theory is attributed to Shannon during 1948-49 (Shannon, 1948, 1949). However, Bell and Goldman first used the term information in 1953 (Bell, 1953; Goldman, 1953). The term information was defined as a probabilistic measure of the quantity of message that can be obtained from a message source and is based upon Shannon's information theory.

Traditionally, the classical information theory has been based on communications, signals analysis and coding theories. However, in the domain of modern applied computer science and in the software and information technology industries, the term information has a much more practical and concrete meaning that focuses on data and message presentation, storage and processing. With this orientation, information is regarded as an entity of messages, rather than a measurement or metric of messages in the classical information theory. Based upon this view, a definition of information and information systems can be derived, as shown below:

Definition 1. Information is a set of organised data that represents messages, knowledge and/or abstract real-world entities. With the above definition of information, an information system can be described as a system which manipulates information as shown below:

Definition 2. An information system is a computer-based system for collecting, storing, processing (adding, deleting, updating), producing, presenting, searching and/ or retrieving information.

It is worth noting that the latter definition is a broad implication of the concept of an information system, rather than the conventional implication on database systems only. For instance, with this definition, an advanced word processing system in a PC can be regarded as a typical personal information system.

To appreciate the difficulties of engineering information systems one must understand the philosophical foundations of this discipline. Wang et al. (1998) compared the nature of information systems with other science and engineering disciplines and found a number of interesting fundamental differences. The key elements of information systems, namely Information, Accumulation of Information and Virtualisation, were analysed. The comparisons are outlined below.

Information vs ***matter***: Human knowledge about the world can be categorised into two systems: concrete and abstract worlds. Matter or natural entities form the first; and the latter is represented by information – the human abstraction of the real world. From this perspective, our world exists in two basic forms: information and matter. Therefore information science and technology are fundamental branches of science in the human knowledge structure, which study theories and methodologies of information processing.

Accumulation of information vs. ***conservation of matter***: According to the natural law of conservation, matter can neither be reproduced nor destroyed. However, in contrast, important attributes of information are that it can be reproduced, destroyed and accumulated. The accumulation of information is the most significant attribute of information that human beings rely on for evolution.

Virtualisation vs ***realisation***: In conventional manufacturing engineering, the common approach moves from abstract to concrete and the final product is the physical realisation of an abstract design. However, in information systems engineering, the approach is reversed. It moves from concrete to abstract. The final software, database and knowledge base are the virtualisation (coding) and invisibility of an original design, which describes the real-world problems. The only tangible part of an information system is the storage media or its run-time behaviours. This is a unique feature of information system engineering.

What is an Information System?

The term 'business' denotes an organisation that is involved in trading. Trading is the exchange of one thing for another. Running a business includes purchasing and selling products or services. The customer or receiver of the product/service pays a price to the supplier of the product/service. One of the main goals in business is to maximise profit. The profit is the amount of net gain derived from trading. This explanation of the term business is the bare minimum. In reality it is much more complicated than this.

Running a business has become extremely complex. There are many issues, concepts and variables involved in understanding and efficiently running a business. These require better tools and techniques with which to manage and run the business and help the business work effectively, efficiently and productively. Building information systems has been seen to be one of the solutions to some of the business problems. It can also be used for improving the running of the business.

A working definition of information systems and its component parts such as systems, data, information and knowledge is provided below:

Definition 3. A system is a set or arrangement of elements that are organised to accomplish some predefined goal.

Within the context of the business domain definitions 1 and 2 are valid; however, we need to extend these definition as shown below:

Definition 4. Information is a set of organised data that represents messages, knowledge and/or abstract real-world entities and it has a value to the stakeholder in a specific content.

Definition 5. An information system is a set or collection of collaborating resources (e.g. hardware, software, people, database, documentation, etc.) organised for the goal of storing, browsing, accessing, retrieving, handling, manipulating and processing data to provide information to the stakeholders.

In coming to the above definitions, we have defined data as:

Definition 6. Data is a representation of things that are known such as names, dates, quantities etc. that can be captured, stored, retrieved and transmitted. Data can be precise or judgemental. Also data has a price and can be sold, lost or stolen.

To extend the perception of information systems within the context of the business domain, we need to look at the purpose of information and information systems and how they are used for the benefit of the business. Both the amassing of information and its constructive utilisation results in knowledge. Therefore we can define knowledge as:

Definition 7. Knowledge is the sum of what is known, a state or condition of understanding. Knowledge is the aggregate of the information held with understanding.

What is Business Information Technology?

The use of computers in complex organisations has changed in that manipulation of knowledge and information are undertaken as cooperative activities (Smørdal, 2000). In information systems development the concept of artefact mediation is interesting. The computer is an artefact that can mediate several aspects of activity. Based upon this, activity theory postulates that the nature of any artefact can only be understood within the context of human activity, i.e. by identifying the ways in which this artefact is used by people, the purpose it serves and its developmental history (Smørdal, 2000; Kaptelinin, 1996).

The software engineering and the information systems perspectives focus on the problem of developing systems for a given problem domain. Therefore, in traditional computing the purpose of the computer system is to handle, control or monitor. The discipline of Business Information Technology, however, extends the software engineering and information systems disciplines by focusing on both the problem and the application domains. Therefore, the application domain takes a broader view of the role of the computer system (the artefact) and how it is used within the organisational context (Mathiassen et al., 1993). The emphasis is placed on the integration of the real world and the computer world.

Business Information Technology is not merely the integration of people, technology and organisational structures, but also how all of these can be utilised as a knowledge resource for the benefit of the organisation. Therefore, the integration of definitions 5 and 7 defines the discipline of Business Information Technology.

Fundamentals of Object-Orientation

Although object-orientation (OO) is one of the broadly used concepts in computing and information systems, the literature presents few clear and unified definitions of OO. In this section we trace the history of object-orientation, describe the implication of object and OO, analyse the extension of the concept and categorise the technologies for OO. We define the discipline of Object-oriented Information Systems (OOIS) and review the research reported in OOIS' 94-03 (Patel et al., 1994; Murphy et al., 1995; Patel et al., 1996; Orlowska et al., 1997; Rolland et al., 1998; Patel et al., 2000; Wang etal., 2001; Bellahsene et al., 2002; Konstantas et. al., 2003), a generic structure of OOIS is derived, and trends in OOIS are analysed.

What is object-orientation? To enable the question of what is object and object-orientation to be answered, one needs to address the following issues: what is the implication of OO? What is the intention and extension of OO? Tracing back the history of programming methodologies, it can be concluded that object-orientation is a natural extension and combination of two mainstream programming approaches: functional-oriented and data-oriented programming. Therefore, the definition of object-orientation can be based on the concept of object in programming and system design. An object is defined as an abstract model of a real-world entity and/or a computational module that is packaged by an integrated structure of interface and implementation, and is described by methods for its functions and by data structures for its attributes.

Object-oriented technologies were originally designed for programming. Therefore, OO was initially an implementation tool rather than a design tool. However, as OO programming became broadly accepted, it was found that OO technologies could be used not only in programming, but also in design and analysis. OO technologies are fairly generic and are applicable in almost every phase of the software development life cycle. Based on this view, object-orientation can be defined as a type of system design, analysis and/or implementation approach which supports an integrated approach to software development.

Basic attributes and classification of OO technologies. The fundamental attributes, which can be commonly identified in OO technologies, are encapsulation, inheritance, reusability and polymorphism. Within this set of basic attributes, encapsulation is a direct representation of the fundamental concept of abstraction, information hiding and modularisation in objects; inheritance and reusability are powerful features for improving productivity and quality in software and system development; and polymorphism is a supplement of flexibility to the other attributes of OO.

In viewing OO technologies as generic system analysis, design, implementation and reengineering approaches, a classification of existing OO approaches can be presented as in Table 11. 1.

Table 11. 1. Classifications of object-oriented methodologies

OO Category	OO Approaches
OO design	OO requirements analysis
	OO specification languages
	OO system design
	OO framework
	OO patterns
	OO component development
OO implementation	OO programming
	OO testing
	OO system integration
OO reengineering	OO application systems
	OO operating systems
	OO network systems
	OO database systems
	OO information systems

Object-oriented information systems. Based on the discussion of the implications of business information technology, the analysis of the nature of information and the formal description of object and object-orientation, an OOIS can be defined thus: An OOIS is an information system which employs object-oriented technologies in system design, analysis and/or implementation.

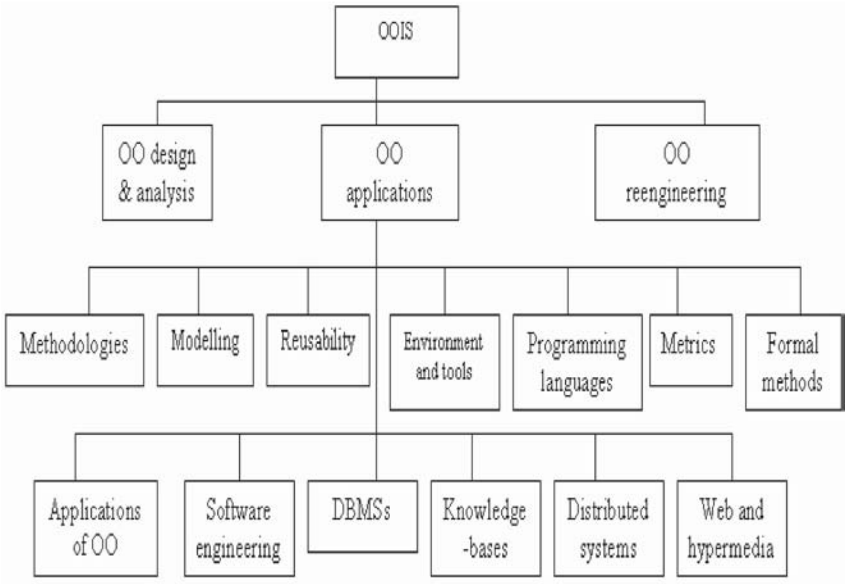
This definition indicates that an information system can be classified as an OOIS if its analysis, design, implementation and testing adopt object-oriented technologies.

An overview of OOIS research and trends. A review of the subject areas in the past events of OOIS' 94-03 (Patel et al., 1994; Murphy et. al., 1995; Patel et al., 1996; Orlowska et al., 1997; Rolland et al., 1998; Patel et al., 2000; Wang et al., 2001; Bellahsene et al., 2002; Konstantas et al., 2003) has identified that the domain of OOIS has covered a wide range of areas, such as hardware, software, people, organisational infrastructure, networking, communications, processes, incoming data, outgoing data, and other resources.

Analysing the distribution of the OOIS subject areas, it can be found that the areas of increasing interest in OOIS include OO methodologies, OO reusability, application of OO approaches, OO software engineering and OO Web and hypermedia. The areas of declining interest include OO modelling, OO environment/tools and OO knowledge bases. But the decline of research in certain areas by no means shows that those areas were no longer important in OOISs.

With the fundamental studies on OOISs and the analysis of their domain coverage, a generic structure of the OOIS knowledge hierarchy can be derived in Figure 1.

Figure 11. 1. Generic structure of OOIS



Progress and trends in OOIS technologies. Reviewing the work on OOISs with regard to the generic structure of OOISs described in Figure 11.1, it has been found that research intrests in OOIS have mainly focused on how to develop new systems. Increasingly important aspects of OO reengineering of legacy information systems have been left relatively uncovered. Thus, reseasrch on methodologies, processes and case studies of OO reengineering of a large number of legacy systems would be a worthy area to explore. Some other trends identified are for example, development of formal OO methodologies, temporal OOIS technologies and development of integrated OOIS tools.

Conclusion

This paper has reported on basic research in seeking the foundations of OOIS. Fundamental concepts of object, information, information system, object-orientation, OOIS and their relationship have been formally described. A generic structure of OOIS has been derived. Based on a review of the past OOIS proceedings, trends in OOIS research and development have been analysed.

Trends of OOIS technologies in reengineering, development of formal OO methodologies, temporal OOIS technologies and development of integrated OOIS tools have been identified for future research.

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12

Exploring "Myths and Meanings" in Higher Education Planning

Jon Warwick, Gary Bell and *Micheal Kennedy*

This chapter outlines the 'managerialist' approach to higher education planning, an approach that favours private sector solutions to public sector problems in the governance and direction of UK Higher Education institutions. It identifies limitations with this approach and argues that if real improvements in teaching, research and administration are to be made, then planning needs to draw on ideas from the systems movement so that it can take cognisance of the complex interrelationships that exist among the issues and problems within a higher education institution. It describes the Holon Framework for higher education planning and then suggests that some ideas from semiotics can be used to help a client group engage with the 'myths and meanings' in addition to the logic and facts of the problem area. Examples drawn from a higher education case study using the Holon Framework illustrate the way that myths might be addressed.

Introduction

Higher education (HE) in the United Kingdom has, over the last 20 years, been presented with a number of challenges that have forced senior managers to think carefully about the way in which their institution will evolve. The one constant that has concentrated the minds of managers in virtually all HE institutions is that of financial resourcing which has seen the per student funding from the UK government dwindle and which has left some universities operating on margins that are perilously thin. When one adds to this ever-present financial stricture the additional risks of high levels of competition for students, changing population demographics and general economic conditions (both of which will impact on the potential demand for existing courses) and the impact of government policy (the UK government has set targets for the inclusion of 18-30 year olds within HE and, more recently, allowed universities to charge top-up fees to generate additional income) then the environment within which universities operate can be clearly seen as unstable.

Typically, university responses to these challenges are fairly common across all institutions (both within the UK and abroad) and will include contracting out selected services, 'centralising' management and administrative functions common to faculties, reducing staff development and conference budgets and freezing staff recruitment (Guskin and Marcy, 2005). At the same time, of course, the university tries to protect the core functions seen as crucial to its role as a university which are typically learning and teaching standards, student support and research with the weightings applied to each adjusted to reflect the nature of the institution concerned.

All of this makes it imperative that effective strategic planning processes are in place so that the university can focus limited resources on those activities that support the mission of the institution, set priorities and achieve competitive advantage (Franz and Morrison, 2005).

Concerns with Orthodox Strategic Planning in Higher Education

Coupled with the environmental pressures already described, governments have demanded greater accountability of quality and cost of universities for public scrutiny. Trow (1994) believes that hard and soft managerialism concepts are being applied to higher education institutions. Hard managerialism generally involves people from government and business who resolved to reshape and redirect universities through funding formulae and other mechanisms, e.g. criteria to assess teaching quality. Soft managerialism usually revolves around senior administrators and some academics from that university. The soft concept views managerial effectiveness as an important component in the provision of higher education of quality at its lowest cost, and is focused around the idea of improving the efficiency of the institution. This notion of managerialism is encouraged by the types of review process that universities are subjected to both externally and internally, for example by the Quality Assurance Agency (QAA) Subject Review process or by Research Assessment Exercises (RAE), processes which are sometimes mimicked within the organisation and which emphasise measurable outcomes and a 'tick-box' approach to quality measurement and quality enhancement. There is not even any agreed definition of 'quality' with regard to HE with, for example, the QAA attempting to assess 'fitness for purpose' while the Higher Education Funding Council for England looks at efficiency.

Galbraith (1998) identified the dominant HE planning approach that is associated with soft managerialism. The key parts of the approach are: a strategic plan; performance indicators (PIs); mathematical models and artificial structures. A strategic plan usually has a mission statement and related strategic aims that assist in achieving it, e.g. excellence in teaching. These strategic aims are treated separately and expressed in terms of goals that are evaluated through the use of PIs. Furthermore, regression models and spreadsheets use the collected data for forecasting and budgeting purposes.

Galbraith highlighted some limitations of the dominant HE planning approach to justify the use of the system dynamics (SD) technique (Forrester, 1961). For example, a university is divided into faculties, each containing a number of schools or departments. The underpinning argument of managerialism is that departments in competition will optimise their efforts and so optimise the overall performance of the faculty. Maximising faculty performance in turn optimises the performance of the institution. Galbraith demonstrates, however, how competition for resources among departments is counterproductive to the overall efficiency of the institution and cannot be maintained. He further argues that the strategic aims should not be treated separately but linked systemically so that, for example, an aim to increase research activity does not impact negatively on teaching quality.

Bell et al., (2000) identify other concerns about the managerialist approach relating to the production of the vision for the institution or department in that there seems to be no clear method. The authors of the vision may be writing for a specific external audience (e.g. the Higher Education Funding Council for England) or for central university offices. Many academics consider the visions to be meaningless because of the lack of specificity which may be due to the lack of dialogue about the direction of the university or department concerned.

The major concern here can be encapsulated by the view that, typically, university management take the orthodox planning approach which views analytical thinking as key. Following Galbraith's lead, we adopt an alternative conceptual view of HE planning which takes a holistic expansionist approach more suited to the complex real-world situation with which we are dealing (Bell et al., 2005).

Dealing with 'Messes'

All planning processes have limitations. The extent to which these limitations vitiate the resultant plans will, to a certain extent, depend on the nature of the organisation concerned and the organisational culture. In terms of HE planning, we have already made reference to the lack of 'connectedness' that characterises managerialism and we can add to this potential problem relating to achieving 'buy-in' both from academic and non-academic staff and from senior management, the difficulty in embracing creativity and intuition into the process and the desire for plans which are sufficiently detailed so as to give clear direction but also remain flexible in response to environmental changes. Classic texts (such as Mintzberg, 1994) document many of these issues.

We believe that resolving these issues centres around the ability to understand the nature and culture of the organisation and to be able to capture some of the complex behaviour and beliefs of the actors within the organisation. This belief is, of course, not new. Ackoff (1979) contends that managers are not confronted with problems that are independent of one another, but with situations that consist of dynamic, transient and complex problems that interact with one another. He calls such situations 'messes'. Furthermore, he states:

> *Messes are systems of problems, the sum of the optimal solutions to each component problem taken separately is not an optimal solution to the mess. The behaviour of a mess depends more on how the solutions to its parts interact than on how they act independently of each other.*(Ackoff, 1979)

Much work has been carried out in recent years in developing problem-structuring methods that aim to provide tools for thinking about these messes (Rosenhead and Mingers, 2001) and one such tool is Checkland's Soft Systems methodology (Checkland, 1981). The Soft Systems methodology (SSM) advocates two streams of enquiry which explore the facts and logic of the situation from the perspectives of those involved (logic-based enquiry) and also the myths and meanings which constitute what we (as individuals) mean by an organisation and organisational culture (cultural enquiry). Cultural enquiry will include roles, norms, and values as well as a political and other power-related relationships and control processes. Note here that the phrase 'myths and meanings' encompasses a wide range of descriptors and is used to contrast with 'facts and logic' which make up the complementary stream of enquiry.

SSM refers to the importance of enabling change that is both systematically desirable and culturally feasible. Two questions arise at this point in relation to this. Firstly, how shall we know if the planned changes are culturally feasible? In other words, how do we uncover the organisational culture that we are working within? Secondly, it may be the case that the changes are not culturally feasible within the current dominant culture so how might we perhaps influence change in the organizations culture? Both questions point to a need to uncover or make more explicit the nature of organisational culture.

At this point it is worth pausing to consider what we might mean by organisational culture and how such culture might emerge since this might have an impact on the effectiveness of planning processes and may well be something we would want to address.

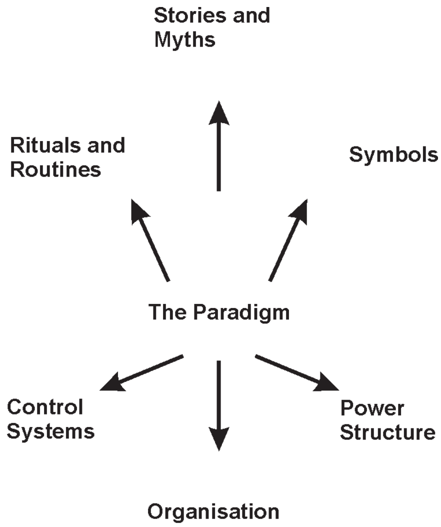
Richard Seel (1999) draws comparisons between complex adaptive systems and organisations to examine whether one has anything useful to say about the other. Morgan (1986) offers three metaphors of organisations, viewing them as machine, as culture and as complex systems. Seel argues the ontological distinction between these metaphors particularly in that organisational culture is an emergent property of organisational activity. Two questions that immediately arise are what we mean by organisational culture and how might we facilitate the process of emergence?

Organisational Culture. There are many definitions of 'culture' applied by anthropologists to societies and groups and by business analysts to organisations. Some cultural models describe characterists of the organisation that try and allow something meaningful to be said about how the organisation operates. For example, the Goffee and Jones cultural model (Goffee and Jones, 1998) describes organisational culture in terms of two variables: Solidarity and Sociability. Solidarity refers to the degree that people think together in the same ways and Sociability comes from mutual esteem and concern for one's colleagues. The degree to which an organisation exhibits these characteristics determines the type of organisational behaviour expected to be observed. As Seel points out, the problem with models that imply that organisational culture is at times static and has characteristics that can be changed is that they fail to address the levers of cultural change. Seel offers a definition that emphasises the emergence of culture:

Organisational culture is the emergent result of the continuing negotiations about values, meanings and properties between the members of that organisation and with its environment (Seel, 2000)

A further model by Johnson (1992) is illustrated in Figure 1.

Figure 12.1. A Model of Culture (from Johnson, 1992)



The paradigm at the centre of this model is the set of core beliefs that result from the interactions and conversations of staff and these core beliefs maintain the unity of the culture. In this model, the six concepts surrounding the paradigm represent the manifestations of organisational culture resulting from the paradigm. Some of these manifestations are clearly observable (such as rituals and routines, power structures, organisation) and are open to analysis. Stories and myths, however, are a manifestation far harder to pin down and describe. A permanent change of culture will not result from forcing change on the manifestations alone – it is the core beliefs that must be addressed.

Emergence of Culture. Emergence has been a major component of systems theory with the notion of the emergent properties of a system being fundamental. One key idea that separates systems thinking from analytical thinking is that the system is greater than the sum of its parts. In other words, analytical thinking with its accent on reductionism cannot hope to capture fully the emergent behaviour of the system under study. In the hierarchy of system interaction, the emergent behaviour of a system contributes to the emergent behaviour of the wider systems of which it is part. Emergence has also become important in the study of complexity theory in which, for example, simple rules applied to cellular automata have been shown to give rise to quite surprising and complex emergent behaviour (see for example Kauffman, 1996 or Axelrod, 1997).

There are two aspects in which this idea of emergence is important in the analysis of complex messes. Firstly, we would be interested in influencing (if possible) the culture of an organisation if it was felt that the organisation's current culture was inhibiting change in some way. If we believe that culture is an emergent result of organised behaviour then encouraging cultural emergence and recognising it can be part of the learning and planning process. Secondly, any planning framework that is employed within the organisation will want to encourage the emergence of ideas, opinions, assumptions etc.

from the client group so the framework itself should encourage emergence as part of the intervention.

Again, Seel has suggested seven 'conditions' that would encourage emergence based on his own working experience and also the work of complexity theorists experimenting with agent-based simulation (Seel, 2003).

The conditions relate to connectivity, diversity, rate of information flow, lack of inhibitors, good boundaries, intentionality and watchful appreciation. 'Connectivity' and 'information flow' emphasise the importance of communication, interaction and conversations. New ways of working or thinking need exposure within a system so that any changes to the central paradigm (of Johnson's model) can take root. This is not just related to formal channels of communication, but applies equally to informal and casual communication as well. They are all important in establishing the emergent culture. 'Diversity' is something that needs to be encouraged in any planning process because it is only by the injection of new ideas or ways of thinking that organisational change will occur. This can also be linked, in a sense, with 'lack of inhibitors' since new ways of thinking can also be constrained by anxiety, power differentials, threats or just a reluctance to change. 'Good boundaries' emphasises Seel's experience in which he observes that emergence benefits from being set within a well bounded space. He believes that it is the clarity of the boundary that aids the process of creativity. 'Intentionality' has a role that is less clearly defined. It seems that it is possible to influence the broad direction of emergence as in the process of Appreciative Enquiry (Watkins and Mohr, 2001) but that it is not necessarily intrinsically present. Seel suggests that this is more a consequence of positive feedback which builds over time as a result of human interaction. We would go further and suggest that intentionality can grow over time, but that the original seed can be planted in the initial stages of the planning process and given conditions under which it can flourish. Finally, 'watchful anticipation' relates to the need to resist moving to action too early. Emergence takes time and should be allowed this time.

The Holon Framework

Checkland argues that researchers who apply systems concepts to investigate social situations face difficulties because these situations are never clearly defined. He prefers to use the word 'Holon' rather than 'system' as it highlights a distinctive approach to investigating such situations. Checkland indicates that the word 'Holon' was originally coined by Koestler to express the principle of hierarchical structure. We consider a Holon to be an abstract representation of a social situation that captures all problems. It is used as a framework to discover relevant issues from stakeholders' points of view; these are organised in a layered structure.

Table 12.1: Aims of Holon Framework Stages

Stages	Stage Aims
Framing	This stage has a number of objectives among which are that the stakeholders are identified and become familiar with the framework and that the investigators gain a broad understanding of the situation so that relevant holons (and sub-holons) can be identified and labelled
Enquiry	This stage aims to identify the problems as perceived by the stakeholders
Visioning	This stage attempts to collate various problems into themes to be addressed. These can be linked with a sub-holon hierarchical level
Metrication	This stage analyses the themes and links the emergent problems with the appropriate hierarchical level. Metrics are generated to characterise specific problems
Mathematical Modelling	This stage aims to analyse the data further using appropriate modelling techniques – for example a system dynamics model might be used to explain the situation of concern
Action	This stage aims to facilitate change having achieved understanding of the area of concern

The Holon Framework combines soft elements (Framing, Enquiry, Visioning) and hard elements (Metrication and Modelling). It addresses 'the who', 'the what', and 'the where' type questions for the current state, $S_{0,}$ and generates a vision of a desired state, S_1. Additionally, this produces a relevant metrics programme, and the collected metrics can be used as dynamic behaviour patterns. It is then possible (using modelling techniques such as system dynamics) to tackle 'the how', 'the why' and 'the when' type questions (see for example Bell et al., 2005). Table 12.2 illustrates the most important traits of this framework.

Table 12. 2: Key traits of the Holon Framework

1	An holistic view of a situation
2	The use of a soft methodology to enable the capture of the stakeholders' point of view
3	Controlling the effects of bounded rationality
4	The researchers' role as facilitator
5	Development of a desirable and feasible vision
6	Creation of a relevant metrics programme
7	Emphasis on the SD model ownership problem
8	Producing the 'best solution' to achieve the vision given the cost constraints
9	The continuous use of an SD model for examining various 'what-if' scenarios

The Framing and Enquiry stages are means of exploring issues, and drawing out themes, boundaries and experiences that the stakeholders feel are important within the problem context. These first two stages encourage a thorough examination of the current state, S_0, resulting in its definition. Next we move to Visioning in which the client group explore a vision of the future that they feel is achievable and desirable. The vision will be expressed in terms of the holon structure used throughout the enquiry and may be expressed formally in terms of root definitions. It is important though that the discussion of S_0 and the vision, S_1, are linked through issues and problems. The stakeholder group should identify the critical issues and problems, which require resolution if movement towards the vision is to be achieved. The issues and problems will generate goals, questions and metrics. The Metrication stage allows the stakeholders to learn more about the problems and issues in S_0, and the subsequent Metrics Collection Stage enables them to measure their progress towards S_1. This is followed by the Action stage in which modelling is undertaken to clarify the processes which can effect movement from S_0 to S_1.

Naturally, although the stages are denoted sequentially, it is likely that, for a large project, different modes of working may happen simultaneously. For example, the metric collection process could well be undertaken over a long period of time (a year or more) and during this time modelling might be undertaken, further enquiry might take place, and the vision might change as the environment changes.

If the Holon Framework is to be able to capture and engage with the myths and meanings that reflect organisational culture, then it should allow organisational culture to emerge as the intervention progresses. We can examine whether it encourages such emergence by mapping the framework against the conditions for emergence suggested by Seel. This mapping is illustrated in Table 12.3.

Table 12.3: Encouraging Emergence

Property for Encouraging Emergence	Holon Framework Representation
Connectivity	The client group is drawn from as wide a cross section of interested parties as possible. This includes levels of authority. Holons will include the holon under study and wider framing holons to connect with the environment
Diversity	Diversity within the client group and also in modes of working encourage multiple perspectives
Rate of Information Flow	Meetings with the client group and individuals to work on holons and feed back information for verification of holon structures etc.
Lack of Inhibitors	In working with the clients, individual sessions and group sessions allow for free expression of views
Good Boundaries	Working with holons sharply focuses work on particular aspects to enhance the richness of the material. The holon framework has a clear process model and meetings and interviews are structured
Intentionality	By identifying a vision and using models to understand the dynamics of change and metrics to measure progress the framework encourages understanding of how movement towards the vision can be maintained. This provides positive feedback as to the attainment of the vision
Watchful Appreciation	The framework has no defined timescale – movement towards the vision is captured by the metrics and an understanding of the dynamics of change which emerges over time

Having described the Holon Framework and illustrated how it can encourage emergence of organisational culture, we now consider how the myths and meanings embedded within organisational culture might be addressed within the process.

Myths and Meanings

In order to engage with the myths and meanings that reflect the core beliefs of the client group, we contend that some simple ideas from semiotics can be used to provide a window into this world. Semiotics deals with the study of signs and symbols, with a good deal of work relating to the study of language, its use, interpretation and meaning. In the organisational setting this is important as, according to Johnson's model described earlier, the paradigm at the centre of this model results from, and is given expression by, the interactions and conversations of staff and these interactions involve the use of language – both written and spoken. The 'meaning' of a sign or symbol is, of course, not fixed and is in some senses an arbitrary construct dependent on context. The methods of natural science are not well suited to the study of cultural phenomena and so we look instead to explanatory or interpretive results.

If we restrict ourselves to considering the ways in which meaning is communicated, then the use of metaphor has been described as one of the more important methods of communicating meaning (Jackobson and Halle, 1956) and, furthermore, can be regarded as forming the core of much of our understanding of the world around us (Lackoff and Johnson, 1980). Milton Dawes (Dawes, 2005) goes further still:

> *Metaphors play an extremely valuable part in all areas of our lives – in our speaking, writing, myths, perception, meanings we give, beliefs, knowledge, communication, learning and so on.*

The idea and use of metaphor have further importance in that myths can be understood as extended metaphors and are just as valuable as metaphors in that they allow a way of making sense of experiences and interactions within the context of a particular culture (Lackoff and Johnson, 1980) (note that we are not restricted to the popular definition of a myth as something false or unreal). For Barthes, myth serves to overturn culture into nature, i.e. to make dominant cultural and historical values, beliefs and attitudes seem as 'the norm' or just common sense (Barthes, 1977). The power of myths is that they appear so natural as to be in no need of deciphering, interpreting or demystifying (Chandler, 2005). Yet to be able to engage with them as reflections of organisational culture we need to identify, understand and, if necessary, challenge them.

The meaning of a sign includes both denotation and connotation – denotation referring to the definition, literal or obvious meaning of a sign, and connation to the socio-cultural, personal or emotional associations of a sign. Indeed, metaphors generate connotations, and as our experience is enriched by the embracing of additional metaphors then so the connotations of a sign will multiply. Barthes considered that there were different orders of signification with denotation as first order, connotation as second order. Denotation and connotation combine to produce ideology and myth, later described by others as third order signification (O'Sullivan et al., 1994). For analytical purposes, the different orders of signification have been differentiated along the following lines:

> *The first (denotive) order of signification is seen as primarily representational and entirely self-contained. The second (connotive) order of signification reflects 'expressive' values attached to sign. In the third (mythological or ideological) order of signification the sign reflects major culturally variable concepts underpinning a particular worldview …* – (Chandler, 2005)

Thus the sign itself will have some denotive interpretation but signify a number of connotations. The sign plus the connotations will further signify myths and ideology and we can use this to structure debate and as a learning tool. We therefore contend that such semiotic analysis of outputs of the Holon Framework can provide a means to understanding and reflecting upon the myths and meanings inherent in organisational culture.

Once we have examined a sign, its connotations and possible myths, we would then be in a position to challenge the myth if necessary. Claude Levi-Strauss considers that: *"… the purpose of myth is to provide a logical model capable of overcoming a contradiction …"* (Levi-Strauss, 1963)

This has been used in other fields as a means of examining the creation of new myths that can overcome what was originally (naturally) thought of as a contradiction in that it did not conform to the established cultural norm. An example of this can be found in advertising where a new brand myth is created to overturn concepts that were originally thought contradictory (Alexander, 2005). The idea here is to identify a pair of concepts that relate to the existing brand and express them on orthogonal axes with their opposite poles of the concepts displayed as well to clarify the meaning. For example, in fables 'pretty/handsome' and 'good' are linked as the cultural norm for a hero and 'ugly' and 'bad' are linked for the villain. A new myth is created when we consider a hero who is 'good' and 'ugly' or a villain who is 'bad' and 'pretty/handsome'. In advertising, a new market niche and brand myth can be found by changing the cultural norm for a product. The same analysis can be applied to myths generated within the Holon Framework. By considering appropriate pairs of connotations the client group can see whether and how a new myth might be created by changing the connotation associated with an issue.

A Higher Education Case Study

Over a two-year period the early stages of the Holon Framework were applied to a university academic department which acted as a case study for the application of the Framework (Bell et al., 2005). The initial work with the case study (Framing) involved identifying stakeholders and familiarising them with the framework being used, identifying the framing and environment holons (including sub-holons where necessary) and that the investigators gain a broad understanding of the problem situation. Outputs from this stage were the identified stakeholders (the who) and an agreed holon structure that could be used to guide the investigation and further analysis. There was an initial meeting with the Head of Department at which the Holon Framework was discussed and primary issues to be addressed were agreed. A review of the RAE and QAA literature assisted in the initial identification and labelling of the relevant holons (i.e. the where). Also, relevant academic and support staff were identified as participants for the study (i.e. the who). The holons finally selected related to Admissions, Research, Resources, Student Progression, Student Support, Quality Management and Cost Management.

The Enquiry stage aims to identify the problems as perceived by the stakeholders. The agreed holon structure provided a focus for the dialogue. During group meetings with the stakeholders, information was placed in the relevant holons through the use of rich pictures and written notes. The outputs from this stage were rich pictures and narratives for each holon and sub-holon highlighting the problems (or the mess) associated with the situation of concern and these were verified by stakeholders. It should be mentioned here that the rich picture will contain elements of, and clues to, myths and meanings but these will generally lack the structure to enable a clear description of myths and meanings to emerge.

The Visioning stage attempts to produce a vision of the situation of concern through the development of themes as collections of related problems. Stakeholders were asked whether a theme was a 'must' or a 'want' and to generate an attainable vision which attempts to solve or control certain themes within the foreseeable future. The outputs of this stage were the identification of themes and the construction of an agreed vision of the situation of concern. We contend that it is during this visioning mode of working that the client group should begin to explore myths and meanings and that the issues and problems can form the 'signs' for analysis, since it is through these signs that the myths and meanings are being expressed. Furthermore, some myths and meanings might be challenged in the attempt to produce a vision that has resonance with the current or desired organisational culture.

We now give three examples of how such engagement might proceed by considering issues/problems identified in two of the holons used in the case study. These holons referred to 'Admissions' and 'Research'. Within the Admissions holon concerns were raised about the 'high number of students recruited through clearing, their motivation and qualifications' and 'the provision of academic resources for staffing the clearing system'. Note here that clearing refers to the period during August and September after UK 'A' level results are released in which students who fail to secure a place at their chosen university apply to other universities to try and secure a place for a September start.

Treating each of these concerns in turn as a sign (in the medium of the English language) we can examine via the client group the second and third order significations. Examples are illustrated in Figures 12.1 and 12.2.

Table 12.4 Myth 1 from the Admission Holon

<table>
<tr><th>Sign</th><th>Connotations</th></tr>
<tr><td rowspan="8">Concern about the high number of students recruited through clearing, their motivation and qualifications</td><td>Courses unattractive</td></tr>
<tr><td>Poor reputation</td></tr>
<tr><td>Students struggle to succeed</td></tr>
<tr><td>Poor market profile</td></tr>
<tr><td>Flexible entry policies</td></tr>
<tr><td>Liberal admission profile</td></tr>
<tr><td>Lack of student 'selection'</td></tr>
<tr><td>Opportunities for non-standard students</td></tr>
<tr><td colspan="2">Myth: An organisational culture which values student opportunity, support and achievement but does not foster consistent engagement with the local community</td></tr>
</table>

It should be noted at this stage that connotations may be seen as positive (flexible entry policies) or negative (poor market profile) and that these connotations may well be a matter of debate. However, as a group they provide a framework for describing elements of the story that make up the myth, the web of beliefs, that surround the sign.

Table 12.5: Myth 2 from the Admission Holon

Sign	Connotations
Concern about the provision of academic resources for staffing the clearing system	Perceived value of clearing?
	Lack of staff goodwill towards management
	Lack of funding for departmental reward structure
	Low management propensity to reward staff
	Low value of staff to management
Myth: An organisational culture in which staff goodwill is poor and management undervalue staff and do not see the need for defined and resourced reward structures for certain core academic activities	

The third example illustrates a concern from the Research holon in which the issue of peer review of individual and group research activity is raised:

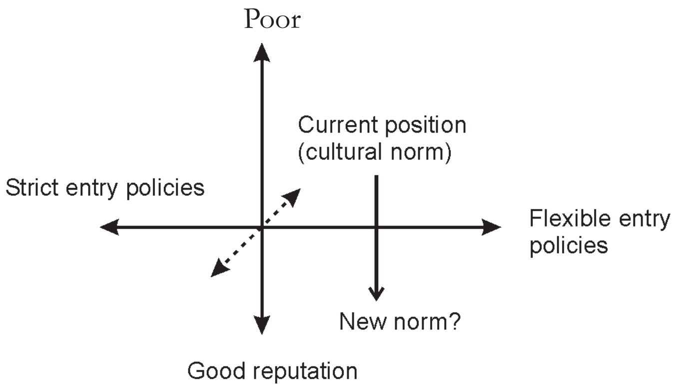
Table 12.6: Myth from the Research Holon

Sign	Connotations
Concern about the lack of an internal peer review system for research activity	Research quality is important
	Variable research quality at present
	No integration of departmental research effort
	Little communication between research scholars
	Lack of focus for research activity
	Research quality left to the individual
Myth: An organisational culture in which trust is located with research scholars for the local control of research quality and which places little value in communicating and integrating research activity	

Of course, these myths may be challenged by the client group or may be confirmed as valid in the sense that they are shared at that moment in time. If a myth is challenged as being inconsistent with the vision the client group are developing then the group would need to consider which aspects of their daily interactions, conversations, procedures etc. could be used to amend the core paradigm so that a new or altered myth might emerge.

One way to do this would be to refer back to the connotations associated with the issue or sign. If we return to the first example taken from the Admissions Holon we may pick out two connotations and represent them as in Figure 5 below:

Figure 12.2: Challenging the Myth



In Figure 5 we have contrasted two connotations showing the current position of the department in terms of perceived reputation and entry policies. The figure shows an established cultural norm relationship depicted by the dotted arrow in which universities with 'strict' entry policies are perceived as having a 'good' reputation and 'flexible' entry policies leading to a 'poor' reputation. The challenge for the client group now would be to see how they could change the culture of the organisation so that they establish a myth in which a move to the new norm is possible by positioning the university so that it keeps flexible entry policies but establishes a good reputation.

Conclusion

In this paper we have described the importance of systems thinking in HE planning as a counter to the dominant paradigm of managerialism. In particular we have outlined the Holon Framework as an aid to stregic planning that utilises systems thinking and which, like SSM, tries to address the myths and meanings as well as the logic and facts of a situation.

We have suggested that using the Holon Framework allows the emergence of organisational culture and that semiotics can be used as a means of engaging with myths and meanings that are reflective of the core managerial and cultural beliefs of an organisation.

The application of these ideas within the HE sector is of potential benefit both in debating a range of issues (these could be part of a large organisational 'mess' or a smaller, more tightly defined problem) and in application to organisations of varying size and maturity. We have made reference to some of the problems within the UK's established higher education sector yet for higher education establishments in developing countries there is, arguably, an even greater need for these methods and ideas. In the latter case there may well be significant issues to be debated within a rapidly changing environment – issues perhaps relating to establishing robust quality management and enhancement procedures and the allocation of limited resources. The basic argument still remains though which is that development and change will be enhanced by an understanding of the emerging organisational culture and that this process can be managed using the Holon Framework.

This work is currently in its early stages but we feel that there is scope to develop tools which will allow a client group using the framework to expose and engage with myths and meanings in a structured way so that meaningful debate can take place which may well reflect in their future actions and plans.

Postscript

Since the completion of the early parts of this case study the institution concerned has undergone a period of considerable change. The university has redefined its mission statement and now, for example in relation to learning and teaching, talks consistently about delivering pedagogical innovation, excellence in teaching, an exemplary record in widening participation, student retention and graduate employment and a range of successful partnerships with employers, schools and colleges. As Seel observed, you cannot permanently change an organisation's culture by forcing change on the emergent descriptors of the culture. However, if the institution can redefine its central paradigm so that this vision (or myth) emerges clearly for all staff then it will have successfully engaged with and generated a new myth, a new cultural norm, making the transformation hinted at above.

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13

Complexity Reduction in the Formative Evaluation Process using the Quizintegrator

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There is no silver bullet to the process of developing interacting e-learning material. In all cases, the domain expert must develop the content and structure it before initiating the next stage which is largely technology-intensive. It is at this stage that tools can be used to support the process. In this paper, we discuss a tool that has been developed to support one of the critical stages in the e-content development process. The software helps content experts to quickly develop self-evaluation formative and summative test-cases that are crucial in the learning process. The background and motivation of the study are discussed and the software design presented. The system is flexible and its crucial features are modular, which makes it portable across various operating systems. Experiences from the use of the software have shown that the task of test-cases development is accomplished within less than 25% of the total time that was previously spent doing the same thing.

Introduction and background

The teaching methods present themselves in a continuum: from expository to heuristic. Starting with the lecture method on the expository end, the next in the continuum is the demonstration method then the history method, followed by discussion or questioning. Others include the assignment and supervised study method and finally discovery or inquiry, in that order. As one moves from the lecture method through to the discovery method, the learners' participation increases as the teacher's diminishes. Quite often a teacher may combine these methods during a teaching session (Ayot, 1992). However, some methods are better suited for teaching certain concepts or subjects than others.

In this classical education system, the delivery of course material is through interaction between the lecturer and students in the classroom environment. The process of formative testing is likewise an interactive activity in which different methods come in handy. In the continuum described, some methods are better suited than others.

Current advancements in the learning realms tend towards enabling students to take their courses privately, outside the classroom, and this makes testing assume a somewhat more prominent role. Technology-mediated learning must be supported by technology-mediated testing, hence at each stage of the continuum, a mechanism must be realised to evaluate not only the process but also the output.

Feedback and Capturing Attention. In the lecture method, the teacher is, in most cases, the only active participant in the teaching-learning process and the learners are passive listeners. This learner attribute, infact, becomes a major disadvantage because learners' passiveness increases chances of lack of attention and concentration. Notable merits of this method include easy presentation of content in a verbal and logical manner while adjusting it to the learner's level. Note-taking, asking questions, and the use of teaching aids such as charts and diagrams tend to increase the learner's involvement and hence attention. In e-learning the process takes the form of presentation of material in a sequential manner while ensuring that interactivity is implemented. The questioning technique helps the teacher to get or provide feedback to his students. Self-assessment questions and end-of-unit tests can be excellent substitutes during e-learning sessions. There are a variety of questions which help achieve this. Cognitive questions involve the recollection of facts and procedures, while convergent thinking questions go beyond the recollection of facts and procedures and measure learning at concept and principle levels. On the other hand, divergent thinking questions probe the area of skills learning by seeking originality in students. They involve the learner's ability to predict, hypothesise, infer or reconstruct. Finally, evaluative questions require that a learner must have passed through all the other levels of learning and he should be somewhere at the productive skills level. These questions are very demanding and the learner should possess a wealth of information and understanding to be able to tackle them effectively.

Software and the Instructional Process. With software, it is possible to give instruction using a combination of teaching strategies; the success of which is dependent on the design of the software. Expository methods such as the lecture method are easily modelled as a series of Web pages, which unfortunately may not always serve the same role as lectures presented in a classroom. However, great care must be taken when modelling heuristic methods where the learner is supposed to discover the knowledge by himself. The Internet is like a deep ocean with a large pool of resources that are up for grabs, but require guidance on where to find them. Well-designed Web-based software can provide such guidance (Omwenga, 2003).

There are many different types of software that exist to support the learning process. The instructional process, generally referred to as e-learning, is a necessary approach to providing pace-and space-teaching and learning flexibility. To this end, these software systems should provide the content developer with user-friendly interfaces to support the development of pedagogically-sound materials that have all the necessary ingredients.

Motivation for the study

In this paper we discuss a tool that has been developed out of several years of experience in the process of e-content development. The tool is a piece of software that complements e-learning systems that support the instructional process. During the training workshops such as reported in Omwenga (2004) April 2005), it was realised that it is not always possible to enforce strict pedagogical principles when the e-content developers are not professional web designers but rather university professors who want to make their materials available to students within a minimum amount of time using affordable human resources. The development of test cases and self assessment questions can be a difficult task for many, not only owing to the required professional competence and experience but also owing to the kind of technical demands that are required of the developer in the use of web authoring tools or equivalents (Omwenga et al., June 2005). For fully-fledged e-learning systems, this is a rather straightforward exercise that can be accomplished within a short time.

Most of such e-learning systems provide templates for filling in the test questions of various types. But for asynchronous e-content that resides on portable media such as CDs, the approach is a lot more complex. This requires techniques that are based on text files or dynamic data structures which are later processed in order to produce run-time codes. In the study with various cohorts of trainees, it was established that although most participants were able to polish up their skills as they went about their work, it was not lost on them that the tasks were challenging. In order to reduce the complex tasks involved and bring the process within the capability of many, it was imperative that certain tasks be automated. It is clear that web design is an activity which requires mastery of technical skills and the ability to learn new techniques. This can be a complex task and needs to be replaced with an automated process. The task of automating test-cases development and hence reducing the overall time of the process was done using a software script that was implemented to run on either text files that are automatically converted into web pages or using a database-driven content repository which stores content objects that are accessed on the fly.

When this software was used in a life application environment, experiments showed that the overall process of test-cases development was accomplished with even better results within only 25% of the total original time.

System description

The software whose acronym is QuizIntegrator, aka QuizMaker, is a web-based system that is designed to run on any platform that supports any web client program. Coded in JavaScript, the system works by first capturing the details of the test cases into an array which is later demarcated into constituent parts to reconstitute an equivalent HTML code to render on the browser. The test cases could optionally be stored in temporary text files or a database that is removed from the disk storage during the garbage-collection process.

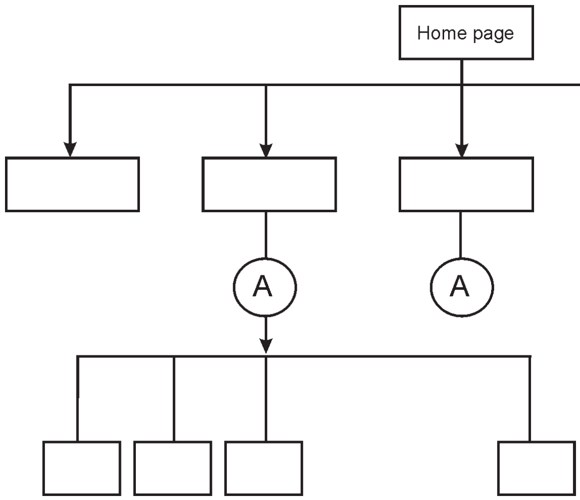
The system has been developed on the MS Windows XP operating system platform. HTML and JavaScript were the main programming tools used. To install and use QuizIntegrator effectively, one only need to have at least MS Windows 98 or above operating system and any HTML editor where the HTML code generated is pasted onto an empty page and saved as an HTML file. This is the file that is called from any point within the e-learning CD. A modular design approach was adopted in the development of the system. We briefly describe the interface and process design aspects.

Interface design

The system is web-based and is run from any web client browser. From the home page one can choose to construct any of the four different types of questions in multiples of five. There is also an online help module which gives some hints on how to develop good questions.

Figure 13.1: Overall Interface design for Developing the Test Cases.

Figure 13.1 below helps to explain the interface design approach



Process Design

The process of developing the quiz is depicted in Figure 2 below. The user has to fill in preliminary information about the quiz: such as special instructions, duration, and name of the quiz author. After this is done, the template for creating the quiz is now ready to accept the test-case objects such as the stem, the choices and the correct answer. Upon completing all the questions, the user will then hit the generate HTML code button in order to generate the code which is pasted onto the HTML editor and saved accordingly. Figure 3 illustrates this part of the process.

Figure 13.2 Quiz development process

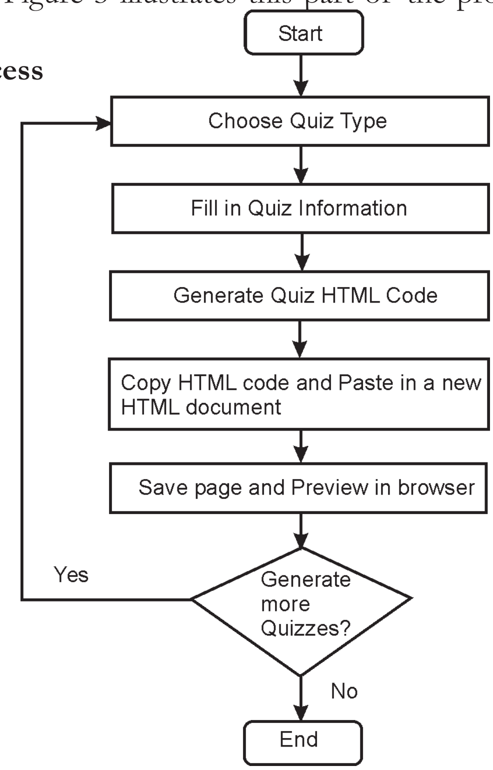
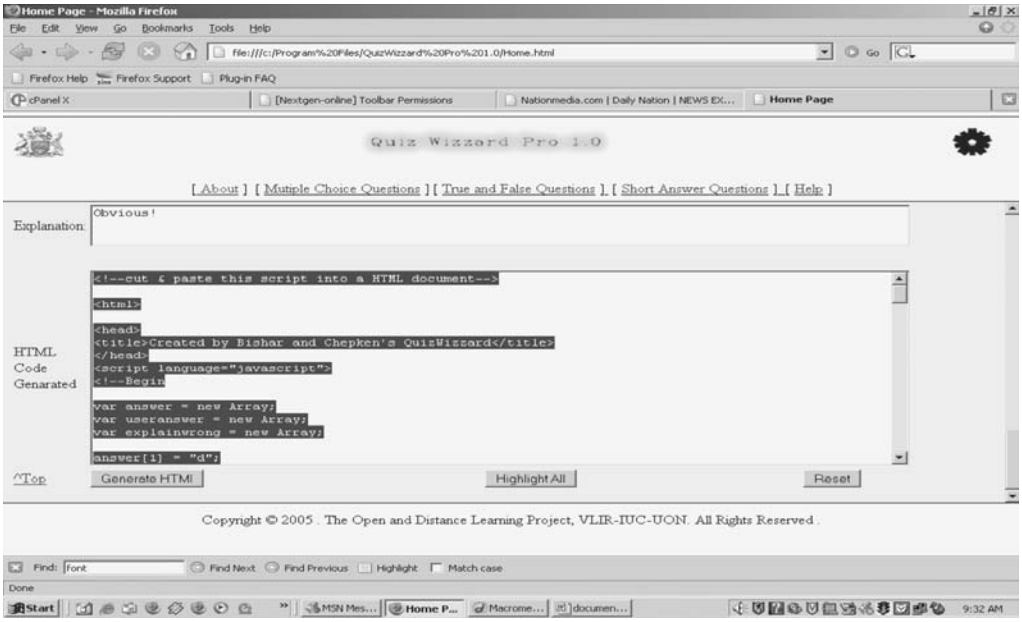


Figure 13.3: Upon visually developing the quizzes, one produces the HTML code that is cut and pasted in an HMTL editor

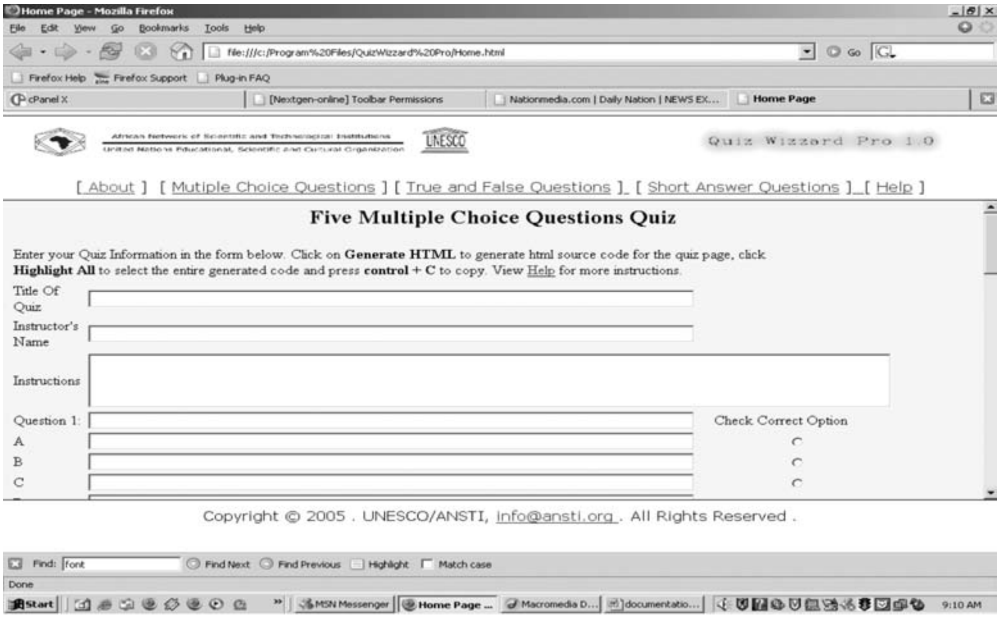


System functionality

The QuizIntegrator has been designed to provide a number of features and functionalities. Different question types are used to accomplish different levels of cognitive testing and reinforcement. The objective type of questions such as the multiple type of questions with optional distracters, true/false questions as well as short-answer questions are used to test concepts covering large portions of the syllabus. Such questions, if well designed, can test the student on simple remembrance of facts and yet also cover application, analytical and synthesising skills. This system is designed to help prepare all these types of questions. The system allows the assignment of weights to answers and offer grading statistics after the quiz has been done and submitted for online marking. The output is displayed with the examinee's answer alongside the correct answer. The percentage mark attained and the grade are also displayed. The series of screen shorts shown below help illustrate these concepts.

Instructor Side. The instructor side of the system allows for input of the questions using an interface such as the one shown in Figure 4 below.

Figure 13. 4 Screen shot shows the interface for keying in or pasting the questions



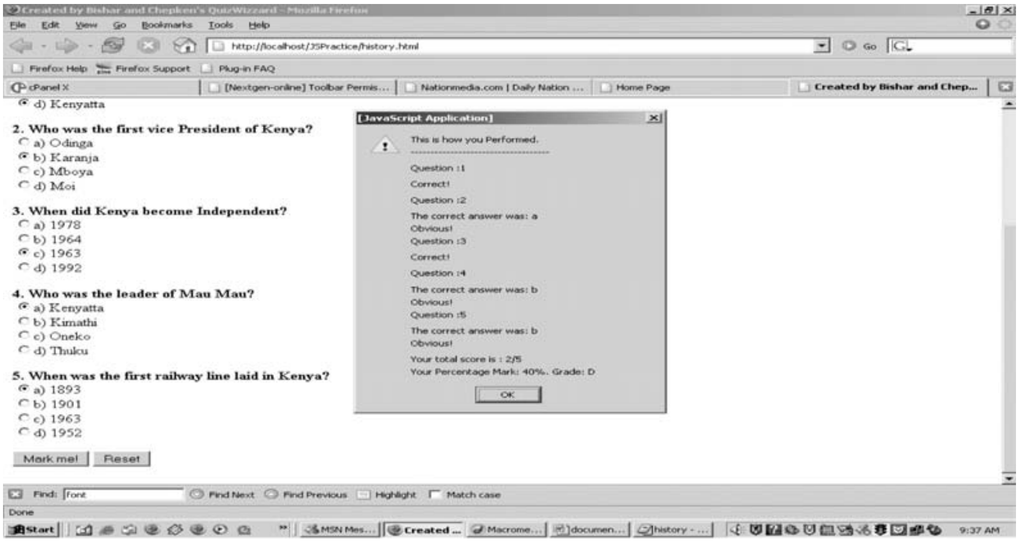
The user will provide any instructions and check the correct answer on the right-hand corner of the screen.

Client Side of the System. Figure 5 shown below shows the screen that will appear when the student user of the system is ready to tackle the questions. The title of the quiz, the name of the instructor as well as special instructions are all displayed. The student will take the quiz and submit it for marking.

Upon marking the quiz, the student will receive a feedback screen such as the one shown in Figure 6 below advising him on the outcome of the test.

Figure 13. 5: Learner interface for taking the Quiz

Figure 13.6: Output screen upon submission and marking of the test



The information that will displayed on the window will include the correct answer for the wrong options, the percentage score and the overall grade.

Suggested extensions of the system

It is proposed that the QuizIntegrator be extended to provide for pointers to the places where the correct responses are found within the content. This will require careful integration of the system into the e-content for which the quizzes are developed. It will also require a modification of the design to provide for classification of the various types of questions into the five cognitive levels as advocated by Bloom (Bloom, 1956). The time taken to do the quiz might be of help in discriminating among learners. This is also proposed as an extension of this system. As a further extension to incorporate the essay type of questions, machine-learning algorithms shall be employed.

Conclusion

The idea of automating the process of developing test cases is not new. But the system described above has some unique features that most others tend to ignore. For instance, being able to generate the HTML code and having the opportunity to change it (although not necessary in most cases) is an important option. Moreover, it is possible to generate the quiz package on the fly without necessarily using a database. This gives the system yet another unique feature that makes it flexible, especially when there is need to produce content on portable media such as CDs.

We have described the system in detail and given the motivation for developing it. The power of this system lies in the amount of time it saves content developers in creating the test cases. It not only reduces the time taken but also makes the process much easier and bearable both for the experienced web designers and the subject professionals alike.

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Part Six

Gender and Information Technology Development

14

Access to ICT Higher Education: Reflections on Good Practices in Promoting Gender Equality at Makerere University

Aramanzan Madanda and *Peace Mutuwa*

This chapter explores access to Information and Communication Technology (ICT) training in Makerere University by gender. It focuses on selected examples showing the promotion of general access to ICT training in the university. Examples of the Department of Women and Gender Studies (DWGS) and the Faculty of Computing and Information Technology (FCIT) are utilised. The paper also analyses the efforts of the gender mainstreaming division (GMD). The division is charged with the role of mainstreaming gender into all aspects of the university, including gendering the ICT training process. In all, the measures aimed at promoting and / or improving access to ICT higher education are tackled. In this context, the purpose of this paper is twofold: one, to present good practices that can be emulated in developing relevant ICT training policies and practices in similar higher institutions of learning; and two, to make recommendations for possible utilisation by organisations and institutions of higher learning as well as governments.

Background

Information and Communication Technology (ICT) has been identified as one possible means of leapfrogging poor economies from peasant to modern information societies (UNECA, 2003). Similarly, higher education in ICT is becoming widely recognised by several countries worldwide as a means of developing an efficient human resource capacity that is required to ensure economic growth and sustainable development (Changeiywo, 2002). The Uganda government fully recognises the roles of ICT and has formulated a national policy framework that covers information as a resource for development, mechanisms for accessing information, and ICT as an industry, including e-business, software development and manufacturing. The policy looks at various categories of information from different sectors, essentially aimed at empowering people to improve their living conditions. The sectors include: health, education, agriculture, energy, environment, business, and science and technology. The policy recognises the role of private and public sectors as critical in promoting ICT. The government further identifies Makerere University as key in ICT education provision (ROU, 2002). The Uganda National Gender Policy framework recognises that gender is integral to all development initiatives, including ICT education. Therefore strengthening equal access of women and men to ICT in higher levels of education is one important way of addressing this concern.

Makerere University's Strategic Plan prioritises ICT and gender mainstreaming as the main areas to be addressed in the 2000/01 –2004/05 period. Henceforth, the university has put in place a broadband fibre optic infrastructure that spans most of the main campus providing opportunity for high-speed connectivity to the intranet and the Internet. A policy and master plan for ICT is in place and its vision is "to provide a university-wide access to, and utilisation of information and communication technology to enhance the position of Makerere University as a centre of academic excellence, and its contribution to the sustainable development of society". Several units in the university are mandated to ensure that ICT training and services are made available to the university community and beyond.

There are academic, professional and in-service ICT training programmes conducted within the university. The Faculty of Computing and Information Technology (FCIT) is the lead provider of these programmes. The Directorate of ICT Support (DICTS) was established to provide university-wide back-up support. This is in recognition of the scarcity of ICT expertise, and to rationalise and contain the escalating costs that would result from multiple hiring of such expertise. The directorate has a central service unit that provides expert services and guidance to all academic and administrative units of the university.

Other units, however, do offer ICT training, research and outreach. For example the Department of Women and Gender Studies (DWGS) offers the CISCO programme; the School of Education offers the Master of Science (MSc) in ICT Education, while the Makerere University Business School (MUBS) offers Business Computing and ICT Policy and Regulation courses. Other units have courses related to their mandates and needs such as statistical computing in the Institute of Statistics and Applied Economics (ISAE) and typing and keyboarding skills in the Institute of Languages (for Bachelor of Secretarial Studies students). This paper focuses on the bigger question of access to ICT higher education by gender, using three examples of the DWGS, FCIT and the efforts of the Gender Mainstreaming Division (GMD). By higher education we mean training offered at university.

Using the above examples we would like to answer the following questions: Do women have equal access to ICT education? Does the ICT education curriculum in place enhance employment and education opportunities for women? Do the new trends in ICT education replicate patterns of inequality in the education sector? What are the main barriers women have to overcome to participate actively in digital education? Can we draw any lessons from the existing initiatives at Makerere University? This paper attempts to respond to these questions using the available anecdotal evidence. This may raise further questions for enquiry rather than trying to close debate on this topic.

Gender Disparities in Higher Education

According to the UNESCO World Education Report (UNESCO, 2000), literacy rates in sub-Saharan Africa stand at 50.1% for women and 66.7% for men. More and more girls drop out of the system between primary and secondary school and again at different secondary levels, making the disparities more glaring in higher education. Women form only 33% of total enrolment in higher education.

Another observable fact noted worldwide is the disciplines or professions taken up by women in higher education. Women are found mainly in education, humanities and social sciences rather than science, mathematics and technology. The need to have all this changed is clear.

There are a far smaller number of women in the computing and IT field than men today. According to a Massachusetts Institute of Technology study (MIT, 1983), women in the field are just as qualified as men, yet their numbers remain small. After research, the Association for Computing Machinery (ACM, 2002) concluded that in general women stop their training in computer science earlier than men, thus accounting for the difference in proportion, especially at higher professional levels. While women receive about a third of the undergraduate computer science degrees, much fewer women receive master's degrees, and fewer still stay on to get their PhDs. This means that there are far more male computer science professors than female ones, which perpetuates the male-dominated atmosphere of computer science.

Makerere University has since 1990, given a 1.5 points bonus to any eligible female entrant to the university in addition to the individual examination scores. This has increased girls' enrolment from about 20% to about 49% at Makerere University. However, girls are still concentrated in the traditional subjects and courses. Women are beginning to outnumber men students in fields such as Law but not in science, mathematics and technology courses (Kwesiga, 2002). Women now constitute the majority of the teaching assistants at Makerere University. We explore the question of access further using two case studies below: the DWGS and FCIT.

The Case of the Department of Women and Gender Studies (DWGS)

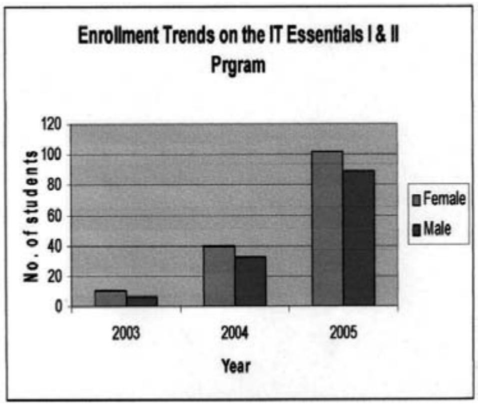
The DWGS in the Faculty of Social Sciences has the mission of ensuring that gender is mainstreamed into all aspects of economic, political and socio-cultural development. It works towards developing the discipline of women and gender at the local, national and international levels. Through its outreach programme, the department, like other university units, works to "take the University to the people". From 2002, DWGS commenced the Cisco Certified Networking (CCNA) course under the CISCO Networking Academy Programme (CNAP) with the aim of contributing towards reducing the gender digital divide. The CNAP is an international training programme that covers designing, building, and maintaining computer networks. One argument for placing this course in DWGS was that "you can get more women to take on ICT initiatives if you placed them in units where women are in the majority than in units that are traditionally male-dominated." The CCNA programme was closely followed by the establishment of another computer maintenance course, Information Technology Essentials (IT ESS) under the CNAP. In between the establishment of CCNA and IT ESS, it was learnt that most students who enrolled had no training in basic computer skills. The department responded by introducing a basic computer training course.

Furthermore, in addition to basic computer skills, a theoretical discussion of Gender and ICT is part of the curriculum of the Master of Arts (MA) and the Bachelor of Arts (BA) students taking the gender, science and technology course.

What have been the lessons and achievements?

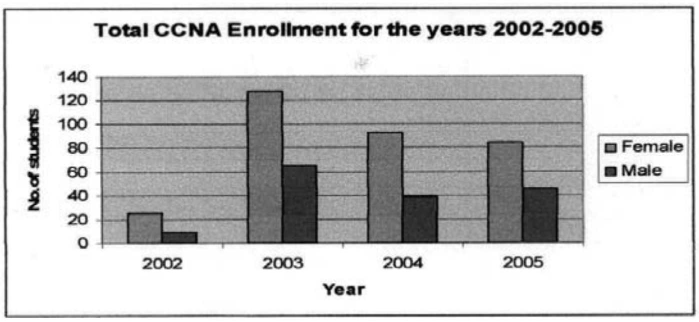
True to the initial thought, placing the IT programme in women and gender studies, where women are in the majority, has resulted in the fact that most of the students and graduates are female. The graphs below illustrate this point.

Graph 14.1: CCNA enrolment Oct. 2002 – July 2005. Source: DWGS Sustainability Plan, 2005



Graph 1 shows the enrolment trends on the CCNA programme at DWGS over the years, since the time of inception in October 2002. High enrolment of female, is maintained each year. This serves as a good indicator in promoting female participation in the programme.

Graph 14.2: Enrolment IT ESS 1 & 2 programme since 2003. Source: DWGS Academy Sustainability Plan, 2005



Graph 2 shows the enrolment trends on the IT Essentials I & II programme at DWGS over the years, since the time of inception in 2003. Similarly, high enrolment of female, is realised per year.

However, while placing the IT programme in Women and Gender Studies was necessary in ensuring a higher number of females in the programme, it was not sufficient. Building on donor support for infrastructure, equipment and software provision, the department has had to employ other strategies. These include: offering scholarships and tuition subsidies to females; offering career guidance and mentoring students beyond the training period; following up with parents and working in partnership with women's organisations and mainstream institutions that support women's ICT initiatives. More important, however, has been the support from critical Makerere University organs such as the Directorate of ICT, the top university leadership, the Faculty of Social Sciences as well as the presence of the FCIT. FCIT provision for admission of CCNA students to the degree level has provided a useful upward opportunity for female students. In a way this programme has provided a stepping stone for students to advance their academic career in Computing and IT education. This was made possible by the university's move to recognise the CCNA qualification as an equivalent to a Diploma in Computer Science. A large number of the openings available in the Computing and IT courses have been filled up by the CCNA holders.

Coupled with this has been a strategy of "looking for the women" wherever they are, the most effective method being person-to-person contact. In short we have learnt that whereas it is much easier to attract males to ICT training, for females you need extra effort and commitment. The department is now, with support from the Carnegie Corporation sconducting research to explore factors influencing university-wide access and utilisation of ICT. Hopefully this will provide more information on this subject.

The Case of FCIT

The Faculty of Computing and Information Technology (FCIT), Makerere University, was established in 1986 as the Institute of Computer Science (ICS). The purpose was to meet the increasing demand for computing and information technology services in Uganda in particular and the African region in general. The institute rapidly grew into a Faculty of Computing and Information Technology (FCIT) with four departments, namely Computer Science, Information Systems, Information Technology, and Networks in 2005. The institute provides a wide range of training opportunities from "certificate to PhD", including research and consulting services to the wider public. It runs both academic and professional programmes with the latter including the CNAP and Microsoft Academy courses. FCIT has probably the largest enrolment of students in IT and Computer Science, placing it at the top of computer training in Uganda. Below we report on the growth in enrolment over the years by sex of students for the diploma, undergraduate degree and graduate programmes.

Table: 14.1: Undergraduate Admissions 2002/3- 2004/5

Year	Course	M	F	Tot.	F%
2002/3	BSC	57	18	75	24
2003/4	BSC	115	54	169	32
2004/05	BSC	169	103	272	38
	BIT	522	383	905	42
	DCS	48	20	68	29
Total		911	578	1489	39

Source: Makerere University Undergraduate Admissions Records

Table 1 indicates growing enrolment of females in Bachelor of Computer Science Course (BSC). When the FCIT introduced the Bachelor of Information Technology Programme in 2004, general admissions went up but the percentage of women in the BIT course was higher than in BSC. The diploma in Computer Science (DCS) is attracting fewer females than BIT. The introduction of the BIT course mainly explains the general rise of female enrolment to 39% overall. Note that FCIT performs far better in proportional female enrolment than the traditional science courses which are not the subject of this paper.

Table 14.2: Graduate Registered Students 2001 to 2005

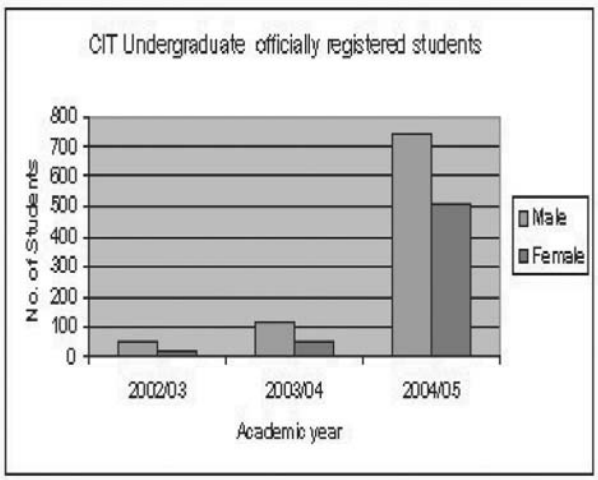
Year	Course	Male	Female	Total	Female%
2001/2	PGDCS	108	23	131	18
	MSCCS	26	7	33	21
2002/3	PGDCC	4	0	4	0
	MSCCS	25	8	33	24
	PhD	0	1	1	100
2003/4	PGDCS	37	21	58	36
	MSCCS	66	22	88	25
	PhD	0	2	2	100
2004/5	PGDCS	40	17	57	30
	MSCCS	74	20	94	21
	MIT	0	1	1	100
		380	122	502	24

Source: Graduate School Statistical Summary of Registered Students, as at 09/08/05

Key: PGDCS = Postgraduate Diploma in Computer Science, MSCCS = Master of Science in Computer Science, and MIT = Master of Science in Information Technology. Note that this is not a complete list of courses offered in FCIT.

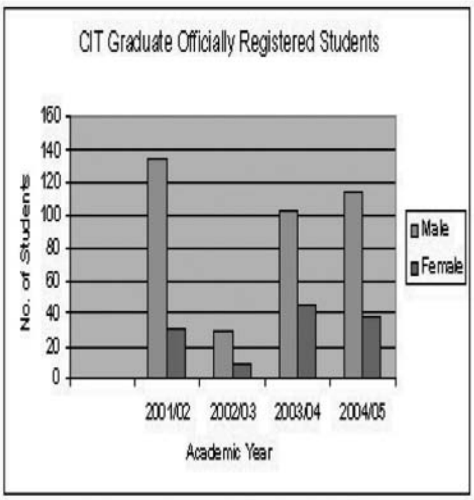
Table 2 shows the officially registered graduate students pursiomg the Postgraduate Diploma in Computer Science, Master in Computer Science, Master in Information Technology, PhD in Computing and IT at FCIT from 2001/02 to 2004/5. Graphs 3 and 4 below present a more vivid picture.

Graph 14.3: Registered Undergraduate Students



Graph 14.3 shows the enrolment trend in the bachelor's degree programme at the FCIT. Despite the increased enrolment figures with the introduction of new programmes such as BIT, fewer females still register for the programmes.

Graph 14.4: Registered Graduate Students



Graph 14.4 shows the enrolment trend in the graduate programmes of Postgraduate Diploma, Master and PhD at the FCIT. Even when the both registered Ph.D students are female, overall there are far more males at graduate level than females.

What do we learn from the trends?

Notably, the proportionate number of females has risen from 24% for undergraduate programmes in 2001/2 academic years to about 39% in all undergraduate programmes in 2004/5. The largest concentration of females however is in BIT, where they constitute 42% of the total. Furthermore, there is a gap in female enrolment between undergraduate and graduate programmes. Relatively higher enrollment numbers have been registered on the undergraduate programme (29% overall) as compared to the graduate programmes that is considerably low (24% overall). Additionally, growth in enrolment in the graduate programmes has been very low. Curiously, though, all registered PhD candidates so far are female. This however may be due to the preference by females to register at home universities rather than study abroad owing to conjugal and family responsibilities.

It is important to note that the rise in the number of females in FCIT has been a result of a number of strategies. Our personal interview with the Dean of the Faculty indicated the utilisation of four strategies to increase female enrolment: employing 50% female instructors, especially on professional programmes; the role-model effect on girls; creating open entry requirements, e.g. CCNA; offering scholarships to some brilliant female students. Further analysis indicates that efforts to increase female enrolment in Computer Science and Information Technology have included efforts outside FCIT, such as those of DWGS already discussed above and the Gender Mainstreaming Division discussed below, including factors that are beyond the scope of this write-up.

The Contribution of the Gender Mainstreaming Division (GMD)

To strengthen the gender mainstreaming programme, Makerere University established the Gender Mainstreaming Division (GMD) in 2002. Gender mainstreaming in Makerere University is a strategy for making women's and men's concerns and experiences an integral dimension of the university function so that women and men benefit equally, thus ensuring that inequality is not perpetuated. The division was "strategically" placed as a unit within the department of the Academic Registrar (AR). The logic was that the AR department interfaces with all university units, hence an anticipated greater effect. The GMD was established with the aim of engendering the university function across the board. Among other specific objectives of the division are: to ensure gender balance in students' enrolment and improved performance across all disciplines; to advocate increased recruitment, promotion and retention of female staff; and to promote the integration of gender in the university curriculum and research. One of the key contributions to the enrolment of females in science in general and ICT courses in particular has been the Female Scholarship Initiative (FSI). Under the FSI, the division offers scholarships to females admitted to Makerere University, 70% of whom must be science students. The Carnegie Corporation-supported initiative is a scholarship scheme for undergraduate female students who qualify for university education but fail to enrol owing to financial difficulties. The scholarship scheme applies to Ugandan females not more than 25 years from genuinely poor socio-economic backgrounds and who hope to be admitted to Makerere University on the Private Sponsorship Scheme (first years only) on full-time study programmes (day, evening or afternoon) . The selection criteria givepriority to those admitted to Science programmes and females from underrepresented and disadvantaged districts of Uganda. Table 3 below shows the number of beneficiaries of this scheme since the 2001/2 academic year.

Table 14.3: Arts and Science FSI beneficiaries 2001/2-2004/5

Year	Arts	Sciences	Total	Science %
2001/02	47	92	139	66
2002/03	71	138	209	66
2003/04	40	114	154	74
2004/05	25	73	98	74
Total	**183**	**417**	**600**	**70**

Source: GMD Records

From Table 3, the FSI did not obtain the envisaged 70 entrants in the first two years. From the 2003/4 academic year females sponsored by the programme on the science courses have exceeded the target. While the increase can be attributed to factors such as increasing publicity of the FSI initiative, it can also be seen that growth coincided with the introduction of BIT, one of the courses of choice for female FSI beneficiaries.

Table 4 below shows the distribution of FSI beneficiaries in the selected science courses offered at Makerere University for the years 2001 to 2005. Again it is clear that Bachelor of Information Technology and Bachelor of Computer Science have had the largest share compared to courses in engineering or science education.

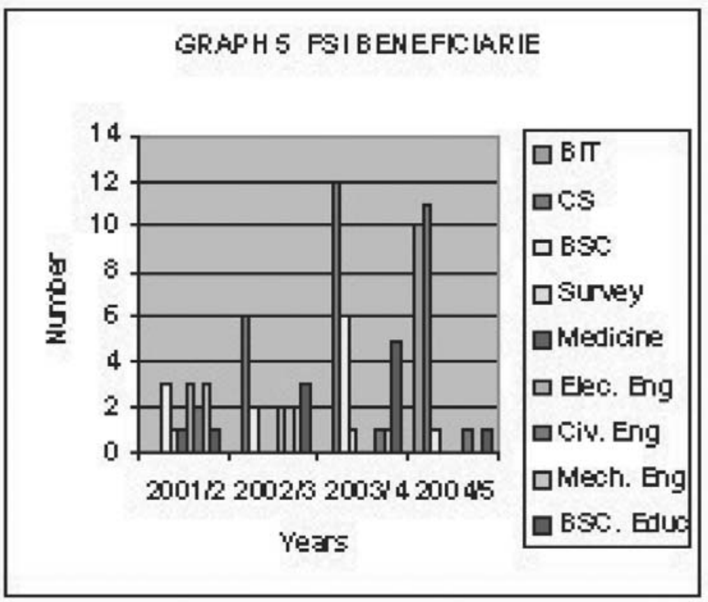
Table 14.4: FSI beneficiaries for selected science courses

Course	2001/2	2002/3	2003/4	2004/5	Total
Bachelor of Information Technology	0	0	0	10	10
Bachelor of Science in Computer Science	0	6	12	11	29
Bachelor of Science	3	2	6	1	12
Bachelor of Science in Survey	1	0	1	0	2
Bachelor of Medicine and Surgery	1	0	0	0	1
Electrical Engineering	3	2	0	0	5
Civil Engineering	2	0	1	1	4
Mechanical Engineering	3	2	1	0	6
Bachelor of Science with Education	1	3	5	1	10
Total	14	15	26	24	79

Source: GMD Records

A look at Table 14.4 shows that the largest single group of beneficiaries of the FSI initiative enrol for Information Technology and Computer Science. Graph 14. 5 below illustrates this point more clearly.

Graph 14. 5



BIT and Computer Science take the largest number and proportion. As the enrolment in these grows courses over the years there is a corresponding decline in the beneficiaries sponsored for courses in Engineering, Education or Survey.

Conclusion and Recommendations

From the foregoing one can see the strides that have been so far made. These have to be understood in perspective. One does not need to lose sight of the broader gender equality initiatives in the country and outside, for instance by the government, non-governmental organisations and other agencies. The internal University-wide initiatives are critical, including the policy of gender mainstreaming which has had many gender equity initiatives at the university such as:

- The 1.5 Points Scheme, an affirmative action programme to increase female student numbers. This provides for additional bonus points to eligible female applicants. The scheme has progressively raised the percentage of female students from an average of 20% to about 35% in 1998 and to 42% in 2004;
- Establishment of the Department of Women and Gender Studies in 1991;
- The Female Scholarship Initiative (FSI) and a series of gender-oriented academic and institutional capacity-enhancement initiatives in the university;

- Gender mainstreaming in the Faculty of Agriculture, comprising scholarships for women in agriculture-related fields, gender mainstreaming of the curriculum and gender sensitization workshops for academic staffs;
- Commencement of course units focusing on gender in diverse disciplines in many faculties, schools and departments, e.g. the Department of Political Science, Faculty of Law, Institute of Languages, Department of Mass Communication, Department of History and Department of Sociology.

The specific initiatives mentioned above make one point: Gender equality does not just come by; you have to work for it. However, despite the gender initiatives, there are persistent gender gaps in enrolment in both undergraduate and postgraduate levels, in the humanities as well as in Science programmes. Specifically the Computer Science and Information Technology programme has done relatively well compared to the other science disciplines in the university though gaps still persist, especially at the graduate level. In view of the foregoing, we would like to make some recommendations for possible adoption:

1. It is clear that science initiatives focusing on women can lead to increased female enrolment in the sciences. Governments could as a policy look at the establishment of Women's Science and Technology institutions.
2. There should be a broader gender-friendly policy framework in the country and institutions of higher learning. In the medium term, affirmative action initiatives for women have worked for Makerere University to an extent. A comprehensive gender-friendly framework is important.
3. Flexible entry requirements to university ICT courses are a good initiative. When Makerere University recognised the CCNA as adequate for entry, the number of females in BIT went up. Similarly, establishing more courses related to information technology and management has attracted many females. This is a lesson some other science courses can emulate, including putting up remedial programmes if necessary.
4. There is need for mobilisation and provision of resources and adequate financing. Scholarships have played a role in the case studies discussed in this paper. Governments, however, will need to plan and provide for a sustainable source as some of the funding has been largely sourced from donors and may not be available perpetually. For a start, all university units could frequently budget for their gender programmes. There is no course that does not require gender.

Summary

The paper has indicated that access to ICT higher education training at Makerere University is from a gender perspective and improving particularly at the undergraduate level. This is particularly true to the BIT course. Computer science is still largely a male area. ICT training holds out the promise of reducing gaps in science and technology training compared to the traditional sciences. The current position has been the result of a number of comprehensive efforts in the past and currently involving a wide range of actors.

At the graduate level, gender gaps in ICT training are still much wider and the challenge of keeping women in this filed up to the top levels is not yet over. Questions of sustaining and improving the trends to reach a point of equality need to be addressed. Gender-focused initiatives like what pertains at DWGS need emphasising.

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15

Design of Engendered Information Society: The Challenges

K.R.Santhi and *G. Senthil Kumaran*

The overwhelming consensus that new information and communications technologies (ICTs) such as the Internet have ushered in a new age, created new economic and social opportunities the world over and the development paradigm has become more technology-centric. So success in the global economy will depend on access to ICTs and equitable access to ICTs is fundamental for maximizing the impact of ICTs. So integrating gender considerations into ICT strategies and policies is very important. Santhi and Kumaran explore the potential of ICT that address both the fundamental issues on equality and gender and key barriers to ICT usage by them. It provides a considered and detailed understanding of some of the ways in which ICTs might be used most effectively for socio-economic development and poverty alleviation. The authors also provide an insight into how KIST, Rwanda is promoting gender equality in the context of education, technology, ICT, poverty reduction etc.

Introduction

ICTs play an important role in the world's societies, and have the potential to help disadvantaged groups increase their participation in the civic, social, political, and economic processes critical to achieving change. Johnson (2003) says that access to ICTs is a prerequisite for new knowledge creation, and until the gender dimension is incorporated into their design, women in the developing world will continue to be marginalised. Gender segregation in education and the working life has remained stronger in Africa than in other countries. The paper aims to understand the dynamics of promoting gender equality in the context of ICTs and ICT-mediated society. We start by discussing the understandings of gender, equality, and equity and finally present our recommendations for an engendered ICT society.

Various definitions

These definitions are vital to recognise when undertaking research on gender and ICTs.

Gender. Gender refers to the social differences and relations between men and women, which are learned, vary widely among societies and cultures, and change over time. The concept is used in analysing the roles, responsibilities, constraints and needs of women and men in all contexts (UNESCO, 20003).

Gender Equality. Gender equality in the context of ICT means 'equal access to technology' and 'women's and men's similarity'. It does not mean that women and men have to become the same, but that their rights, responsibilities and opportunities do not depend on whether they are born male or female.

Gender Equity. According to the Concise Oxford Dictionary (7th ed., 1982) equity means fairness and it also means recourse to principles of justice to correct or supplement law. It is in this sense that specific measures must be designed to eliminate inequalities between women and men, eradicate discrimination and to ensure equal opportunities. Gender equity leads to equality (UNESCO, 20003).

Gender Mainstreaming. Rees (2004) discusses gender mainstreaming as the systematic integration of equal opportunities for women and men into the organisation and its culture and into all its programmes, policies and practices – into ways of seeing and doing.

ICT. Information and communication technologies (ICTs) refer to the broad range of digital technologies such as computer hardware and software, fixed lines and mobile phones, electronic mail, satellite technology, wireless or cable networks, multimedia tools, and the Internet, which are used to create, transmit and distribute information and services.

Qualities of Gender-neutral ICT

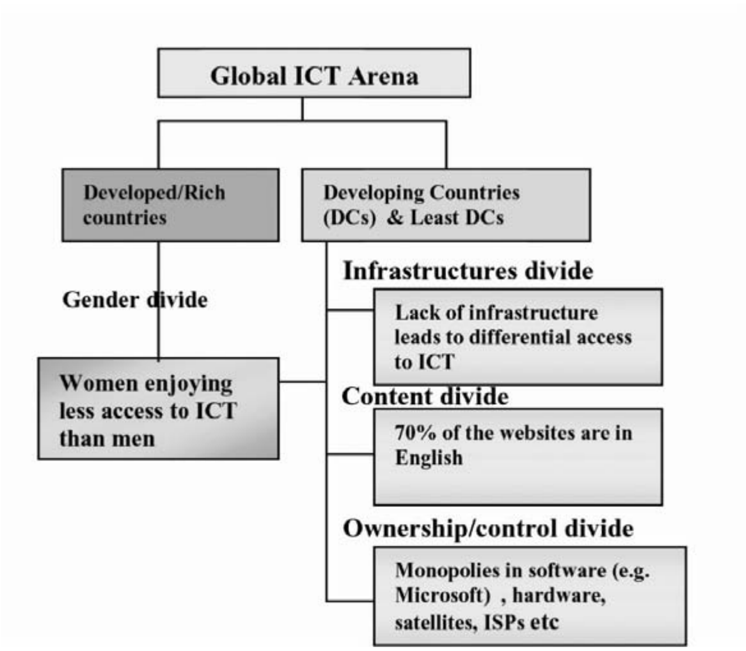
ICTs cannot create gender equality, or end poverty, but they can be tools for social action and positive social change. A gender-neutral ICT must satisfy equality, diversity and equity in various fields, especially in ICT education, training and usage.

Equality in all shapes and forms. The masculine image of content and approach must be addressed by feminine examples and approaches. Give students examples where problems from women's lives need to be solved, e.g. introduce a program to calculate average weights of babies, programs for washing machines etc.. Resources often reinforce limited views about what it means to be a girl or a boy, a man or a woman in our society. In choosing software or an Internet site, a teacher must make decisions about its suitability. For example check the language, talk about the "she" programmer instead of the "he" programmer.

Diversity in all shapes and forms. Gender researchers have shown that interest in the use and design of ICT varies from women to men and women to women in numerous ways. Women in the ICT sector are a heterogeneous group who vary in terms of age, ethnicity, income levels, living arrangements and geographical location. From such differences comes the possibility of diversity in their experiences, and the barriers they face individually. What might appeal to some women will not appeal to others. In this sense it may be better to highlight the broad and varied nature of ICT work to all potential 'recruits' (including women), whilst specifically appealing for the diverse skills and attributes women (perceive themselves or are perceived to) hold Moore et al., 2004). Resources need to promote diversity, encourage non-violent behaviours and appeal to

the needs, interests and aspirations of the broad range of students.
Equity in access. Inequities in the digital divide starts from the global level to the local level by country, by infrastructure, by ownership of technology, by gender etc. as shown in Figure 1. So technology is skewed towards the rich countries in all respects except for the gender divide. For example, voice over IP (VoIP) is a cheap option for telephony but not free/allowed in many countries. So the issue of skewness needs to be addressed by appropriate regulatory frameworks at international level and equity in all forms must be achieved for a quality ICT.

Figure 1. Inequities in the ICT Arena



Realising the potential: Opportunities of empowerment

Across the developing world, ICT is helping women and men improve their lives, take advantage of new opportunities and realise their full potential (as discussed in UNDP,). Let us now consider the concept of empowerment.

What is empowerment? Empowerment refers broadly to the challenging of social norms, a shift in power, or an increase in confidence to represent oneself more effectively in the social world. Women most commonly define it in terms of increased confidence. By dealing with challenging experiences, interacting with others and moving outside restrictive social norms, they discover in themselves the ability to do what they thought was beyond them, and to discover new possibilities.
Concept of empowerment . As documented in SNGI (2004) technological invention itself is no guarantee of empowerment. Unevenness in the diffusion of new ICTs is indeed

stark. Analysis of empowerment must be done based on the following questions: (i) In what ways can ICTs increase women's access to and control over resources? (ii) In what ways can ICT enhance women's agency? (iii) What can women achieve by using ICTs? The indicators for each of the above are mentioned below.

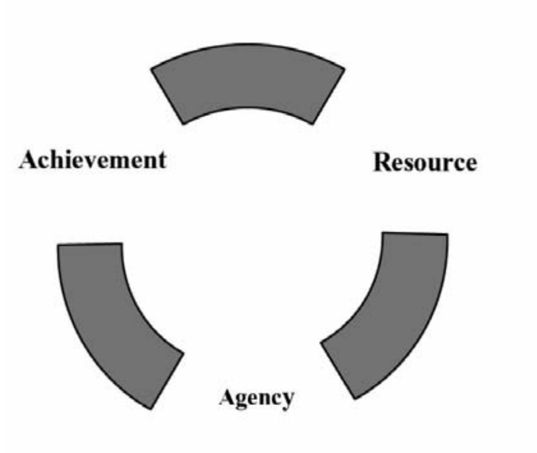
- ***Resource***

1. Material resource
2. Economic resource
   - o Income-generating opportunities, Micro finance
3. Human resource
   - o ICT skills
4. Social resource
   - o Information (human right, health, etc.)
   - o Communication

- ***Agency***
   - o Overcoming marginalisation, oppressive social norms.
   - o Offering women choices and opportunities
   - o Encouraging women to fulfil their potential being considered as knowledgeable people in their society, becoming more creative, as community leaders)
   - o Giving voice and capability to counter their seeming powerlessness (increase in bargaining power, enhancing of negotiating power)

- ***Achievement***
   - o Personal empowerment
   - o Employment in the ICT sector
   - o Solidarity among the women in society
   - o Increase in income
   - o Higher education
   - o Better health, etc.

Figure 2. Concept of Empowerment



For good impact, various methods must be developed to assess women's empowerment and the impact of ICTs for development based on the above factors.

Benefits of ICT

For instance, ICTs can benefit women by providing them with access to information and the global knowledge network. This section will shows unique and emerging cases of the way in which ICTs help to increase womens' empowerment

(i) ICTs and Health: Health educators have used radio to communicate information related to women's sexual and reproductive health, on the availability of vaccines etc.

(ii) E-education: ICTs offer many possibilities of non-formal and continuing education. Open distance learning can deliver education content to the doorstep, which for women with constraints on mobility and access to public place, can be a significant starting point (Gurumurthy, 2004).

(iii) E-commerce: ICT allows access to the global market for even a small business with minimum initial investment. ICT therefore provides a unique opportunity to promote the growth of women-run small businesses. In rural villages where no telecommunications services exist cellular phones can be provided to poor women to operate businesses.

(iv) ICTs and Agriculture: seventy percent of agricultural produce is handled by women in Africa. Combining Internet (websites) and radio (community radio stations) has the potential to reach wide audiences. By using the Internet and radio women farmers can obtain information in local languages on markets, agricultural inputs, food preservation and storage without travelling far, or being dependent on a middleman.

(v) ICTs and Social Factors: An online complaint system can be used that allow women to report human rights abuses, e.g. sexual harassment and domestic abuse directly to government officials.

Gender and ICT

Gender concerns in relation to new ICTs were beginning to be raised in the late 1990s. Gender issues in the ICT arena cover a broad spectrum.

Women's interest in ICT

In a 'women and technology project' Creamer et al., (2005) have developed a model that depicts the factors that have a direct effect on ICT interest and career choice by women. They concluded that unfamiliarity with the field, the failure to actively pursue information about a range of career options, and dependence on the opinions of parents are key reasons why women avoid ICT and, probably, other unfamiliar technical fields.

Factor 1: Parental support. This includes providing support for the importance of a career under the perception that parents have an idea of the appropriate career choice for their child and the encouragement given towards career exploration.

Factor 2: Positive attitudes about the attributes of IT/ICT workers - that ICT-related jobs are interesting, challenging, smart, and creative.

Factor 3: Amount and type of computer use. The sense of satisfaction in using computers to solve problems.

Participation of women in ICT: Obstacles

In developing countries (DCs) and least developed countries (LDCs) women, particularly poor women, often lack the necessary infrastructure, skills, literacy and knowledge of English to make the most of the opportunities opened up by ICTs. They are further marginalised in the information sector as a result of domestic responsibilities, cultural restrictions on mobility, low economic power and the lack of relevance of most of the content on the World Wide Web. So many of the obstacles women face in accessing and using ICT are entrenched in behavioural, cultural, and religious practices. Unless explicit measures are taken to address these divides, there is a risk that ICT will increase gender disparities and that the impact of ICT will not be maximised (WorldBank, 2000).

(i) Literacy: Women need basic literacy and numeracy to read and compose simple messages, navigate the Internet, and execute commands in most software applications. As most women are illiterate, this prevents them from taking advantage of ICTs.

(ii) Education: Inequitable allocation of education and training resources often favours males. High student-to-computer ratios and first-come-first-served policies do not favour girls who are heavily outnumbered by boys at all levels of education.

(iii) Seclusion: In some countries, women's seclusion from the public arena makes accessing community Internet centres difficult.

(iv) Language: The dominance of the English language on the Internet.

(v) Skills development: Unfamiliarity with ICTs together with a perceived lack of demonstrated benefit from ICTs in addressing local-level challenges are key barriers.

(vi) Time: Women frequently pointed to lack of time to participate in centres after attending to household work and daily labour to meet daily needs. Another key factor that limits time is the gendered 'burden' of cares, i.e. parent/carer.

(vii) Infrastructure: Rural women have the least access to infrastructure in DCs and LDCs. In many of these countries there is a lack of basic infrastructure, resulting in high costs of installing and running ICTs.

(viii) Cost/financial resources: Women are often financially dependent upon men or do not have control over household expenditures. This makes accessing ICT services more difficult.

(ix) Location: Even if computers may be physically available, as centres are mostly in urban areas this affects women's access.

(x) Mobility: Participation of the rural poor may involve enormous costs in time and transport. Women are often dealing with restrictions on their mobility.

(xi) Social/cultural norms: Cultural and social attitudes often discriminate against women's participation in the fields of science and technology and limit their opportunities in the area of ICT.

(xii) Caring responsibilities: Even women in IT jobs shift to part-time work as a result of having children to care for and in the worst-case scenario move to a different company, closely followed by no changes at all and then a move to a different role.

(xiii) Marginalisation: The poorest often fear that ICTs and ICT centres are not places for people like them. The ICTs are not global for most of the world's poor not simply because technology is not available to them but because with or without these technologies the poor are likely to remain marginalised from the benefits of society if they are excluded from the benefits of over all development.

(xiv) Relevance: For the poorest and most marginalised, the relevance of ICTs to their conditions is harder to demonstrate, and has to be demonstrated in terms of more direct practical outcomes.

Need for gender inclusion strategies in ICT policy

ICTs can serve as an organiser, equaliser and, perhaps most importantly, an institutional catalyst for social change and economic development (Hornick et al. 1987). Men and women have different needs and constraints to accessing and using ICTs. In addition to these is the issue of gender and women's equal right to access ICTs. Women continue to represent an inordinately large proportion of disadvantaged groups largely because of the absence of gender-sensitive policies and design rules, and are unable to harness new technologies to redefine their roles in the increasingly interconnected world community. Engendered ICT policy will have an impact on poverty alleviation and improve the future of women who are the centerpiece of society.

Poverty Alleviation

Poverty is not just being unable to meet one's daily needs, but also the inability to build and maintain life in the longer term. Poverty is frequently defined in terms of the development of the individual: it means restricted choice and opportunity, and the inability to develop one's talent, potential and aspirations. Women talk about the restrictions, i.e. lack of freedom and oppressive social structures like restrictions on mobility, education, work and social life, that both arise out of and reproduce poverty.

Situation of women in ICT globally

The number of women in ICT education and the ICT business has not increased, but is rather once again on the decline. The ICT profession is still dominated by 'young, single males'. Women are not equally paid for equal work in many industries and the computing industry is not an exception Creamer et al., (2005). While the number of women managers is increasing inWestern countries, the statistics that indicates only 21% of senior and 8% of top managers in the computer industry are women. Also it is necessary to remember that while the numbers of women in computing education are extremely low, according to Creamer et al., (2005) there are some 50,000 women with science, engineering and technology degrees in the UK alone, who are not using their qualifications. So bringing more women into education is not likely to remedy the situation in the IT industry.

The above statistics reveals that even women in developed countries like the UK have problems and hence will be very severe in developing nations. So special care should be taken when making policies meant to attract more women into IT-related jobs.

On the part of the World Bank, total funding for the IT component in projects is estimated to be more than $1.0 billion per year. However very little attention has been given to the needs of women in this sector, according to a review of World Bank ICT sectoral projects from a gender perspective. Women are underrepresented in the private sector and government bodies, which control the ICT arena, meaning they have relatively little ownership of the ICT sector.

Future of women in ICT

The ICT sector in many countries, including developing countries, is contributing to increased employment and economic opportunities for women. For instance, in the Kerala Technopark in India, women form nearly 40 % of the computing workforce. ICT allows access to a global market for even a small business with minimum initial investment. ICT, therefore, provides a unique opportunity to promote the growth of women-run small businesses.

National ICT policy

The ability to harness technology is political as it involves a shift in power relations and a redefinition of technology that reflects women's needs, interests and aspirations. The lack of focus on gender dynamics has given rise to the emergence of a gender divide in many developing countries seeking to transition into the information age.

DCs and LDCs must work on integrating gender perspectives into national ICT policies and strategies, providing content relevant to women, promoting women's economic participation in the information economy, capacity-building, and regulating violence against women and children connected to pornography on the Internet. A complex array of factors must be considered when designing and deploying new technologies in historically disadvantaged areas instead of viewing them as gender-neutral. Some of the factors that have to be considered are:

- Gender representation at all levels of policy and decision-making.
- Promoting gender-responsive e-governance.
- Creating an enabling environment where women can use ICTs to improve their lives should be the vision of the policy.
- Women's active participation in ICTs must be focused rather than passive consumerism in the emerging information societies.
- Developing effective and sustainable ICT programs/content that are contextually and culturally gender-relevant.
- Supporting research into gender dimensions in ICT-supported learning.
- Developing special ICT projects that focus on empowering resource poor women to use ICTs.
- Inclusion of various evaluation mechanisms for the impact of ICTs in gender-sensitive roles.

In short, the national ICT policy must improve women's access to ICTs that in turn can increase their ability to use information and knowledge transfers to recast their roles as knowledge consumers and producers, thus helping them to move away from the periphery of African societies.

Recomended projects

DCs and LDCs must focus on ICT development projects that build best practices and clinics for task managers and country teams to integrate ICTs into rural information provision, including support to women farmers and rural entrepreneurs. Promising solutions to the problem may be the community learning centres, telecentres, formation of information self-help groups etc., some of which are discussed below.

Community learning centres

Networked community computers in provinces promote community-building and learning through critical ICT use and content development in critical areas of concern; for example, Indira Soochna Shakti (ISS) in India (SNG1, 2004). The main purpose of the centres is to empower individuals and organisations for local development by providing public access—particularly for low-income populations—to the Internet and other ICTs. Training and skill-building opportunities in areas such as electrical and mechanical can be offered at the centres in order to attract large numbers of people from all walks of life. Most of the trainers at the community centres could be recent computer science graduates from nearby universities. To make the centres interesting the following factors must be considered (Fontaine, 2000).

1. Skill-building opportunities must be affordable.
2. Trainers should be friendly, competent, and enthusiastic about their work and their computers.
3. Training should present an opportunity and individualised attention and personalisation of experience.
4. Length of training classes must not be too long.

Telecentres

Telecentres are community-based centres with ICT equipment to deliver services. Female-led telecentres have become an important component of development programmes that seek to narrow the digital and knowledge divides that exist throughout the world. Despite the proliferation of telecentres in DCs, women continue to be cut off from essential info-communication resources that could improve their lives. So the relationship between gender differences, telecentre design and women's accessibility to ICTs must be analysed before implementation (Johnson, 2003).

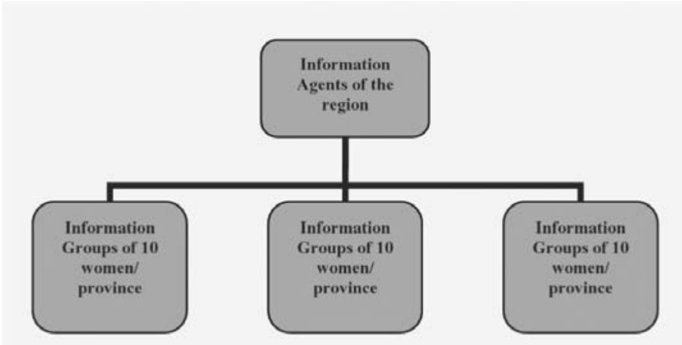
Capacity-building for women

Marginalised women must be provided with training to use ICTs to learn marketable skills and build their awareness of health issues, their rights and livelihood opportunities. They must receive training on computers and the Internet to use ICTs and obtain training on the English language and data entry operations to get lower-skilled IT jobs. Interactive multimedia content must be developed and used to support vocational and life-skills training and provide rights-based information on various areas to poor girls and women.

Women Self-help information groups

Self-help information groups can be formed in various provinces with at least 10 women with various backgrounds, from busy working women to students and mothers with part-time work. These groups/councils in every province can be given the mandate to monitor and follow up gender-related issues. Computers with connectivity can be put in the homes of women's self-help group members. These groups can meet and share experiences and create programme content, which can have a positive impact on their empowerment and the profile of their issues and concerns and promote gender equality and equity throughout the development process. They can as well serve as the information agents to Ministry of Gender and Family promotion. Figure 3 below shows the architecture of forming information agents.

Figure 3: Architecture of creating information agents for a community



IT education for girls

Science and technology education is necessary for women to work in IT at the levels of computer, engineers, systems analysts and designers. Women's low enrolment in science and technology impedes this opportunity globally. Methods and practices must be developed to guide girls' attention and interest to technology.

Suggestions

- Higher institutions of learning should introduce special measures that aim at ensuring that gender issues are mainstreamed into educational systems, in curricula, policy and all educational programmes so as to increase women's enrolment in the non-traditional fields of study, particularly science and technology. For example in KIST girls/women who do not satisfy the entry criteria are allowed to take some bridging courses in the sciences, mathematics and ICT. Once they pass the bridging courses with good grades they are admitted to the regular programme.
- Governments need to act by building gender perspectives into ICT policies through the involvement of gender and ICT experts. For example, women ICT experts must be involved in policy-making at national level so that the real problems faced by women in ICT usage can be addressed.
- Engendering ICTs is not merely about the greater use of ICTs by women, but about transforming the ICT system itself. For example, increase in ICT usage must aim at correcting the huge gender imbalances in all fields like agriculture, education, health, legal and judicial services etc.
- Free training camps on basic IT courses must be organised to create knowledge about ICT usage.
- LDCs must embrace new technologies, especially wireless and satellite solutions, so that more people at the margins of the world will have access to the international communications and knowledge network. For example,

as mobile technologies are becoming more affordable and ubiquitous throughout the developing world, it can be used to harness ICT.

- Governments must develop the strategy to include the poorest of the poor among women in the benefits of ICTs. For example in Rwanda the launching of the budgeting initiative and the gradual integration of gender issues into the national budgeting process is an integral strategy for the empowerment of poor women.
- A course on computer ethics and gender must be included in the tertiary education curriculum - computer ethics is now widely recognised as a field of philosophical, political and social enquiry in the use and construction of computing technology.

Case Study: KIST, Rwanda

The context: Rwanda the country. Rwanda is a small country in East-Central Africa, which is undergoing recovery from the shock of the 1994 genocide that claimed more than a million people in three months. Rwanda is home to a population of approximately 8 million people, with 94% of the population living in rural areas. Women constitute 52% of the population and labour force that is predominantly subsistence agriculture.

Gender imbalance in educational history. Education in Rwanda was also influenced by socio-cultural considerations that limit the education of women and girls. Girls' formal education came only later and mostly focused on basic courses preparing them for domestic management.

Table 1: Overall student enrolment by gender in Rwandan higher education for 37 years (1963-2000)

Institution	Sponsor	Fac/Sch	Students
NUR (1963)	Government	10	4,550 (F: 26%)
KIST(1998)	Government	5	1,200 (F: 28%)
ULK (Free University of Kigali)	Private	3	2,313 (F:49%)
UNILAK	Religious foundation	3	100 (F: 50%)
UAAC (Central African University)	Adventists	4	237 (F: 47%)
KHI (1997)	Government	7	445 (F: 46%)
ISAE (1989)	Government	4	365 (F: 17%)
ISFP (1986)	Government	2	98 (F: 46%)
Grand Seminaire (1936)	Rel. C.Ep.R	1	150 (F: 0%)
Fac de Théologie Protestant	Religion	2	107 (F: 0%)
KIE (1998)	Government	3	700 (F: 32%)
Institut Pédagogique de Gitwe	Government	2	-

This explains why the enrolment of women is low at all levels, and is worse particularly in higher education and specifically in the science and technology domains. Hence the low numbers of women in science and technology education and at managerial and decision-making levels. Initially, only boys were allowed to go school. Quantitative limitations and gender imbalances in Rwandan tertiary education are substantiated in Table 1 above. The total student population in all 12 institutions is barely 10,000, only one-fourth of whom are female.

Rwanda's Vision 2020

Vision 2020 – the national document – and the Integrated ICT-led Socio-Economic Development Policy and Plan for Rwanda 2001-2005, define the national socio-economic direction of Rwanda. It is important to stress that the construction of a knowledge based economy founded on the use of ICT and the application of science and technology is a principal objective of both policy papers.

National gender policy

The national gender policy aspires to engender national policies and programmes, including education to enable government, to achieve its Vision 2020 and poverty reduction strategy programme goals. In Rwanda, women have been generally kept in an inferior position, yet they constitute 52% of the population and participate more than men in subsistence agriculture. The National Gender Policy recognises the need for women to enjoy their human rights and to involve them fully in the development of the country.

KIST – promoting ICT education and gender equality

The Kigali Institute of Science, Technology and Management (KIST) is the first and the only public technological institute of higher learning in Rwanda. Its establishment was part of the Rwanda government's mission to build a strong human resource base that was worsened by genocide. The institute was established with the mandate to produce capable human resource through vocational, scientific, technological and management training. The institute is committed to promoting Vision 2020 and to supporting Rwanda's reconstruction and development through the provision of practical, relevant and results-oriented education that serves national and community needs.

(i) KIST equality and diversity policy: The policy aims at ensuring that in all its functions, processes, and activities, KIST does not discriminate on grounds of gender, marital status, age, disability, ethnicity, religion, or socio-economic background.

(ii) KIST ICT policy: The policy develops good practices for the use of computers, network infrastructure and information systems. The objectives are:

(a) To nsure reliable and efficient connectivity to all students and staff

(b) To build capacity all academic staff in Web-based content development

(c) To treat information as a strategic resource

(d) To ensure electronic access to information and services while maintaining privacy.

(iii) Promotion of women enrolment in Science and Technology: The KIST strategic plan has set as a target increasing women's enrolment to at least 45% by the year 2008. KIST has intervened in increasing women's enrolment in science and technology by giving priority consideration to women in cases where both women and men have the same admission cut-off points. Currently, women's enrolment is 38%, although the majority are still enrolling in management courses. More affirmative action is therefore required.

(iv) Poverty reduction academic programmes: KIST operates a number of service and training centres and demonstration units, all of which support the equality and diversity policy and enhance core programmes.

(a) Centre for Innovations and Technology Transfer (CITT)

An invaluable dimension of the KIST programme is the prominence of applied research leading to environmentally friendly appropriate technology innovations and subsequent transfer to the marketplace, particularly among the peri-urban and rural communities.

- The Department of Women in Technology and Community Development (WTCD) has three key functions:

1. Identification of communities' technology and training needs
2. Identification of and collaboration with intermediary agencies
3. Analysing gender barriers and mainstreaming gender into technology-transfer activities

- The Department of Technology, Research and Development (R&D)
- The Department of Entrepreneurship

The result is a better understanding of community needs and technologies that have better chances to succeed and be sustained by the communities themselves, for improved rural livelihoods and poverty alleviation.

(b) ***Information and Communication Technology (ICT) Service Centre***

In collaboration with the Department for International Development (DFID) UK, KIST has established an ICT centre which provides intensive practical ICT training programmes to students of Computer Engineering and Information Technology as well as offering computing services and consultancies in web-page design, hosting, networking and development of software packages. Through collaboration with the World Bank, KIST has been selected to host the Regional ICT Training and Research Centre under the umbrella of the Development Gateway Foundation. Beside the general IT programmes that will be offered, to which everyone in the region will be eligible, the centre will also conduct short-term IT professional programmes for policy-makers, advocacy groups and IT managers in the region.

Through a strategic partnership, KIST has been officially registered as a Training and Testing Centre for International Computer Driving Licences (ICDL). In addition, KIST has also established a collaborative partnership with the British National Computer Centre to offer a one-year International Advanced Diploma in Computer Studies.

With the support of SIDA, through the Rwanda Information Technology Authority (RITA), and in collaboration with the Institute of Advanced Technology (IAT) in Nairobi, KIST has been selected to offer one-year ICT training services for technical staff in various ministries.

Through partnership with Glasgow Caledonian University (Scotland), KIST brings in specialists from the former to evaluate the ICT technicians' training programmes and advise on improvements where necessary.

This is intended to ensure that KIST maintains the highest quality of training. KIST has also introduced CISCO Network Academy and Microsoft certification programmes on campus for both regular students and private sector people.

(c) Centre for Continuing Education

The evening programmes at the Centre for Continuing Education have not only boosted the academic output of KIST tremendously but also availed access to women, the majority of whom, because of the nature of their socio-cultural responsibilities, could not afford to enrol in full-time programmes. Table 2 shows increased women enrolment in part-time courses.

Table 2: Growth in part-time students enrolment KIST Graduates.

Year of Study	2000/2001			2001/2002			2002/2003		
	M	**F**	**Total**	**M**	**F**	**Total**	**M**	**F**	**Total**
I	52	59	111	90	207	297	65	136	201
II	33	30	63	62	65	127	91	204	295
III	30	13	43	125	85	210	68	73	141
IV				25	12	37	83	113	196
TOTAL	**115**	**102**	**217**	**302**	**369**	**671**	**307**	**526**	**833**

KIST's curriculum is different from the conventional approach that is dominated by abstract analysis and theory. This is so because its short-term courses and degree programmes have been designed to respond to specific national development needs while meeting international standards as follows:

KIST graduates acquire a blend of theory and practical, hands-on experience intended to give them skills that are directly applicable and attractive to prospective employers.

The Community and Industrial attachment programmes provide an opportunity for students to identify and address development needs. For example, projects in agriculture, water supply, fuel- and energy-saving technologies, sanitation and hygiene, low-cost housing, and feeder-road construction help to bridge the gap between the rural community, the public/private sector and academia.

KIST offers a compulsory course in entrepreneurship which ensures that its graduates have the necessary skills and knowledge to enable them to start small - and medium-scale businesses upon graduation, with an institutional vision of training job creators rather than job-seekers.

Following the decision taken by the Rwanda government to retrench staff without proper qualifications to pave way for upgrading their skills, there were many vacancies sprouting up. Most of these positions were filled by qualified KIST graduates. They act as role moles in the dissemination of knowledge and propagation of skills throughout Rwandan society.

Conclusion

KIST's efforts towards academic excellence by combining education with the actual development of Rwanda through serving community needs, poverty reduction strategies, and enhancing the national gender policy hardly comply with the institution's short history.

Yet there is a lot to be accomplished by KIST. Its strategic plan for 2003-2008 is the target for achieving the institute's mandate. Equal access to ICT and the skills related to it have been given the status of a universal right in information society strategies. The forces of globalisation have made this one world and one economy and we all must join in to sustain it. There is no longer a choice. Engendered ICT policy is important at every level-international, national and programme so that more women are encouraged to enter the ICT sector in the longterm.

As a first step, in Rwanda critical achievements have been registered from the grassroots level to the cabinet. Rwandan women overwhelmingly and effectively participated in the 2003 general elections and they constitute 48.8% of members of parliament. This shows the government's high commitment to gender equity and women's advancement so that in the future Rwandan men and women are equal actors and beneficiaries in all fields, including ICT.

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PART SEVEN

Software Architecture and Web-based Systems

16

Affordable E-governance Using Free and Open Source Software

Rehema Baguma

In this chapter, we see how e-governmence increases the convenience and accessibility of government services and information to citizens (Carter and Bélanger, 2005). Despite the benefits of e-government – increased government accountability to citizens, greater public access to information and a more efficient, cost-effective government – implementation is not yet wide enough. High costs of deployment and management is one of the major factors in most parts of the world, especially the less developed nations of the south. This paper explores the applications and benefits of open source software/free software (OSS/FS) as an alternative to developing and deploying cost effective and sustainable e-governance solutions. It includes a brief on the origin of OSS/FS and a background on e-governance, and looks at what makes a software OSS/FS and its sustainability culture. The paper then presents an evaluation of how to use OSS/FS for e-governance: tools for an OSS/FS-based e-governance, attractions of using OSS/FS for e-governance and case studies of OSS/FS implementation for e-governance. The paper also provides an analysis of why, despite the enormous benefits, OSS/FS is still struggling to outcompete proprietary software in e-governance and application of other e-applications and proposes possible solutions to the inhibitions.

Introduction

Definitions: Backus, (2001) defines e-governance as the use by government agencies of information technologies (such as wide area networks, the Internet, and mobile computing) that have the ability to transform relations with citizens, businesses, and some arms of government.

Open source/free software (OSS/FS) is the software where users have the freedom to run, copy, distribute, study, modify and improve the software, and the source code is freely available.

Background

The concept of free software is as old as computers, just as sharing of cooking recipes is as old as cooking. It dates to the back 1960s when computers were first used as research tools in universities. At that time, software was freely passed around between programmers in different labs. Programmers were paid for the act of programming, not for the programmes they created.[1]

Later, however, when computers reached the business world, programmers began to support themselves by restricting the rights to their software and charging fees for each copy.

Free software as a political idea and as a movement came into force with the founding by Richard Stallman of the Free Software Foundation and its GNU/Linux Project in 1984. The name GNU was chosen following a hacker tradition, as a recursive acronym for "GNU's Not Unix"[2]. It is the GNU/Linux project that produced the Linux operating system.

What Makes Software OSS/FS?

Bruggink (2003) describes open source/free software (OSS/FS) as the software which may be copied and used freely. Open source/free software is often available free of charge on the Internet so it can be acquired only at the cost of downloading it or obtained on CDs at packaging cost. The most popular open source software is the GNU/Linux operating system.

Unlike proprietary software, OSS/FS can be copied, used, studied, modified, distributed with few or no copyright restrictions.[2.]

Bruggink reasons that, like the generic drugs that have transformed health care in the South, open source software is loyalty-and licence-free and is therefore substantially cheaper to acquire than branded alternatives. This has been possible because OSS/FS is developed by a group of volunteers not seeking to profit from its sale.

Just as the recipe for generic drugs is made public, the source code or inner workings of open source software is accessible to the user where any qualified person can see exactly how the software works and can easily make changes to its functionality.

More precisely, users of free and open source software have four kinds of freedom:

- The freedom to run the program, for any purpose.
- The freedom to study how the program works, and adapt it to their needs. Access to the source code is a precondition for this, hence the open source concept.
- The freedom to redistribute copies so they can help their neighbour.
- The freedom to improve the program, and release their improvements to the public, so that the whole community benefits.[3]

Gnu.org, the official home of the free and open source software movement, upholds that:

"Free software" is a matter of liberty, not price. To understand the concept, you should think of ``free" as in "free speech',' not as in "free beer'.' This is in relation to the associated freedoms to free software.[4]

To date, open source is particularly popular in back-office applications such as mail and web servers but open source content management systems, email clients and desktop usage are also gaining momentum. Some open source products like the Linux operating system, php and apache web server are global market leaders in the Internet/web industry. Linux is very popular with Internet service providers and major companies like IBM; Sun and Oracle have adopted the open source model. Educational institutions are also key users of open source software in student computer labs owing to its reliability, low cost of acquisition and maintenance and the market potential for computing students. The Uganda Martyrs University to date has all its labs running OSS/FS and Makerere University is in the process of migrating some of its labs too.

This is clear testimony that open source software can and does compete with proprietary software.

How is OSS/FS Culture Sustained?

To preserve the OSS/FS culture, promoters of OSS/FS under the umbrella organisations, the Free Software Foundation (FSF) and Open Source Initiative (OSI), came up with the concept of copyleft.[5]

Copyleft is a general method for making program-free software and requiring all modified and extended versions of the program to be free software as well. Instead of just putting software in the public domain, free software activists "copyleft" it. Copyleft says that anyone who redistributes the software with or without changes must pass along the freedom to further copy and change it. Copyleft guarantees that every user has freedom.

Copyleft also provides an incentive for other programmers to add to free software. Important free programs such as GNU/ C++ compiler and Emac editor exist only because of this.

In addition, programmers who may want to contribute their changes to the community get permission in case the employer would prefer to turn the changes into a proprietary software product.

E-governance?

Traditionally, the interaction between a citizen or business and a government agency took place in a government office. With emerging information and communication technologies (ICTs), it is possible to locate service centres closer to the clients. Such centres may consist of an unattended information kiosk in the government agency, a service kiosk located close to the client, or the use of a personal computer in the home or office to access online government systems.

Analogous to e-commerce, which allows businesses to transact with each other more efficiently (B2B) and brings customers closer to businesses (B2C), e-government aims to make the interaction between government and citizens (G2C), government and business enterprises (G2B), and inter-agency relationships (G2G) more friendly, convenient, transparent, and inexpensive.

Implementation of e-governance can bring about:

- better delivery of government services to citizens,
- improved interactions with business and industry,
- citizen empowerment through access to information,
- more efficient government management.

The resulting benefits can be: increased efficiency and effectiveness, less corruption, increased transparency, greater convenience, revenue growth, and/or cost reductions for both citizens and the government itself.

According to Dr Maggie Kigozi, the Executive Director of Uganda Investment Authority, expenditure on local government affairs can be reduced by 10% if e-governance is promoted in all the 58 districts of Uganda. She defined e-governance as the computerised administration of government affairs between various administrative levels. Currently, there are only four districts in Uganda that have access to e-governance: Kayunga, Mbarara, Mbale and Lira. Speaking at a workshop themed 'Enabling E-governance in Uganda, in April 2005 in Kampala, Dr Kigozi said that e-governance is the most effective way of reducing costs in running public affairs from the lower levels of government to the central government. She asked the government to speed up the process of e-governance in every district and called on district leaders to embrace the system to cut costs and time.[6]

(Heeks (2001) Carter and Bélanger 2005) highlight application domains for e-governance since the advent of networking technologies as:

- e-administration through networked management information systems on the web, LAN or WAN.
- e-citizen for online government-to-citizen consultation, service delivery and accountability.
- e-services like improving delivery of employment information to citizens, improved legislative services like e-parliament, e-voting, e-visas etc.
- e-society for a linked community of service agencies and the society.

Using Oss/fs for E-governance

Governments and individual government bodies can choose to use OSS/FS based on the needs, capacities and the external environment. As with any technological choice, IT decision-makers should consider advantages and risks in order to make a well-founded decision.

Can one run a whole government unit's IT systems on open source? The table 5 ummarises what is available.

Table 15.1. Examples of OSS/FS tools and their purpose

Software category	OSS/SF	For what?
Operating system	Linux	Desktop & server operating system
Office productivity	Open office	Word processing, spreadsheets and presentations
Web development	PHP, Apache web server, page tool	Web development, hosting and content management
Internet access	Mozilla	Web browsing
Email	Kmail, Send mail, Pine	For email service
Image processing	GIMP	Image processing

Audio/visual player	Helix,ogg Vorbis	Audio/visual players
Database management systems	Mysql	Database development and management
Anti-virus	Clam, ClamWin	Virus, worms and trojans detection and cleaning

The open source operating system (Linux) is shipped with most of the office productivity tools like email client, word processor, spreadsheet processor, presentation processor, web browser, image editors, audio players and instant messengers. In addition, it supports a range of remote free access tools like SSH (secure shell) and VNC (a remote desktop application) and Virtual Network Computing, whose equivalents have to be bought separately with proprietary software.

Why Use OSS/FS for E-governance

The two main attractions are low initial cost and flexibility.

Low initial cost: OSS/FS can be obtained free of charge or at a far cheaper cost, where a manufacturer charges for the packaging/distribution. One pays for the physical CD, with or without an additional small cost of packing additional tools. When it is downloaded from the Internet, the cost incurred is for connectivity. Apart from that no loyalty or licence fees apply and one copy is enough for unlimited installations and distribution. The options are using Linux at UGS 2,000/= equivalent to USD 1.2 (cost of CD) or buying Microsoft Windows XP at UGS 100, 000, equivalent to USD 59. Linux saves UGS 98,000 (USD 58) and one copy is enough for multiple installations. An office desktop computer will need 3 other products minimum at the same price or higher, coming to 100,000 x 4 = UGS 400,000/= on software only, whereas for OSS/FS, these products come bundled with the operating system, and if not can be obtained free of charge. Then comes expensive hardware for the latest high specifications at UGS 2,000,000 (USD 1,176) per PC. OSS/FS can efficiently run on older hardware (Pentium II/III, 32/64MB RAM, 5GB HDD), most of which are available refurbished at approximately USD 150 or less. This makes OSS/FS a far more cost-saving option as opposed to proprietary solutions.

Ahmed (2004) asserts that using Linux for e-governance benefits both government operations and the citizens by:

- lowering the cost of operations.
- providing scalability for future growth.
- following open standards for interoperability with other applications.
- providing a robust and stable system to support ongoing government operations, a vital requirement for reliable e-governance systems.
- Ssimplifying system maintenance and management.

Flexibility and security: Since the source code is accessible and based on public standards, technically inclined users can see how the software works and modify it to suit their needs as long as they continue to comply with the open source definition. In Uganda, a Luganda web browser called "Kayungirizi" translated from the open source Mozilla browser was released in Sept. 2004 by Luganda ICT Translations. Efforts are under way to get it into other languages, such as Runyakitara and Swahili. An Open Office Swahili version called *jambo* has been developed too for use across E.Africa including Rwanda, Burundi and DRC. South Africa also already has a Zulu version of Open Office. With the unique challenges in the South such as very low literacy levels and agrarian-based economies, OSS/FS is a huge opportunity for local customisations and tailoring of software beyond language to widen ICT usage and relevance, a preliquisite for effective e-governance.

The major business value provided by Linux to governments is freedom from outside influence by a foreign corporation like Microsoft. Linux provides governments with the freedom to change vendors as needed, and the freedom to audit the code for spyware and support for open data formats that are accessible to lower-income citizens who cannot afford the expense of proprietary software. Protection against spyware is vital in security conscious government departments (Ahmed 2004).

Ahmed (2004) notes that in the increasingly security-conscious world of post-9/11, Linux provides improved IT security and greater interoperability via open standards in an ever more integrated global society. OpenSSH, an open source tool, provides a secure method for system administrators to instantly access and manage the Linux servers located in remote local government offices.

Other OSS/FS benefits to e-governance include: The global open source community provides opportunities for South-North and South-South collaboration and knowledge-sharing, meaning that there is always someone out there sharing or ready to share experiences with bug-fixing, troubleshooting network problems and developing updates, which means a reliable functional environment for e-government systems managed by even not so technically competent staff.

OSS/FS works well with older computers compared to proprietary software where upon the release of a new type of software, e.g. operating systems, means more processing power, RAM, and storage space than the previous version. Specifications sufficient for Windows 95 need to be doubled for an efficient windows XP installation. This means continuous costly hardware upgrades for e-governance systems set up on proprietary software.

To make matters worse, commercial software developers normally reduce or stop completely providing support for older product versions once a new product is made, an indirect way of forcing the users to migrate. The Low Income Networking and Communications (LNC) Project (2003) of the Welfare Law Centre considered using GNU/Linux, a free operating system that works well with older computers for themselves and the communities supported, when they learnt of Microsoft's decision to discontinue their support for older operating systems, including Windows 95.

Free software is also more stable and reliable with fewer bugs and is less crash-prone because the source code is exposed to the critiques and modifications of a large number of developers around the world. Problems found are often repaired quickly, unlike proprietary software development, which is done through closed projects. The more reliable and stable an OS is, the fewer problems, less need for support and, hence less cost on technical support and maintenance and more productivity. Grass Roots Organising, a Missouri CBO supported by the LNC (2003) Project, before moving to OSS/FS suffered frequent crashes and a prevalence of viruses and application hang-ups associated with Microsoft Windows even with the latest security patches and upgrades. It is this stability and reliability that has made ISPs stick to OSS/FS.

Case Studies of OSS/FS for E-governance

In recent years, national and local governments, including those of UK and South Africa, have recognised opportunities which open source can offer as a way of saving money and a stimulus to autonomous domestic ICT sectors and the development of a local ICT skills base. Key strategies in support of open source have included government procurement policies that favour open source software for government services such as schools, hospitals, public works etc.

Heeks (2003) gives the following case studies of e-governance implementations in Africa:

South Africa: In South Africa, the government approved the proposal that when proprietary and open source are equal, open source will be given preference owing to the improved returns on investment associated with the elimination of licensing and the endless maintenance agreements that lock government into expensive long-term contracts.

Nigeria: In Nigeria, an SMS Helpdesk Application (SMS blackbox) developed with open source is in use to provide helpdesk functionality to citizens in Lagos.

Ahmed (2004) documents that in India, Delixus, Inc., a private IT company, implemented, the Delixus e-Governance Platform 2004 edition in 2004 that leverages the strengths of Linux to provide improved services to widows, pensioners and poor farmers in the Indian state of Karnataka. The Delixus e-Governance Platform addresses the needs of millions of rural poor citizens in India who receive widow or pension cheques through services provided by local government offices.

Ahmed says that the reasons why Linux was selected as the technology of choice for the Delixus e-Governance Platform include:

- It best satisfied technical and legal requirements.
- More specifically, Linux servers provided an optimal level of security and cost effectiveness, as well as supported the local language requirements.
- The support for open standards enabled Linux to serve an interoperable e-governance application that is accessible from Linux, Windows and other desktop operating systems.
- It provides a great benefits to the government operations and to citizens (widows, pensioners and farmers).

Other case studies include:

Venezuela adopted an official policy in 2002 for the use of OSS/FS in their government based on the principle: "Open Source whenever possible, proprietary software only when necessary". This arose from the concern that 75% of the funds for software licences went to foreign nations, 20%to foreign support agencies and only 5% to Venezuelans.

The German government uses the GNU/Linux operating system to run application software for the German parliament.

France's culture, defence and education ministries and the British police and intelligence agencies also use GNU/Linux.

The Finnish Ministry of Finance has estimated that annual savings of 26 million euros could be made by using Linux in state agencies. This has propelled Finish MPs to sign a bill requiring national and local agencies to migrate their IT systems to the GNU/Linux operating system.

The Chinese government has consistently promoted its local software based on GNU/Linux, both for cost reasons and reportedly for security concerns as well.[7]

WHY DO WE STILL HEAR MORE OF COMMERCIAL SOFTWARE THAN OSS/FS?

Despite the various benefits, OSS/FS is still facing some challenges related to attaining wider acceptance and usage compared to commercial software. This is due to a number of reasons: social, political, economic and philosophical.

Bruggink, (2003) notes that a research study carried out in 2003 in Uganda, Tanzania and Burkina Faso identified a number of systematic obstacles to the widespread adoption of open source in African organisations, which included:

- Limited availability. There are few resellers of OSS/FS. Although it's available on the Internet, unreliable connections and the high cost of the Internet in developing countries makes it difficult and expensive to download software from the Internet.
- Lack of technical expertise by certified support personnel. Few certification programmes exist for computer and network support professionals specialising in open source software. Most ICT training programmes are preparing students to work with the most commonly used proprietary software packages such as Microsoft.
- Information on migrating from proprietary to open source systems is hard to find, and there is need for decision-making tools specifically geared to the needs of African organisations.
- In Burkina Faso, it was noted that large hierarchical organisations are more hesitant to use open source software owing to risk the prevalence of a averse organisational culture.
- Finally, researches found that there is a widespread perception that the Linux operating system is the only real open source application and that this type of software is less user -riendly than proprietary alternatives.

Other obstacles include:

Making a large-scale switch from one type of software to another can be costly and complex for the organisation, especially if there is lack of experience, support and information.

- Some proprietary software is not compatible with open source. Sharing files with outside organisations can be more difficult for the individual user. The development community is addressing this progressively; Linux (Suse 9.3) has addressed the compatibility problem between Open Office and MS Office.
- Bias about OSS/FS as hard to set up and later work with, Grass Root Organising, a USA CBO supported by the Low Income Networking and Communications Project (LNC, 2003); sharing their experience when they switched to OSS/FS, they say, they found this to be a far cry from reality. What it means is just a different way of working, not harder, not more technical, just different. "The challenge wasn't in the actual work but it was in getting over our habits."

On a good note, the OSS/FS development community is not sleeping; there are constant developments to make OSS/FS as user-friendly as possible. Recent versions of many OSS/FS tools have GUI interfaces, e.g. Debian and Suse's (Linux Flavours) KDE and GNOME environments, the Mysql database management system and Apache web server are other OSS/FS tools that have been made easier to use with the in-building of GUIs.

Way Forward for Oss/Fs Use for E-governance

There is need to provide strategic and technical information geared to the needs of IT decision-makers about OSS/FS in relation to the following:

- Supporting decision-makers with decision models, toolkits and case studies relating to choice of technology and system migration in different contexts.
- Getting the message across that Linux and open source software in general are increasingly user-friendly and easy to install.
- IT training institutions should also incorporate in the curriculum OSS/FS training to increase the support skill base for OSS/FS.

Conclusion

OSS/FS has great potential for low-cost, flexible and reliable e-governance implementation but to exploit its potential fully, there is need for stakeholder collaboration and augmentation of one another: namely governments should work with the OSS/FS community, educational institutions and other goodwill promoters to groom local expertise and set up local focal points for distribution of the software, user awareness and sensitisation for a wider adoption and appreciation of OSS/FS.

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Automatic Construction of a Kiswahili Corpus from the World Wide Web

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A corpus is a large collection of language data either in written form or spoken form or both. It can be used to construct a language model that is used in many language technology applications. Some of these include speech to text, optical character recognition, machine translation and spell checking. The easiest way to create a text corpus is by putting together electronic text documents. For most languages, getting a huge collection of electronic texts is a time-consuming and challenging task. The monotonous nature of such a task will inevitably lead to much less attention being paid to the errors that might find their way into the text collection. This paper describes the working of an application that was used to build a Kiswahili corpus from the Internet to be used in natural language processing applications.

Introduction: Statistical Natural Language Processing

Statistical natural language processing methods are popular because one does not have to spend a long time learning and discovering all the rules of a language. Considering that natural language is so dynamic it is almost impossible to come up with exhaustive rules.

To use statistical language processing, there is need for data from which statistical information can be derived. This data is usually provided in the form of corpora.

Text corpus

A text corpus is a large collection of language data in written form. An electronic text corpus is a text corpus in a computer-readable format. It can be used to obtain statistical information about the language. The statistical information can range from word counts to the more sophisticated N-gram models.

In many natural language processing applications, a text corpus for a specific language usually comes in handy for the construction of a language model for that language. Some of the language models that can be constructed for a specific language are N-gram models. These include unigrams, bigrams, trigrams etc.

N-gram models are used in many applications, including speech to text, spelling correction and optical character recognition.

A labelled text corpus can also be used as training data for machine learning-based POS applications.

Other uses include dictionary creation and machine translation using parallel texts.

Corpus construction

Constructing a corpus is a challenging task, particularly when the electronic documents to be included in the corpus are not readily available. Traditional methods of correcting electronic texts include typing in the specific texts and scanning the texts. These methods are time-intensive and accuracy is not guaranteed. It is therefore necessary to get alternative methods for construction of a text corpus.

One of the alternative methods currently being used is to construct corpora from the Web (Rosie Jones and Rayid Ghani, 2000). The web currently contains several billion of pages. By February 2004, Google announced that they had a database of 4.28 billion web pages. If these documents could be accessed and converted into the appropriate format, then they could be used for the construction of an electronic corpus.

Several papers have been written on how to go about constructing a corpus from the web. These include automatically building a corpus for a minority language from the Web (Jones and Ghani, 2000) and improving the quality of a web corpus (Youchi Sekiguchi and Kazuhinde Yamamoto, 2004).

Nevertheless, each language presents its own unique challenges. In this paper, we describe the process we went through to develop an application that can be used for the automatic construction of a text corpus and a language model for Kiswahili. Though this application was developed and tested for the Kiswahili language, it can be used for any other language with minimal modification.

Steps for Creating a Web Corpus

Overview

- o We create initial language models, i.e. Kiswahili unigram and bigram counts, and a list of words for other languages
- o We will use these models to determine if a document is in Kiswahili or another language
- o Unigrams refer to a simple words while bigrams refer to pairs of words
- o We will also use the initial Kiswahili model to construct search queries

1. Creating the initial Models

It is necessary to use the initial models to determine which language a document is in. The initial Kiswahili unigram and bigram model is created by providing a document that is in "good Kiswahili". "Good Kiswahili" here refers to the absence of foreign words rather than grammatical correctness. While subsequent documents are downloaded and classified automatically, the initial document is downloaded and classified manually and used to create the initial model (unigram and bigram lists). Documents in other common languages are downloaded and used to create the other languages' unigram model (word list). In our case, we used four documents that were in English, French, Spanish and German. These are the languages that intersected most with Kiswahili particularly in sites that are used to give Kiswahili lessons.

NB: These initial documents are also known as seed documents.

2. Getting Kiswahili documents links

The next step is to get the links of the documents to be used in the construction of the corpus from the Web. There are several ways of getting these links. One method is through the use of a search engine and the second is by using a Web crawler. When using a search engine, you provide a search query such that the search engine will return links for documents of the type required (that is documents in the preferred language). This is the method adopted in our application. In the Web-crawler approach, the application is given an initial page, it then gets the links on the page and uses them to download more pages and get more links. This process is repeated until it has enough links.

In the first method the search engine will return a set of pages each with links to documents found in the search. We need to retrieve and save these links from the search-result pages.

The search query is created automatically using the bigram in the Kiswahili bigram model with the highest frequency. This bigram is then marked so that it is not used again. Subsequent searches used the bigram with the highest frequency that had not been used previously.

3. Downloading and processing the files

After we have extracted the links, the next step is downloading the documents and processing them to the correct format for inclusion in the text corpus. The documents that are downloaded are .htm, .html and .txt files which are easier to process. In addition, they are the most numerous for the Kiswahili language (hence few documents are left out).

The objective of the processing is to obtain sentences that are in an acceptable format for inclusion in the corpus.

Since this process is automated, this cannot be perfectly accomplished, but the steps outlined significantly improve the quality of the text.

There are several processing steps that need to be carried out on a downloaded file to convert it to a proper format for inclusion in the corpus. Some of the processing steps carried out include:

Identification of sentences: This is done using <p></p> tags, full stops, exclamation marks, and question marks.

Removal of special tags and the text in between: These include <style> <script> <xml> <a> and <title> tags. These will most likely contain ungrammatical sentences.

Removal of all html tags

Removal of sentences with numbers in the middle: The best technique would be to turn the numbers to text but we did not do this due to time constraints.

Removal of brackets [], (), {}, and text in between: This is because they tend to interfere with the grammatical correctness of a sentence.

Removal of sentences that are less than five words long: These type of sentences tend to be grammatically wrong.

Creating the Text Corpus and the Models

After a file is processed, it can then be added to the corpus and also used to augment one of the language models. Two models are created. One model is for the target language (Kiswahili) and the other model for the other languages. (Jones et al, 2000). Initially, the Kiswahili model consists of both a unigram frequently count and a bigram. The unigram model is created by getting each unique word in the file and adding it to a table in a database if it is not already there. The number of times the word appears in the text is also counted and added to its current count in the unigram's table. The bigram table consist of each two words that appear following each other in sentences in the text, i.e. word1 word2 and how many times they appear in that order in the texts considered so far (count). To be able to count how many times a word appears at the beginning of a sentence a unique word form is introduced at the beginning of each sentence. The bigram count of this word and other words indicates how many times the other word is used to start a sentence. These entries are used to calculate the unigram and bigram probabilities after the corpus construction process is complete.

The other model is the unigram model for words in other languages. This model is necessary because not all the documents downloaded will be in Kiswahili. This model is used in conjunction with the Kiswahili model to determine which language the document belongs to. In our case, we defined upper limit and lower limit constants. If the number of words in the document that are also in the Kiswahili unigram model exceeds the upper limit and, in addition, the number of words that are in the document and in the other model is less than the lower limit the document is in Kiswahili and can be added to the Kiswahili corpus. If the number of words in the document that are also in the other languages unigram model exceeds the upper limit and in addition the number of words that are in the document and in the Kiswahili unigram model is less than lower limit, the document is in other languages and can be added to the other languages corpus. Otherwise the document is deemed ambiguous and discarded. The setting of the upper limit and the lower limit constants is vital as it ensures that documents in other languages, e.g. English, do not do not find their way into the Kiswahili corpus. Their values can be adjusted until a desirable result is obtained. This also ensures that Kiswahili documents do not find their way into the other languagesmodel. If this happens, the application will discard most documents as it will not be able to tell which model it fits into. They also take care of the fact that there are many bilingual documents on the Web. These need to be discarded to avoid having a Kiswahili corpus replete with many words from other languages. These techniques are borrowed and adapted from *Learning a Monolingual Language Model from a Multilingual Text Database* (Jones et al., 2000).

Summary of the Web-Corpus Construction Process

1. Create the initial models

Repeat

2. Create a search query using the bigram with the highest count (frequency) in the Kiswahili language model

3. Make a get call to the search engine
4. Process the results of the search engine to get the links
5. Save the links

   /*Note that only .html, .htm and .txt files are saved*/

For each link

6. Download the file referred to by the link url.

   If the get is not successful continue to the next link.
7. Process the downloaded file so that you are left with only acceptable sentences.
8. Determine the language of the document.
9. If the document is in Kiswahili, add the document to the Kiswahili corpus and use it to augment the Kiswahili unigram and bigram count models.
10. If the document is in the other language(s) model, update the other language(s) word list.
11. If the document is ambiguous, discard it.

End For

Until termination condition

Application Architecture

The application consists of five main components. These are:

i. Graphical user interface

ii. HTTP module

iii. PHP scripts

iv. Web server

v. Database

The role of the various components is described below.

The database

The database is used to store the data needed and used in the application. This includes the urls of the documents to be downloaded, the Kiswahili unigrams (word list) and bigrams (pairs of words) and the other languages unigrams (word lists).

Web server

The web server is used to run the PHP scripts. Local documents are also accessed through the Web server.

HTTP module

This consists of an interface to enable us to issue get requests much in the same way as we do using a Web browser. It provides an interface to which we give a url, it downloads the document referred to in the url and stores it locally or returns a failure message if the get command is not successful. The java programming language provides such an interface using the http url connection and url classes in the java.net package.

To run the PHP scripts we will also have to make get requests to the Web server.

Graphical user interface

The graphical user interface provides a front from which commands can be executed. The commands that can be run from the interface include: entering and saving the initial models urls, creating the initial Kiswahili model, creating other languages initial model, creating the corpus.

i) Entering and saving the initial models urls

As discussed in the section on steps for creating a Web corpus (the sub-section on creating the initial models), we need to provide documents to be used to create initial models. These can be provided in the form of urls where the documents are contained. If they are available in the local machine, then they can be served by the local Web server. The application provides an interface where these urls can be entered and saved. In entering a url one has to specify the initial model it will be used to create, i.e. either Kiswahili or other languages.

ii) Creating the Kiswahili initial model

Before this command is run, the urls for creating initial models ought to have been saved in the urls table in the database. Each of the urls designated for creating the initial Kiswahili model is obtained, and a get request is issued using the http interface to download the file which is saved locally. A script to process a downloaded file as described in the section on steps for creating a Web-corpus (the sub-section on downloading and processing the files) is then called using the http interface. If this script completes successfully the processed file is saved. Another script to create the initial Kiswahili model is called using the http interface. This script picks the unique words in the processed file and adds them to the unigrams table together with their counts. If a word already exists in the unigrams table, its count in the processed file is used to update its count in the unigrams table by adding the value of the count in the processed file. The script also picks the unique bigrams (pairs of words) in the processed file and adds them to the bigrams table together with their counts. If a bigram already exists in the unigrams table, its count in the processed file is used to update its count in the bigrams table by adding the value of the count in the processed file. The processed file is then added to the corpus.

iii Creating the initial other languages model

Before this command is run, the urls for creating initial models ought to have been saved in the urls table in the database. Each of the urls designated for creating the initial other languages model is obtained, and a get request is issued to download the file, which is saved locally. A script to process a downloaded file as described in the section on steps for creating a Web corpus (su-section on downloading and processing the files) is then called using the http interface. If this script completes successfully the processed file is saved. Another script to create the initial other languages model is called using the http interface. This script picks the unique words in the processed file and adds them to the other-unigrams table together with their counts. If a word already exists in the other-unigrams table, its count in the processed file is used to update its count in the other-unigrams table by adding the value of the count in the processed file. Bigrams are not needed for the other languages model.

iv) Creating a corpus from the Web

Before this command is run, the initial models ought to have been created. The bigrams table is accessed and the bigram with the highest frequency is used to create a search query for a search engine. A get request to the search engine is made using the http interface. The get call to the search engine returns a search-results page that is saved as a file. A call is made to a script that processes this file and extracts the links which are usually between <A> </A> tags. The links are stored in the urls table.

For each of the links, a get call is made using the http interface to download the file and store it locally.

If the get is successful, a script to process a downloaded file as described in the section on steps for creating a Web corpus (sub-section on downloading and processing the files) is then called using the http interface. If this script completes successfully the processed file is saved.

Another script to create the Kiswahili model and corpus is called using the http interface. This script picks the unique words in the processed file and uses them together with the unigrams and other-unigrams table to determine if the document is in Kiswahili, other languages or ambiguous as described in the section on steps for creating a Web corpus (sub-section on creating the text corpus and the models).

If the document is ambiguous, the script discards it.

If it is in Kiswahili it adds the unique words to the unigrams table together with their counts. If a word already exists in the unigrams table, its count in the processed file is used to update its count in the unigrams table by adding the value of the count in the processed file. The script also picks the unique bigrams (pairs of words) in the processed file and adds them to the bigrams table together with their counts. If a bigram already exists in the bigrams table, its count in the processed file is used to update its count in the bigrams table by adding the value of the count in the processed file. The processed file is then added to the corpus.

If the document is in other languages, it adds the unique words to the other-unigrams table together with their counts. If a word already exists in the other-unigrams table, its count in the processed file is used to update its count in the other-unigrams table by adding the value of the count in the processed file.

After all the links have been used, we make another search request using the next most frequent bigram and repeat the process.

PHP Scripts

A lot of text processing is necessary in the corpus-construction process. Regular expressions are needed to carry out the text processing. PHP is a good candidate for writing the scripts for this process because of its ease-of-use and the powerfulness of its regular expressions. It also provides an easy to use interface for most database management systems. The following are the scripts needed in our application:

i) Script to process search results

This script takes a file containing the results returned by a search engine and extracts the links. The links are in between <A></A> tags. Only .html, .htm and .txt links are picked. This can easily be done using regular expressions. The links are then stored in the urls table.

ii) Script to process a downloaded file

A file downloaded from the Internet is formatted for display on a browser. It thus contains a lot of formatting words and tags we would not want to include in a corpus. The purpose of this script is to carry out this formatting to remove unwanted words and tags while leaving the desirable sentences in the file. This script implements the steps described in the section on steps for creating a Web corpus the (sub-section on downloading and processing the files). This is done using regular expressions.

iii) Script to create initial Kiswahili model

The working of this script is described in the section on the graphical user interface on (sub-section creating the Kiswahili initial model).

iv) Script to create initial other languages model

The working of this script is described in the section on graphical user interface (the sub-section on creating the initial other languages models.

v) Script to create models and corpus

The working of this script is described in the section of graphical user interface (the sub-section on creating corpus from the Web).

Descriptive Statistics

Table 16.1: Urls (search) statistics

1	Execution time (for application)	21 hours
2	Number of searches	21 (21 bigrams used to search)
3	Number of urls collected	2,253
4	Urls used for Kiswahili corpus	1,202 (53%)
5	Urls used for other languages corpus	1(0%)
6	Discarded (ambiguous)	800 (36%)
7	Not used (application stopped)	246(11%)
8	Urls for initial models	4 (0%)

Table 16.2: Ten most frequently used words

1	Number of words in the corpus (tokens)	4,843,581
2	Number of unique words in the corpus (types)	150,274
3	Number of words appearing just once	81,152 (54 %)
4	Number of words appearing two times and below	98,666 (66%)
5	Number of words appearing three times and below	106,641 (70%)
6	Words appearing 125 times and above	3,046 (0.02 %)

Table 16. 3: Unigram Statistics

1	na	308,655	6.37%
2	ya	219,197	4.52%
3	kwa	147,973	3.05%
4	wa	132,981	2.74%
5	ni	78,509	1.62%
6	katika	66,589	1.37%
7	Mungu	41,229	0.85%
8	kuwa	41,033	0.84%
9	za	38,572	0.79%
10	yake	34,254	0.70%

Table 16. 4: Bigram Statistics

1	Number of bigrams (total)	214,8275
2	Number of unique bigrams	58,3871
3	Number of bigrams occurring just once	419,171 (72%)
4	Number of bigrams occurring twice or less	479,760 (82%)
5	Number of bigrams occurring three times or less	504,67 (86%)

Table 16.5: Ten most frequent bigrams

1	mwenyezi Mungu	mighty God	8156	0.379653%
2	juu ya	On	4393	0.20449%
3	baada ya	after	3786	0.176234%
4	pamoja na	with	3448	0.160501%
5	kwa sababu	because	3445	0.160361%
6	kwa ajili	because	3147	0.14649%
7	ndani ya	in (inside)	2569	0.119584%
8	ajili ya	due to	2511	0.116884%
9	kutokana na	as a result of	2210	0.102873%
10	na kwa	and "… because"	2009	0.093517%

Discussion

Table 1 shows that with more searches, a bigger corpus can be constructed. It also shows that there is a lot of intersection between Kiswahili and other languages. These discarded urls can be investigated to find out what the languages are and also the kind of documents they are.

Table 2 shows that most words appear only once (54%). Seventy percent of the words appear three or less times. This translates into sparseness in an N-gram probability model. Thus there is need for smoothing techniques to be used. Also the corpus needs to be as large as possible.

Table 2 and *Table 3* show some information about the most frequent words in the Kiswahili language. A large percentage of these can be assumed to be in any Kiswahili document. Thus they can be used to automatically determine if a document is in Kiswahili or not.

Table 4 shows that most bigrams occur just once (72%). The bigrams occurring three or less times account for 86% of the bigrams.

Table 5 shows "Mwenyezi Mungu" as the most frequent bigram. This is a pointer to the fact that a lot of the Kiswahili documents on the web have religious content. The other most frequent bigrams are pairs of words used as prepositions.

Limitations

More statistics need to be done on the corpus. For instance, we could compare this corpus with a manually generated corpus.

More processing of a document before it is included in the corpus in needed. One can go through processed documents to pick out what mistakes the current processing is making. One can then add a feature to the processing process to remove these mistakes. This should aim to ensure that only well formed sentences and bigrams are included in the text.

Further Work

- o Use of most frequent words (Table 3) to speed up recognition of documents.
- o Compare with other approaches.
- o Investigate quality and type of documents in the corpus.
- o Make an attempt to classify the type of documents, e.g. newspaper, religious, sports, academic, corporate etc. using the words "unique" to label the different kinds of documents.

Conclusion

Using the process discussed, it was possible to create a corpus of about 5 million words within about 24 hours. The limitation of quality that might result from a corpus created by this method is compensated for by the size. Thus, for the purpose of quickly creating an individualised corpus this application and the methods discussed in this paper can be used. The methods discussed here can be applied to any language. The only parameters that will need to be changed are the seed documents.

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Towards Excellence in Internet Security Research for Developing Countries

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In recent years the World Wide Web, seen by many as the main facilitator of e-commerce, has developed at a very fast rate. Many developing countries around the world correctly identify the Internet as a prevailing tool to advance social, economic and human development. At the same time, however, lack of trust in the Internet to cope with security threats jeopardises development goals that could otherwise be supported by a widely accessible and widely trusted Internet. It is imperative to investigate information security controls to cope with these threats. Apart from being an important enabler of e-commerce in developing countries, the area of information security also offers many opportunities for interesting research for scholars in developing and developed countries alike. By reflecting on our own work in this new field in computing, we try to draw some conclusions about how to obtain research excellence in ICT research for developing countries.

Introduction

Effective use of the Internet for commercial purposes is based on a set of good laws, industry self-regulation and technical standards that give users control and confidence. These are the elements that make the Internet what it is today.

Many developing countries correctly identify the Internet as a prevailing tool to advance social, economic and human development. At the same time, however, criminals also see the potential of the Internet as a place to perpetrate criminal activities and as a communications medium of universal reach at minimal cost. Hackers, virus writers, and scam artists abuse the available resources and take advantage of unsuspecting computer users. Worsestill, terrorists threaten to disable critical infrastructures on which more and more consumers and businesses are becoming dependent. The number one concern of consumers and businesses alike seems to be the lack of security, with privacy concerns most prominent for consumers, and loss of reputation and intellectual property for businesses (Tan et al., 2000).

The current setup of the Internet enables the developed and developing countries to work together as a global village. The Internet brings opportunities, but at the same time also many challenges to both worlds. In terms of trust and security, this environment includes criminal law, laws of privacy and consumer protection, and the commitment of industry to build and operate more secure systems. Research (GIPI, 2002) into cyber crime and ICT development suggests four components which together form a framework for trust and online security:

Cyber crime– Most of the developed countries have laws to help protect the security of information systems. These laws declare certain activities to be acts of cyber crime.

Standards regulating government access – Most developed countries have introduced policies, procedures, and standards that define and limit government access to communications and sensitive data. These assure consumers and businesses that the government cannot unjustifiably monitor their communications.

User protection – In most developed countries Internet solution providers and researchers have developed policies, procedures and standards to regulate online payments. These measures ensure that consumers have recourse if transactions do not go through or if the goods or services purchased online are not satisfactory. Frameworks using these controls provide confidence for both consumers and businesses.

Technical security controls – The developed world has adopted many relevant laws, yet recent surveys show that Internet-related crimes such as identity theft are on the increase. The problem of computer crime will be solved only when researchers and makers of computer technology build technically more secure systems and when users and organisations have been made fully aware of the threats and vulnerabilities associated with the users of these systems.

Researchers in this area should concentrate on making the Internet a better medium not only for the developed world but also for developing countries. There is an opportunity here for problem-driven research, focusing on the above discussed Internet-related problems in respect to the emerging markets.

The outline of this paper – Section 2 – elaborates on the threats that consumers and businesses are faced with when attempting to use the Internet for e-commerce and similar applications. That section also looks at some of the legal controls that might be employed to counter those threats. Section 3 sketches the current state of information security research. Section 4 lists some of the problems with deploying Internet technologies in developing countries. Section 5 ends the paper by proposing two strategies that researchers follow when looking at information security problems. A mix of these strategies is most likely the best solution for developing countries.

Threats to Security and Trust

The growth of the Internet has made communication between different communities much more feasible and has resulted in large-scale use by industry and commerce. This has led to the growth of electronic commerce. Unfortunately, it has also led to increasing threats to sensitive assets. Increasingly, organisations and individuals fail to protect sensitive data and infrastructure (Novak, 1999). With the world being much more interlinked, both good and bad things are introduced through the Internet.

The physical interactions between human beings, through which conventional trust relations used to propagate, have been replaced by the invisible network connections. Internet users still find it difficult to trust websites and remote networked information systems. Yet, currently, there seems to be little option other than to just trust in the good intentions and reputation of the organisations operating those websites and systems. A real solution would be to develop systems that enhance the trust and security of this useful medium (Egger, 2000). Below are some of the aspects of Internet security and trust that make the Internet media a challenge to both the developing and the developed world (GIPI, 2002).

Cyber crime provisions

The legal framework suggested in GIPI (2002) has the intention to promote trust and confidence in cyberspace. The framework proposes basic criminal laws against on-line activities that threaten confidentiality, integrity or availability of information assets. While the notion of cyber crime can be defined in many different ways, legal and organisational controls to counter cyber crime should at least deal with the following four kinds of activity:

Data interception: According to GIPI (2002) it should be prohibited to *"… intentionally intercept, without right, by technical means, non-public transmissions of computer data to, from or within a computer system."*
Controlling data interception is essential if one wants to achieve cyber-trust, since it protects the confidentiality of communications. Existing laws dealing with interception of conventional forms of information interchange (such as telephony or ordinary mail) could be amended to also include electronic communication.

Data interference: According to GIPI (2002) it should be a crime to *"… intentionally damage, delete, degrade, alter or suppress data in someone else's computer without permission."*
Controlling data inference is essential if one wants to achieve cyber-trust, since it protects the integrity of data. This provision also covers intentional spreading of viruses, breaking into computer systems and changing or deleting data, and defacing of websites.

System interference: According to GIPI (2002) it should also be a crime to *"… intentionally cause serious hindrance without right to the functioning of a computer system by inputting, transmitting, damaging, deleting, deteriorating, altering or suppressing computer data."*
Controlling system interference is essential if one wants to achieve cyber-trust, since it protects the availability of systems and services.

A problematic point with this form of offence is that the border between fair use and abuse is not clear cut. GIPI (2002) warns that:

> *It is important that this offence includes, as an element of the offence, the concept that there must be significant harm (e.g., a certain threshold of monetary loss) in order for an offense to occur; otherwise, ordinary on-line behaviour, such as sending one or just a few unsolicited e-mails, would be a crime, which is not sensible.*

Illegal access: According to GIPI (2002) illegal access is the crime of *"… intentionally accessing, without permission, the computer system of another. It can be thought of as the cyberspace equivalent of trespass."*

As with system interference, this form of offence is a little problematic in the borderline cases. If the computer system in question is not sufficiently protected by technical controls, unsuspecting users might access it without permission by accident.

Combinations of the above activities, especially the combination of illegal access with any of the other three offences, are of course possible and widespread. Combinations with conventional offences are also common.

Conventional offline offences can also be facilitated by the use of computers. GIPI (2002) goes on to also describe these:

> *In many cases, traditional criminal laws will cover offences committed online. And to the extent they do not, rather than establishing separate offences for computer-related crime, it might be better to amend the general crime laws to make it clear that they cover online conduct.*

Technical and organisational controls can only do their work when embedded in a legal framework such as the one sketched by GIPI (2002). McConnell (2000) warns that: *"Outdated laws and regulations […] create an inhospitable environment in which to conduct e-business within a country and across national boundaries."*

Still, rules and regulations alone are not enough, and more research is needed to come up with effective technical and organisational controls.

The Current Status of Information Security Research

Recently, there have been many advances in information security research, in domains ranging from management practices to network security. Research in security tends to progress on different levels. First, at a high level of abstraction, researchers are looking at topics such as trust, identity, anonymity, privacy. Providing these concepts with unambiguous formal semantics is much more difficult than providing traditional concepts such as confidentiality, integrity and availability with clear semantics. Second, at a somewhat lower level of abstraction, a lot of attention has been focused on security principles that seem to work well in practice. These best practices are being standardised in international standards such as ISO 17799. Finally, there is still a lot of basic research concentrating on cryptography, formal analysis of security protocols, and detecting vulnerabilities in software programs.

But most of the above initiatives have been targeting the developed world; there is little research in the area of security targeting developing countries.

Problems with Internet use in Developing Countries

Security researchers in developing countries should focus on Internet security-related problems, and they should especially give attention to the needs of developing countries. The developing world has unique problems that need specific attention of researchers and vendors in order to develop superior solutions that match them. Below are some of the challenges that most developing countries face. Researchers need to seek solutions in order to make the Internet work for the developing world:

Lack of ICT capable financial institutions

In many developing countries, credit card institutions are not available (A. Pfitzmann et al., 2003). In contrast to the developed world, where credit card companies almost force consumers to have many credit cards that facilitate them in e-commerce transactions, in the developing world it is very rare to find banks giving credit cards and actually very few individuals own credit cards. There is need to develop mechanisms to enable the developing countries to access goods and services on-line in a secure way, with or without credit cards. This means that researchers need to look at alternative means of online payment or at means of introducing credit cards in the developing world. Researchers have to look at the element of trust on both sides of the supplier consumer relation, because of the element of paying fees. There is need for researchers to suggest and develop solutions that will bridge the credit card gap.

Poor ICT infrastructure

There is a huge difference in quality and quantity of the information communication infrastructure between the developed and the developing world. The developing world lacks the infrastructure which limits its participation in the electronic world. This calls for a different set of solutions to enable it to securely interact with the rest of the world. In most of the developing countries Internet speed is very slow, which makes some Internet applications practically impossible to access; for instance there are some electronic services that heavily depend on aspects such as audio and video. Given that the speed of Internet connections is limited this greatly impacts the usability and functionality of such applications. Particularly the security goal of availability of some systems or services is threatened here. Researchers should propose better mechanisms that can match existing infrastructure for the Internet users in the developing world to access Internet-based services and systems in the same way.

Lack of security awareness

The information security awareness level is very low in the developing world; to some extent developing countries consider the Internet revolution as another way of colonising the emerging markets (Federal Register 15898). While security awareness among consumers and businesses in the developed world is low as well, they perceive the Internet as full of opportunities. Threats to security are thought of as challenges which need to be fixed or controlled. There is need to develop research on how to reduce the technophobia found among the decision-makers in the developing world, so that they can embrace the Internet revolution and know that the security threat that exists can be fixed.

Lack of proper ICT governance

Most of the developing countries do not have rules and regulations that govern the operations of the Internet. Cyber space needs proper rules to govern activities like e-commerce, and other electronic transactions (Laukka, M., 2000). There is need to develop good laws that are suitable to these specific countries, because solutions that work in the developed world may not automatically fit in the context of developing countries. At the organisational level it is necessary to have information security policies that address Internet security issues and show how organisations can participate in the digital world.

Lack of secure systems

The Internet brings opportunities of globalisation but, at the same time, also many challenges for the developing world. There are many threats ranging from Internet criminals, hackers, to viruses that can bring down connected systems. The developed world has developed solutions that can safeguard critical systems that might be the target of an attack. Yet the costs are too high for the developing countries to afford such solutions. There is serious need to have systems that are cheap but effective to guard systems that are being developed to serve the developing world.

Lack of proper ID-management systems

The developing world has been deploying systems to serve different purposes, but the issue of authentication and user identification is still a problem. The identity management systems developed in the developed world may not serve well in the context of developing countries, because of the existance of different business processes and protocols.

Improving Internet Security Research for Developing Countries

In the previous sections we argued that research into information security is both important and interesting. Information security research is important because it could enable developing countries to use the Internet to its full potential. Information security research is also interesting since some very challenging research questions need to be answered in order to achieve this. We propose two strategies that researchers could follow in order to deal with Internet security-related problems. Both strategies have advantages and disadvantages.

Action research

The first strategy, called action research here, proposes that security researchers concentrate on concrete problems that matter in the developing world. Following this research strategy, a researcher takes on challenges that emerge from practice. Typically one formulates many new concrete research questions, which generate new challenges. Applying this strategy can be difficult because many concepts have to be built up from the ground. There is no previous research to build on. This limits the depth one can reach. Case studies are a means of attempting to gain some insight into the real problems.

Action research is very suitable when concepts and problems are not yet very well understood, but industry is already attempting to build technologies to deal with the problems. It helps one to understand the concepts and recognise the research questions.

Practitioners in the field are, in general, appreciative of this kind of research, as it is flexible about new short-term problems. This kind of research can attract funding, since it is geared to solving an existing problem.

Basic research

The second strategy, called basic research here, proposes that researchers focus on existing scientific theory in an attempt to extend it.

One advantage of this strategy is that researchers are already familiar with the underlying existing research. This research is mostly driven by existing technologies, theories, and already-developed research results. Here researchers concentrate on building a solid base of theories and technologies for the long-term future. Researchers following this strategy may go very deep and work with complex theories to come up with non-trivial results.

People in practice may not understand the use of the results generated by this kind of research and these results are only interesting in the short-term to a small number of experts. This kind of research needs time to evolve and a good understanding of concepts, which makes it more precise because research questions are already clear and just need to be answered.

In the developed world, the two strategies are followed, and are working well. There is availability of funding and human resources to do the research.

In the developing world there is need to use more of action research and less of basic research. This is because of lack of expertise in the latter field and inadequate resources. Developing countries have more problems that need immediate attention, than doing research for the future when current problems are still unresolved. It is good to build a solid base of theories, tools and methods using the second strategy, but this can be focused on later when immediate problems are solved.

Conclusion

Plenty of opportunities for research excellence are present in Internet security and more so when we focus our attention on developing countries. There is need to take a pragmatic approach here, and try to see what practitioners are doing in the field in an attempt to solve the real problems. There is also need to develop new methodologies and theories and see if existing research can be bent towards this new area of research.

Ideally, the best approach is to adopt both action research and basic research. However, we feel that in the developing world action research is the preferred strategy. Of course one should keep validating scientific results against reality, to avoid creating false expectations by practitioners in the field.

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A Dynamic Framework for the Protection of Intellectual Property Rights in the Cyberspace

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This chapter looks at the protection of intellectual property rights in cyber space. The general trend in advances in technology shows that regulatory frameworks on the protection of intellectual property rights applicable to geographical boundaries cannot keep pace with changes in technology and in effect regulatory effort of the same rights in the cyberspace remains a challenge. The existing legal and/or regulatory framework applicable geographically cannot be effectively applied in cyberspace because of lack of a central policing mechanism. Thus, there is need to develop an appropriate regulatory framework for the protection of intellectual property rights in the cyberspace. In this study, the mode of protection of intellectual property rights was reviewed and the effectiveness of existing regulatory frameworks covering intellectual property rights was evaluated. A dynamic regulatory framework for protecting digitised intellectual property rights that can accommodate changes and/or advances in technology and also enactments and/or amendments of legislations governing intellectual property rights which can serve as a governing framework for cooperating countries such as the COMESA countries was designed and recommended. In designing the framework, an object-oriented approach was adopted to take care of the uniqueness of cyberspace and also changes in information and communication technology. The object-oriented approach focused on classes and instances of classes also known as objects. The class which encompasses the different intellectual property rights like copyrights, patents or trademarks specifies what data and function are included in the object or instance of a given class.

Introduction

The Internet's behaviour is far from traditional because information travels instantaneously and events in virtual space occur simultaneously (Bordone,1998) [3]. This effect has an influence on cyberspace which has a unique spatial order where physical distance is no more valid and accessibility depends thoroughly on the topological linkage. Cyberspace is also unique in that spaces can be easily modified and different places can be united. Global computer-based communications cut across territorial borders, creating a new realm of human activity and undermining the feasibility and legitimacy of applying laws based on geographical boundaries (Johnson and Post,1996) [12].

However, something has to be done and as Shapiro (Lessig, 99) [19] puts it: "Seeing cyberspace as elsewhere misconstrue[s] its legal significance. It keep[s] us from seeing the way that regulatory forces like code, which some say are 'there,' are actually affecting us here."

The existing intellectual property laws, like any other law, are prima facie territorial, since they apply within a given territory delineated for the same. This new boundary however, defines a distinct cyberspace that needs and can create a new legal institution of its own (Johnson and Post,1996) [12]. Kizza(2003) [15] states that intellectual property rights form a wide scope of mechanisms that include copyrights, patents, trademarks, protection of trade secrets and, increasingly, personal identity rights. Each of these instruments of protection are regulated by a body of laws and statutes which are, however, not universal.

Intellectual property systems are complementary to technology. It is an area of law that evolves with the development of technology rather than social and political needs (MacKie-Mason,1997) [21]. It is therefore vital that the content and the design of the law governing the operations in cyberspace should conform to its uniqueness for ease of applicability and enforcement. It is contended that cyberspace is a creature of technology and the possibility of regulating intellectual property rights therein by both law and technology is feasible. However, what vital ingredients should the law take into consideration for effective regulation?

Information on the World Wide Web is available simultaneously to anyone with a connection to the global network. The notion that the effects of an activity taking place on the website radiate from a physical location over a geographical map in concentric circles of decreasing intensity, however sensible that may be in the non-virtual world, is incoherent when applied to cyberspace (Johnson and Post,1996) [12].

This is because cyberspace by its nature and design has no tangible location.

Trademark law, taken for example, aims at the protection of the associations between words or images and particular commercial enterprises.

It is distinctly based on geographical separations and the rights typically arise within a given country, usually on the basis of the use of a mark on physical goods or in connection with the provision of services in specific locations within that country (Gilson,1991) [11]. This legal protection, however, does not extend to trademarks in cyberspace.

Ginsburg (Ginsburg, 1995) [10] enquired as to whether the rights in a work can be determined by a multiplicity of inconsistent legal regimes when the work is simultaneously communicated to scores of countries. Simply taking into account the country's laws, the complexity of placing works in a digital network is already daunting; should the task be further burdened by an obligation to assess the impact of the laws of every country where the work might be received? In answering Ginsburg's (Ginsburg, 1995) [10] arguments one can say that attempts can be made to reconcile the various inconsistent laws of various countries to conform to a common regulatory framework that can be designed to bring it into line with changes in technology with the aim, among others, of designing intellectual property laws that can be easily applicable in cyberspace as well as protecting intellectual property rights in this digital era.

Conflict between jurisdictions is not a new problem (Athanasekou,1998) [1] and the scope and geographical spread of intellectual property rights infringement will continue to grow. However, widely divergent approaches to jurisdictional issues in relation to intellectual property rights emerge in the digital environment, leading to distorting effects.

Arguments have also been put forth to the effect that (Samuelson, 1990) [24] because authors can now, for the first time in history, deliver copies of their creations instantaneously and at virtually no cost anywhere in the world, one might expect authors to devise new modes of operation that take advantage of, rather than work counter to, this fundamental characteristic of the new environment. This view seems to counter the need for the collective protection of such creation in cyberspace, but should it be an initiative of the authors or any other rights holder? The cost, however, of devising such a mechanism eludes many individuals in developing countries if it is to be undertaken as a single venture.

A domain name, when initially assigned to a given machine, may be associated with a particular Internet protocol address corresponding to the territory within which the machine is physically located (e.g. a ". uk" domain name extension), the machine may move in physical space without any movement in the logical domain space of the Internet. In the alternative, the owner of the domain name might request that the name become associated with an entirely different machine, in a different physical location. Thus, a server with a ". uk" domain name may not necessarily be located in the United Kingdom, a server with a ".com" domain name may be anywhere, and users, generally speaking, are not even aware of the location of the server that stores the content that they read (Johnson and Post,1996) [12].

The foregoing sceneario, therefore, can give any person with the intent to infringe on or pirate any intellectual property right over cyberspace leeway to reconfigure his or her connection so as to appear to reside in a different location, outside the particular locality, state or country. This is because the Internet's design and architecture housing cyberspace is based on logical as opposed to physical and/or geographical location. What form then can these laws take so as to conform to the operations in cyberspace? It may be noted that an intellectual property rights-holder anticipates basic protection of his creations, from inventors of technology, and not to be a victim of the same technology. In order for the domain name space not to be administered by a legal authority that is not territorially based, new law-making institutions should be developed (Johnson and Post,1996) [12]. This is because any would-be infringer or pirate can use on-line addresses for given users or even for service providers to commit intellectual property fraud and piracy for monetary gain. The pending issue therefore to be determined is whether the advancement in technology which created cyberspace and the absence of regulatory-related cyberlaw is a contributing factor to this dilemma.

It has been noted that taking cyberspace seriously could clarify the current intense debate on how to apply copyright law principles in the digital age. In the absence of global agreement on applicable copyright principles, the jurisdictional problems inherent in any attempt to apply territorial-based copyright regimes to electronic works simultaneously available everywhere on the globe are profound (Johnson, 1996) [12].

Characteristics of digital media that pose a threat to traditional intellectual property rights system is the ease with which digital works can be transmitted and used by multiple users, compared to paper versions of the work. The interaction of copyright and the Internet have resulted in several problems, technological, sociological and legal, that require immediate action. The international nature of cyberspace calls for a cross-jurisdictional approach for the problems to be effectively dealt with (Athanasekou,1998) [1]. No single country can successfully attempt to overhaul this problem because of the unique location of cyberspace.

Problem Statement

Laws limited to geographical boundaries cannot keep pace with advances in information and communication technology. An appropriate regulatory framework for the protection of intellectual property rights in cyberspace therefore remains a major challenge. This, coupled with the fact that the traditional process of enacting the laws is lengthy, can be easily overtaken by changes in the said technology.

Related Work

Technological Protection by Trusted Systems

Trusted systems are hardware and software that can be relied on to follow certain rules called usage rules, which specify the cost and a series of terms and conditions under which a digital work can be used (Stefik,1997) [26]. Architectures of trusted systems allow computers to protect and distribute information in more secure and reliable ways.

Trusted systems use technology as a lock and allows bundles of property rights to be split, such as the right to read, the right to prepare derivative works, the right to copy, and the right to facilitate an on-line payment scheme for each of these rights. The technology also enables exclusion, limitations on distribution, consumer tracking and invasion of privacy (Chicola, 1998) [6].

Studies on the protection of intellectual property rights show that the architecture of trusted systems, also referred to as electronic copyrights management systems will replace the law in offering protection for intellectual property.

Liebert (2000) [18] argues that trusted systems could tip the balance dramatically in favour of the content providers. Lessig (1999) [19], however, articulates the idea that, in the on-line world, the "architecture" (the combination of software and hardware by which information is accessed) can in effect become its own self-regulating law in relation to issues such as intellectual property, freedom of speech and privacy. That is, content owners will not have to resort to the courts for redress because the "architecture" determines what the user can and cannot access.

Stefik (Stefik, 1997) [26] asserts that with the development of trusted systems technology and usage rights, languages with which to encode the rights associated with copyrighted materials, authors and publishers can have more, and not less, control over their work in the context of digital works. A trusted system is aware of the rights associated with digital work because the rights may come with the work, attached to the work itself or stored in the database. Categories of digital rights are:

(i) Transport rights, covering rights to copy, transfer or loan;

(ii) Render rights, covering rights to play and print; and

(iii) Derivative rights, covering rights to extract, embed or edit.

It is worth noting that digital property rights are neutral to data format and interpretation and they can potentially work with any digital representation of text, pictures, databases, music or video.

If effective trusted systems are developed, and the usage rights to the protected materials are controlled by licences drafted by the content provider, then any information or other digitised material distributed in this manner can be used only in ways approved by the provider (Liebert, 2000) [18]. From the content producer's point of view, trusted systems offer two attractive aspects:

(i) Every instance of use is accounted for; and

(ii) The provider loses control of the protected material.

In academic and civil libertarian circles, "trusted systems" and "trusted computing" are often synonymous with digital rights management (Stefik,1997) [26].

Digital Rights Management Systems

Digital rights management as a form of protection of the interests of copyright-holders generally describes technologies that restrict the use of digital files in order to protect the interests of copyright-holders. They can prevent or restrict a computer from altering, sharing, copying, printing or saving protected digital files (Roemer, 2003) [23]. More importantly, it allows copyright-owners very detailed control over the ways in which a user may access their files, like how long they may view a file or how many times a file may be accessed.

Digital rights management technologies are inherently tied to copyright principles, as a technical means of enforcing the legal rights of content owners (Roemer, 2003) [23]. It is, therefore, possible to have in place an intellectual property rights protection mechanism for digital content for an organisation like the COMESA countries. However, ensuring its effectiveness and security may remain a challenge for the said countries.

Digital rights management relies on containment and marking. Containment is accomplished by encrypting distributed digital content so that only programs authorised by the rights owners may decrypt and thus access the information. Additionally, digital rights management system must 'mark' which uses of digital files are authorised. This may be done by the use of a watermark, flag or an eXtensible Rights Markup Language (XrML)(Roemer, 2003) [23]. According to Roemer (2003) [23], however, digital rights management systems are susceptible to attacks and reverse engineering that renders digital content unprotected.

Cryptography expert Schneider (2001) [25] of Counterpane Internet Security contends that, abstractly, a secure digital rights management system is an impossible task...that everything on the Internet is just bits: ones and zeros, and that bits are inherently copyable, easily repeatedly, that this is a natural law of the digital world, which makes copying on the Internet different from copying Rolex watches or Louis Vuitton luggage (Schneier, 2001) [25].

Scheinier (2001) [25] similarly contends that all digital copy protection schemes can be broken, and once they are, the breaks will be distributed – law or no law. Average users will be able to download these tools from the Web sites that the laws have no jurisdiction over. And while similar laws on digitised content could be passed in many countries, they would never have the global coverage needed to be successful.

Threats to Digital Rights Management

Napsterisation Threat Model

This model assumes that there are many people, some of them technically skilled, who want to redistribute a copyrighted work via peer to-peer networks. It assumes further that once the digital content appears on a peer-to-peer network, there is no stopping these people from infringing (Felten, 2002) [9]. According to Felten (2002) [9], this threat model requires that a digital rights management technology must be strong enough to deter even the most clever and determined adversary, because unbreakable codes do not make unbreakable digital rights management systems. Solving this model, therefore, requires a digital rights management system that can prevent a single attack from threatening the entire system.

Casual Copying Model

This model assumes that you are worried about widespread but small-scale and unorganised copying among small groups of ordinary consumers. The ultimate goal in the digital rights management system design is to create a situation where "knowledge gained breaking one client cannot be applied elsewhere" Biddle, (2002) [2]. Securing against a casual copying threat model is a much more feasible goal for digital rights management systems (Felten, 2002) [9].

Trusted Computing

Trusted computing aims at putting features deep into the hardware of personal computers. It can protect individual files and sensitive data on a computer. Technological trusted systems are only security sub-systems, available for any number of security (Roemer, 2003) [23].

Trusted computing, however, is an incomplete answer to an issue that requires a complete solution.

Most digital rights management security is implemented to secure software but not hardware. The underlying hardware and operating system allow an end-user to access every bit of information in a digital file, even when protected by software digital rights management. With this low-level access, end-users can attack the digital file itself, intercept digital information as a program executes through an emulator or debugger, or access the end result through a screen or audio capture programs (Roemer, 2003) [23]. Roemer (2003) [23] is of the view that when trusted computing is installed in a digital rights management system, the programs and files are protected by the trusted computing system and not the digital rights management program itself. Thus, if the trusted computing system is effectively utilised by the digital rights management producers, the method of attack ultimately defaults a hacker back to the initial and quite difficult option of hacking the trusted hardware system.

Case for Stronger Digital Rights Management Systems

At the intersection of digital rights management and trusted computing lies a new approach to content protection. The content industry is pressing the technology industry to utilise the security of trusted systems to enable a much stronger digital rights management system.

Trusted computing and digital rights management could effectively "privatise" copyright law-enabling content owners, and not the law, to decide exactly what rights the public will have over digital content (Roemer, 2003) [23].

For a digital rights management system to utilise the full security of trusted computing, a secure framework must be available throughout the entire time a computer is operating. Trusted computing provides several critical components missing from digital rights management systems and its engine provides content owners with a funnel to force end-users to access the digital rights management files. Its use of common rights expression languages enables content owners to have an easy and efficient means of communicating digital rights management system rights and restrictions to software programs (Roemer, 2003) [23].

Digital rights management developers, therefore, can create programs that implement content restrictions on digital files (LaMacchia, 2002) [16]. LaMacchia (2002) [16] contends that the most critical needs of digital rights management systems are trustworthy computing devices, robust trust management engines and a general purpose rights expression/authorisation language. Developers must then create systems or engines which can determine which rights to grant users for digital files and which ones are restricted by the content owner.

LaMacchia (2002) [16] is also of the view that the technology community should agree on a common language which programs will understand, so that content owners can designate digital management rights and restrictions once for every digital rights management system and trusted platform, rather than specifying authorisation for every different language that could use a single digital file. The issue arising here is whether if one language is used, it would not be easily manipulated by hackers and crackers, given the increasing trend in knowledge acquisition.

Presently, the eXtensible rights Markup Language (XrML) is the forerunner (for digital rights management) with the Organisation for the Advancement of Structured Information Standards (OASIS), the association that coordinates standards for XrML languages (Boulton, 2002) [4].

Although trusted computing offers a giant leap forward for security for personal computers, it will not be the final piece in the digital rights management content puzzle. However, trusted computing enables a far stronger digital rights management system than currently available and cannot be secure against all attackers. A completely effective digital rights management system is impossible (Roemer, 2003) [23].

Lemos(2002) [17]observes that every single device has to be secure – if one device is not secure then the digital rights management system does not work. In virtually every computer-based digital rights management system trotted out to the present, cracking one single digital file essentially renders the entire protection scheme insecure, going by the Napsterisation Threat Model (Lemos, 2002) [17]. A digital rights management system must therefore be "Break once break everywhere-resistant" to meet the Napsterisation Threat Model.

Trend in Copyright Protection in Cyberspace

According to WIPO (WIPO) [27] the field of copyright and related rights has expanded enormously during the last decade with the spectacular progress of technological developments, which have in turn brought new ways of disseminating creations by such forms of worldwide communication as satellites, broadcasting, compact discs and DVDs.

Dissemination of works via the Internet is but the latest development, which raises new questions concerning copyright and related rights in this global medium. According to its recent publication, WIPO (WIPO) [27] is deeply involved in the on-going international debate to shape new standards for copyright protection in cyberspace.

Copyright has become one of the most important issues in e-commerce. Complex issues have arisen as to how the existing copyright laws should be adapted to apply to the Internet and what new rights and remedies are needed for their protection. Because of ambiguities in legal definitions and technical means of control, the digital medium requires a completely new approach to copyrights (Choi et al,1997) [7].

Trend in Trademark Protection in Cyberspace

Attempts are being made technologically to provide proprietory web-filtering technology that automatically monitors, identifies and takes action against trade mark infringement and brand abuse. This takes the form of Internet surveillance and monitoring. This trend demonstrates the inability of the traditional trademark law to effectively protect on-line digital content that requires rights protection. It should be noted that this can be a costly venture for any rights-holder as well as cooperating countries and the attempt alone eludes many in developing countries.

Proposed Framework

The framework will be composed of different classes of the category of rights being protected under the intellectual property rights framework.

The classes which are the traditional laws maybe copyright, patents or trademarks. Each of the classes specify what data and function will be included in the objects of a given class. Under the concept of inheritance, new classes, also referred to as derived classes, are created from existing or base classes.

The object-oriented approach treats data as a critical element in program development and ties data more closely to functions that operate on it and protects it from accidental modification from outside functions. The data of an object can only be accessed by the functions associated with that object, although the functions of one object can access the functions of other objects. The principle of data-hiding adopted by object-oriented approach enhances the building of secure programs that cannot be invaded by codes in other programs.

It should be noted that the unique nature of cyberspace raises both technological and legal problems for legislatures and policy-makers in determining how to effectively regulate and safeguard the interest of rights-holders in this virtual space.

Vital Ingredients for Designing the Framework

Cyberspace is a creature of technology based on codes and containing electronic information. The framework therefore should model this aspect so as to conform to the uniqueness of cyberspace and also advances in information and communication technology, but should aim at being technologically neutral, in relation to its area of application. In designing the framework, presumption has been made that the overall basic principle of the traditional concept of originality of intellectual property rights shall be considered as a condition for protection.

In determining the vital ingredients of the model framework, the following were considered, bearing in mind that the existence of cyberspace directly depends on technology and its implementation knows no jurisdictional and/or geographical boundaries:

(i) Unique characteristics of cyberspace. The argument here, was that cyberspace, despite its uniqueness, should not be left unregulated, especially if the intellectual property rights-holders do not desire that their digital content be put to uses that disadvantage their intellectual effort;

(ii) Expectations of rights-holders over their digital content. The rights-holders expect relative protection;

(iii) Categorisation of content for the model framework to ensure dynamism. The content was categorised in terms of classes and objects. The different categories of intellectual property rights like copyrights, patents and trademarks were categorised as classes and the major worry for the rights-holders are infringements, taking the form of unauthorised access, unauthorised use of lawful access and use without consent, which were categorised as instances of the classes referred to as objects. If someone, for example, decided to reproduce or distribute any of the protected works without authorisation, an infringement would have occurred.

(iv) Mechanisms to be developed to ensure the enforceability of model framework. The framework aims at being self-regulatory.

The Model Framework and the Concept of Inheritance

Inheritance is a process of creating new classes – also referred to as derived from – existing or base classes. The inheritance concept under the object-oriented approach paradigm is analogous to using functions to simplify a traditional procedural program. It provides an important extension to the idea of reusability. Therefore, in the event of changes and/or advances in technology, an existing class can be added on to additional features and capabilities by deriving a new class from the existing old one, so as to make it conform to the new changes in its area of application, under the concept of reuseability.

The applicable framework for the intellectual property protection will thus be the current trend influenced by the impact of changes in technology; that is as a result of the technological changes and/or advancement, thus the framework which is the class will form a new class under the concept of reuseability.

New data types can also be created owing to, for example, changes in the trend of intellectual property rights protection, and the operations can be represented thus:

Current Trend (Z)= Previous Trend(X) + Impact of Changes in Technology(Y), where X, Y and Z are objects of the framework class, each representing an independent numerical quantity, which is the framework, and the new data type created is Z.

The framework can in effect become its own self-regulating framework in relation to the cyberspace since its "architecture", that is, the class specifies what data and function will be included in the objects of a given class which then determines what can and cannot be accessed.

Inheritance permits code reuseability. This will be a vital component for designing the framework and possible amendments to the framework needed to be done owing to advances in technology. Through the concept of inheritance, redundant codes are eliminated and the use of the existing class is extended. Programs can be easily built from working modules as opposed to having to start from scratch.

Illustration of Inheritance Involving Base Class and Derived Class

In the event of changes in technology, the framework, therefore, is only affected to the extent of the changes caused by the technology, which become the derived class or the derived law. The existing class without being modified can be added on to additional features and capabilities by deriving a new class from the existing old one, so as to make it conform to the new changes in its area of application under the concept of reuseability. It should be noted that new data and functions can be added whenever the need arises and multiple objects can co-exist without interference as illustrated in Figure 1. Features A,B,C are defined in the base class but are accessible from the derived class;however, feature D is defined in the derived class only, created as a result of the changes in technology, which is independent of functions and data in the base class and has the capability of building its own security features under the concept of encapsulation.

Figure 18.1: Base and derived classes

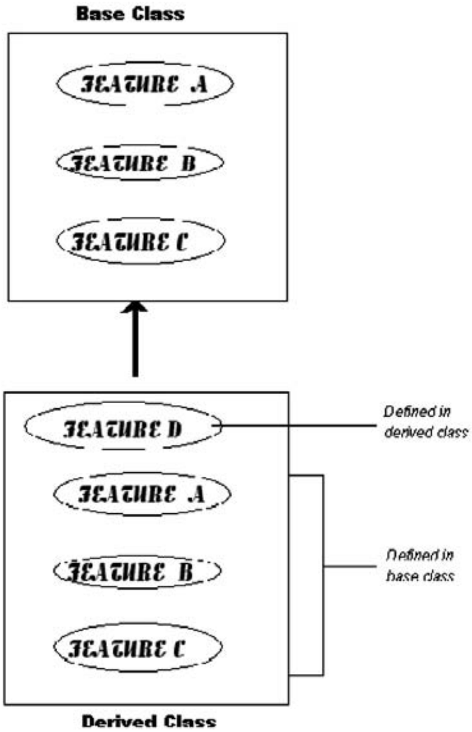


Figure 2 shows how the derivations by class are flexible to the extent that from one base class many sub-classes can be derived, forming different derived applicable laws in the circumstances. Thus the rapid advance and/or changes in technology can be taken care of, where protectable rights are affected in the process of the said changes. It should be noted that for security purposes, data is tied more closely to functions that operate on it and protect it from accidental modification from outside functions. Access to the data can only be done by the functions associated with that object. The principle of data-hiding adopted by the object-oriented approach enhances the building of secure programs that cannot be invaded by codes in other programs.

Some of the derived classes need not inherit new information, which is an important aspect for trend analysis, policy-making and eventual legislation since the trend during a given period of time following a given change and/or advance in the information and communication technology can be traced. It should be noted that the law-making process under this approach then becomes shortened as opposed to the traditional process of law enactment.

Figure 18.2: Class and level hierarchies

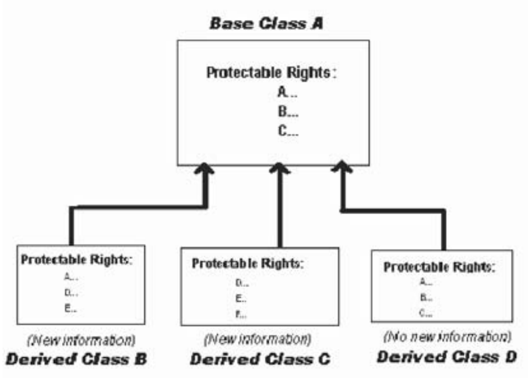
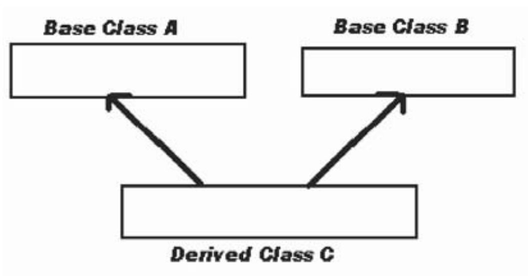


Illustration of Multiple Inheritance

The flexibility of the object-oriented approach extends to multiple inheritance thus extending the same attribute to the framework (see Figure 3).

In the event that changes have occured in two or more classes in for example, copyright and trademark laws and one governing framework is to be developed, under the concept of multiple inheritance, a class can therefore be derived from more than one class to come up with one framework developed from the derived class which then becomes the derived and applicable law under the circumstances. It should be noted that the security features and functions are inherited by the derived class (applicable law) from the parent class, which forms its own independent security features and/or functions by the concept of data-hiding associated with the object-oriented approach.

Figure 18.3: Multiple inheritance



Verification and Validation of Model Framework

The developed model was verified through the use of pseudo codes to show how the model framework is validated in light of changes and/or advances in information and communication technology.

(i) The data and functions are encapsulated in the classes in the framework and define the category of rights being protected.

(ii) The objects or instances of the classes include instances of infringement, instances of wrongful acquisition of rights to access, instances of unlawful and wrongful access, and all related punishments and/or penalties in the form of denial of access.

(iii) The objects of the different classes interact with one another through the sending of messages.

(iv) New classes or derived classes can be created from the initial or base classes and in the event of changes in technology, the framework is only affected to the extent of the changes caused by the technology, which become the derived class. The existing class can be added onto additional features and capabilities by deriving a new class from the existing old one, so as to make it conform to the new changes in its area of application under the concept of reuseability.

(v) Derivations by class are flexible to the extent that classes can be derived from classes that are derived, thus the rapid advance and/or changes in technology can be taken care of.

(vi) In the event that changes have occurred in two or more classes and one governing framework is to be developed, under the concept of multiple inheritance, one class can be derived from more than one class to come up with one framework developed from the derived class.

(vii) Security is guaranteed since the source code is not easily accessible and any threat to the security of the protected rights are checked by the data and functions.

(viii) The framework in effect becomes self-regulating since the class specifies what data and function will be included in the objects of a given class, which then determines what can and cannot be accessed.

(ix) The framework operating under the concept of inheritance and reuseability has the ability and the flexibility to adapt to changes in information and communication technology.

Achieving Protection under the Framework

(i) Protection of the digital content under the framework shall include its preservation in its original state, storage, control and regulation of access to the digital content.

(ii) There should also be in place a mechanism for tracking and audit trails, guarding against accidental or fraudulent modification, detecting, reporting and correcting changes, guarding against changes, destruction or loss in an unauthorised manner and the ease associated with copying and modification of digital content.

An audit trail is critical for maintaining an uninterrupted record of the transactions within the framework like editing, changes, alterations.

(iii) The audit trails will help in the recording of routine editing or replacement of records and all manner of unauthorised modification will result in denial of access.

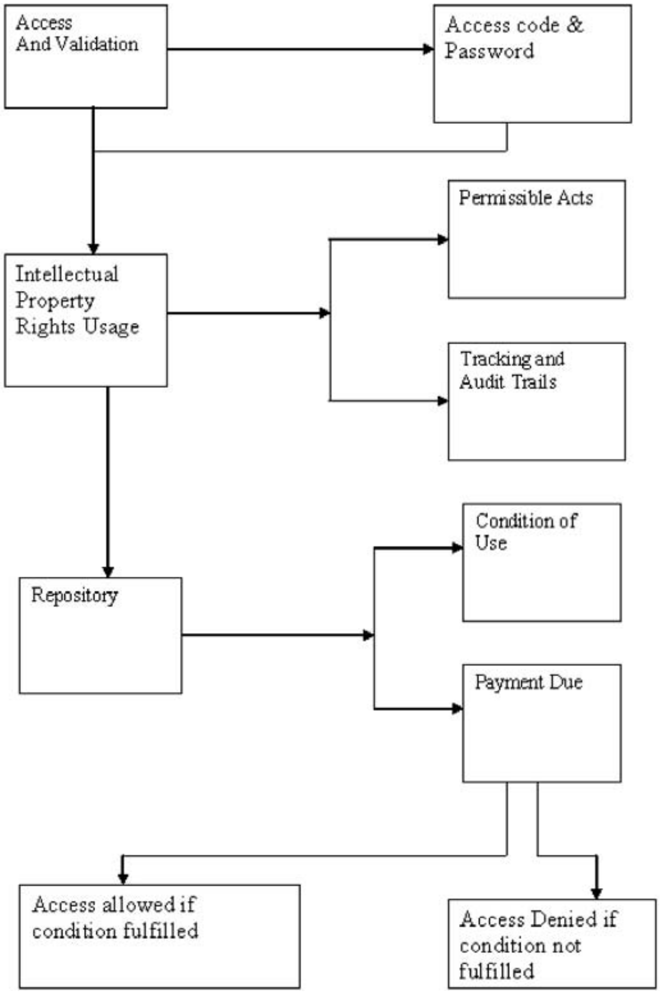
The illustration in Figure 4 shows how the protection and the preservation of digital content have been achieved. Access must first be validated and paymnent of dues and/or fulfilment of conditions associated with access done before accessing protected digital content. Any form of unauthorised access results in denial of access.

In relation to the COMESA member-countries, since it is envisaged that the COMESA countries through their cooperation will participate in electronic commerce, and cognisant of the fact that any transaction in cyberspace is carried out on multiple platforms, the framework should be able to protect against piracy, fraudulent acts, destruction or loss of digitised content and/or the ease associated with copying and modification of digital content to the detriment of the rights-holders.

It has already been observed that trade conducted electronically has a relatively high intellectual property content. The need for a secure, flexible and predictable environment provided by this framework for the protection of intellectual property rights would foster the development of electronic commerce in the COMESA region. The sale and licensing of intellectual property in cyberspace can be made possible under the framework and the rights-holders' intellectual property rights can be protected against piracy and yet persons with authorised access are able to obtain authentic as opposed to pirated services.

Therefore the rapid introduction of new technology, globally, may not compromise existing laws protecting intellectual property rights but law and technology can co-exist under the framework, since the applicable laws are derived from the operation of the framework.

Figure 18.4: Achieving Protection



Discussion of the Proposed Framework

The dynamism of the framework relates to the flexibility and elasticity of the framework, which is the developed regulatory mechanism in this research, and it is dynamic as opposed to static because of the concept of inheritance under the object-oriented approach adopted. Thus, the laws designed under this approach have the ability to cope with changes in technology and at the same time offer relative protection.

The object-oriented approach has been adopted for the redesign of the traditional intellectual property laws to make them applicable in cyberspace, offer protection under encapsulation and also cope with changes in technology under the concept of inheritance. It has been stated earlier that the intellectual property law is an area of law that evolves more with the development of technology than social and political needs. The approach therefore has made it possible to design the content of the law to conform to and govern the operations in cyberspace. It was also contended that cyberspace is a creature of technology, and the possibility of regulating intellectual property rights therein by both law and technology is feasible. The self-regulating law is therefore derived from the governing operations of the framework and the way protection is achieved.

The discussion in this research is not restricted to how the object-oriented approach protects individual rights. However, it is an approach adopted to make effective laws limited geographically applicable in cyberspace, thus enabling the re-designed laws to protect the intellectual property rights in cyberspace. Both the individual and the state can benefit from this framework. The companies which are rights-holders can also benefit since the operation of the framework is not applicable to a given parameter alone but can be customised as long as the rights-holder can be identified. Taxes and any other dues accruing under the framework can be earmarked and collected under the conditionality and fees payable (see Figure 4).

The importance of the object-oriented approach to the framework relates to its flexibility and elasticity as discussed in previous chapters because the traditional laws can be re-designed to cope with changes in technology, amendments can be incorporated and trends can be analysed for policy formulation and designing of a more secure future framework. The framework's self-regulating law has the ability to have a global coverage as opposed to having different protection laws passed by different countries which may not have a global coverage.

However, efforts to establish a technological approach to protection should take cognisance of the fact that technology itself cannot be regulated. The existing intellectual property rights protection schemes are enforceable but may not be effective. An effective framework in this regard must therefore conform as much as possible to the architecture of cyberspace and cyberspace should be viewed as having significance for both human and technological effort in the protection of digital content.

The concept of inheritance under the adopted object -riented approach paradigm in the design of the regulatory framework has enabled the use of functions to simplify a traditional procedural program. It has also provided an important extension to the idea of reusability. Therefore, in the event of changes in technology, an existing class can be added on to additional features and capabilities by deriving a new class from the existing old one, arising out of the technological changes, so as to make it conform to the new changes in its area of application.

It has been possible under the object-oriented approach to consider and model the overall basic principle of the traditional concept of originality of intellectual property and rights protection and the applicable laws to come out with objects and classes to develop the framework for intellectual property rights protection. The object-oriented approach framework has also, through code reuseability, the capability to conform to the changing nature and uniqueness of cyberspace influenced by advances in information and communication technology, yet is technologically neutral.

Subject to the object-oriented approach adopted in the development of the framework, and the limitation in trend extrapolation, the viability of the framework in its operation shall not be dependant on trend extrapolation for its effectiveness. The framework developed through the inheritance and reuseability concepts has the ability to conform and withstand the effects of trend extrapolation and advances in information and communication technology.

Concluding Remarks

The study focused on how intellectual property rights can be managed in cyberspace and has proposed an object-oriented approach in the design of the framework which aims at flexibility and technologically neutrality, thus taking care of advances and/or changes in information and communication technology.

However, the proposed dynamic regulatory framework does not cater for the fair use right provided for under the copyright laws which may not amount to infringement by users accessing information under such right.

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Part Eight

Information and Communications Technology Policies and E-governance in Developing Countries

20

Sub-regional ICT Policy: Case of EAC Headquarters and Autonomous Institutions

Anthony J. Rodrigues and *Joseph Muliaro Wafula*

The EAC sub-region comprises Kenya, Uganda and Tanzania. While other countries have published their policies, Kenya did not publish its draft ICT policy until September 2004. That made the formulation process for what could be the EAC sub-regional ICT policy difficult. This paper suggests some of the possible EAC sub-regional ICT policy statements that have been derived from the analysis of the EAC member-states' national ICT policies, an overview of ICT policies and plans of EAC headquarters and its autonomous institutions, namely: the Inter-University Council for East Africa (IUCEA), the East African Development Bank (EADB), Lake Victoria Fisheries Organisation (LVFO), and the East African Business Council (EABC). The existing ICT policies and plans at EAC headquarters and its autonomous institutions were examined with an the intention of providing an explanation and a link with observed practices. Areas explored included funds and their sources, and ICT priorities. Lessons that could be drawn to reinforce ICT policy statements were noted. The research established that EAC headquarters and its autonomous institutions had adequate information available to them on the cost of different aspects of ICT adaptation and utilisation. Linkages between this finding and the way decisions such as outsourcing services, budget allocations, and ICT initiatives support, were identified. In view of these observations and the difficulties experienced by policy-makers and chief executive officers (CEOs) of organisations when handling similar situations, an option-based ICT investment decision index (IDI) has been developed.

Introduction

The East African Community is the regional inter-governmental organisation of the Republics of Kenya, Uganda and Tanzania, with its headquarters located in Arusha, Tanzania. The East African heads of state signed the Treaty for the Establishment of the East African Community in Arusha on 30 November 1999. The EAC aims at enhancing co-operation among partner states by establishing a customs union, a common market, monetary union and ultimately a political federation. The three East African countries cover an area of 1.8 million square kilometres and have a population of 82 million who share a common history, language, culture and infrastructure. These advantages provide the partner states with a unique framework for regional co-operation and integration. Indeed modern ICT provides both the opportunity and the means to realise co-operation and integration through shared resources, i.e. applications, data, and infrastructure, underpinned by careful planning and design strategies.

Among EAC sub-region member-states, Uganda and Tanzania had published their national ICT policies much earlier than Kenya, which published its draft ICT policy in September 2004. That made the formulation process for what could be the EAC sub-regional ICT policy difficult despite provisions such as that in the Treaty for the Establishment of the East African Community, Article 99, which spells out co-operation latitudes in the sub-sector. The treaty specifically provides for, among other things, that partner states shall take steps to develop harmonised policies and regulatory frameworks in the sector and improve communications links and establish new ones as a means of furthering the physical cohesion of the partner states and facilitating and promoting communications within the community (Yonazi, 2004).

The delay in the publication of the draft national ICT policy may have contributed to the little progress reported by the EAC Secretariat and the Regulatory Authorities on their studies such as the Harmonisation of Regional Communications Regulatory Strategy, which focuses on various sub-regional issues including the harmonisation of national ICT policies, and the development of a Harmonised ICT Policy Framework for East Africa where a task force consisting of key senior policy experts was constituted by the EAC Sectoral Council for Transport, Communications and Meteorology (TCM) in November 2003.

Now that there is a COMESA ICT policy on one hand and national ICT policies for EAC member states on the other hand, the need for the EAC sub-regional ICT policy to provide the missing link has clearly emerged, which this paper targets to enlighten and propose some solutions.

Some of the possible EAC sub-regional ICT policy statements have been derived from the analysis of the EAC member-states' national ICT policies, an overview of ICT policies and the plans of EAC headquarters and its autonomous institutions, namely: the Inter-University Council for East Africa (IUCEA), the East African Development Bank (EADB), Lake Victoria Fisheries Organisation (LVFO), and the East African Business Council (EABC).

There is a threshold beyond which the deployment and exploitation of ICTs could speed up or aid the socio-economic development process of a given country, sub-region or region. That threshold is synonymous with what is also called the 'critical mass' of ICT diffusion. The diffusion of ICTs must achieve a 'critical mass' in terms of coverage, organisational adaptation and 'learning by doing' before widespread productivity gains become observable (Dzidonu C.K., 2003). ICT pilot projects must be replicable/scalable for them to support socio-economic development. To achieve this, attention needs to be given to the following: local-and community-level involvement and ownership of these initiatives, mobilisation of necessary financial and other resources required to implement the project, and addressing administrative problems. ICT investments are effective, successful and sustainable when supported by good ICT policy and coupled with complementary organisational and managerial changes.

A suitable sub-regional ICT policy for EAC should be a hybrid of the Global Positioning and Export Capacity Building Strategies. To acquire the ICT 'critical mass' needed for notable socio-economic development, considerable resources are required.

Individual EAC member-states are faced with enormous challenges such as: lack of a culture of maintenance of equipment, technology or services; the EAC sub-region falls in sub-Saharan Africa, which is considered to be one of the poorest regions of the world; the economy of the sub-region has high dependence on the agricultural sector that is predominantly subsistence-based; the EAC has a narrow and weak industrial base, structures and underdeveloped service sector; the sub-region has relatively low growth rates, coupled with balance of payment difficulties; and the EAC has poor physical, communication and social infrastructure.

This being the case, national ICT policies are more inclined towards first of all cultivating the national ICT sector and the domestic market. Therefore, an EAC sub-regional ICT policy would enable and push its member-states to attain global positioning as well as carve out an export market. This is because it is believed that a sub-regional ICT policy would enable sharing of costs, resource personnel, experts, infrastructure, and information, among others.

These factors are largely supported at EAC headquarters in Arusha except for the legal regulatory and institutional environment, which the EAC is addressing. For that matter, EAC headquarters is strategically placed to develop and implement a sub-regional ICT policy and administration of pilot projects on e-strategies such as e-government. The EAC headquarters is one of those that have made some progress in tapping ICT benefits while still operating in an ICT policy vacuum. The EAC headquarters has developed an application that monitors the Council of Ministers' decisions. The application was developed after assessing the already acquired software for the library and customising it to offer decision-support services. It is bound to be sustainable since it was created out of a need for an e-governance model discussed and presented in this paper.

The EAC Development Strategy 2001 – 2005 is a systematic way of implementing activities designed to achieve the goals of regional integration in the EAC sub-region. The vision for sub-regional integration is to create wealth and enhance competitiveness through increased production, trade and investments (East Africa Community, 2001). The establishment of a customs union has eliminated internal tariffs and the adoption of a common external tariff (CET). Elimination of internal tariffs is being implemented under the principle of asymmetry. Information technology is one of the pillars of the sub-regional integration and development, globalisation and modernisation (East Africa Community, 2001). The development strategy emphasises the importance of information as a resource and a tool for development. The enactment of national ICT policies into law by sub-regional governments, and the development of the sub-regional ICT policy as their global umbrella, will reinforce the information technology pillar for sub-regional integration and development, globalisation and modernisation. For this to happen, the political establishments need to include ICT among their top priorities, which they have started doing.

Research Methodology

A survey was conducted in the year 2003 at the EAC headquarters and its autonomous institutions. One of the objectives of the survey was to evaluate the ICT policy status. Interviews and questionnaires were administered at the EAC headquarters and its autonomous institutions, namely: the Inter-University Council for the East Africa (IUCEA), East African Development Bank (EADB), Lake Victoria Fisheries Organisation (LVFO), and the East African Business Council (EABC). The survey targeted the heads of ICT that sit on the top decision-making boards of those organisations. The analysis of the data collected was done using SAS software v8, where applicable.

EAC Headquarters and Autonomous Institutions

The survey conducted at EAC headquarters and the autonomous institutions revealed three commonalities among them. They were as follows:

i) All institutions had their sources of funding ICT vaguely defined, even where they had an ICT policy or plan in place. All institutions acknowledged having adequate information concerning the financial cost of ICT usage and adoption.

ii) All institutions recognised ICT as important for future economic development of their institutions.

This paper will attempt to argue around these commonalities using the case of EAC headquarters to address their benefits and resultant challenges to the institutions. It also will suggest solutions largely from a strategy and policy perspective.

The survey established that EAC headquarters did not have both a sub-regional ICT policy and a sub-regional telecommunications policy in existence. Despite these findings and status, the list of the top ten sub-regional needs at the headquarters had five of them being ICT as shown in Table 1. This clearly indicated how highly ICT was prioritised. At this initial stage of the revived EAC, the EAC headquarters chose to outsource most of its ICT services. In the absence of an official ICT policy, outsourcing of aapplication development hardware and software maintenance and Internet service provision could be interpreted as a good strategy when human resource capacity is inadequate and ICT is not the core business. This option also tends to minimise risks of ICT investment. On the other hand, customisation of applications and in-house systems maintenance for both hardware and software was being encouraged and could be taken as making steps towards building capacity and as a preparation for being self-reliant. A good example is where Adlib software that was used to automate the library had been customised to monitor the Council of Ministers' decisions.

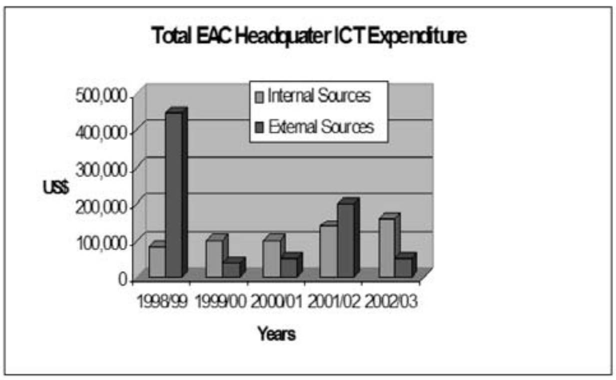
Table 20.1: List of top ten sub-regional needs

	Top Ten EAC Sub-regional Needs
1	Finalization of customs union protocol
2	Harmonization of communication strategy
3	Lake Victoria Development Programme
4	Telecommunication Infrastructure Development
5	Liberalization of cross border trade and movement of persons
6	Promotion of ICT application
7	Macro-economic stability to promote investment
8	E-governance
9	Development of infrastructure and support services
10	Regional Licensing of Private Operators in the Sector

Although EAC headquarters lacked an ICT policy, it was noted that it had a written plan for ICT development. The plan had been written more than three years ago and covered a period ranging between 5 and 8 years. Therefore most of the ICT activities that were going on could only be measured against that plan. The agencies responsible for the implementation of the written ICT development and utilisation plan were: the East Africa Community (EAC), EAC development partners, and the regulatory authorities of partners states. This implied that the EAC strongly supported partnership in its implementation strategy.

It was found that the funding needs and their sources were vaguely defined in the ICT development plan. Fig. 20.1 shows ICT expenditure for a period of five years.

Fig.20.1: Total EAC ICT expenditure over five-year period.



A steady increase with time in funding from internal sources was observed for ICT. This is a good indicator of the high prioritisation of ICT by the EAC headquarters. The projected increase in the ICT budget of over 140% in the years 2004/05, 2005/06 and 2006/07 could have been based on the observed trend of increased funding from internal sources. On the other hand, the external sources of funding appeared to be diminishing with time.

Fig.20.2: EAC Headquarters Budget Allocation

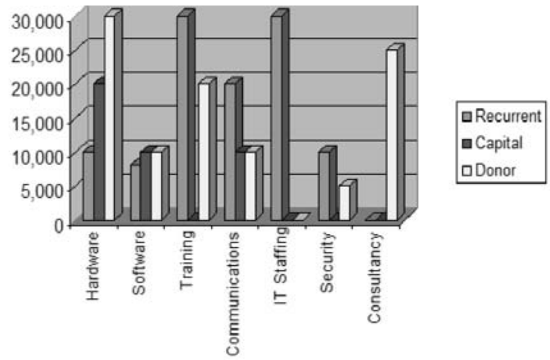


Figure 20.2 shows the EAC headquarters budget allocation for the seven key ICT components. The capacity and sustainability of the expected sources of funding for each ICT component was evaluated and suggestions made.

The reduction, trend observed in donor sources of funding posed a risk to the budget allocation especially for hardware, training and consultancy, which seemed to heavily rely on donor sources that contribute about 1/3 of the total budget. Realisation of this and establishing policies that encourage partnership with the private sector would help solve the hardware problem. Equally, in areas of training and consultancy, policies that promote collaboration with higher institutions of learning in the EAC sub-region would leverage the dwindling donor support to those areas and at the same time help build local human capacity.

The EAC headquarters expressed the need for major support in the adoption of key applications such as e-government, e-governance and e-commerce. These are applications that still demand high budget allocations for training and consultancy that seemed to depend on donors. Given the observed trend of donor funding, the EAC needs to pursue the policy of collaborating with sub-regional universities and, in particular, academia. The involvement of academia in policy formulation and implementation processes would to a large extent solve the problem as well as create sustainability. EAC collaboration with academia would ensure availability of technical information, which the EAC acknowledged is lacking.

Table 20.2 lists six donors and their respective ICT initiatives that were identified at the EAC headquarters.

Table 20.2: Donors and their EAC ICT Initiatives

Donor	ICT Initiative	Type of Support	ICT Component
EU	Databases	Development of Databases, H/W and S/W	Software
WAID	ICT Equipment & Internet	Server & Desktop Computers & upgraded Communication Links	Hardware & Communications
UK	LAN & Internet	Hardware & software	Hardware and Software
Finland	Software	AutoSoftware (Accounting and Registry)	Software
GTZ	ICT Equipment	Computer accessories and software	Hardware and Software
KOREA	Hardware Equipment	Supply of Hardware	Hardware

The EAC headquarters identified six donors shown in Table 20.2 as those that helped fulfil some of its ICT goals. Among the seven key ICT components the EAC headquarters budgeted for, only three, namely hardware, software and communication were supported by the six donors. Yet for the other four, and particularly training and consultancy, the budget allocation was expected to be drawn from donor sources which even at that time were not defined. As long as the EAC still looks to donor communities and the private sector for support towards achieving its ICT goals, it must put in place an ICT policy that promotes the same attitude. The EAC must also embrace mechanisms and methods that support its policy.

The research also revealed that use of closed source software (CSS) in the sub-region was high. The nature of closed source software is such that the internals of the program are intentionally hidden from the user. This software hoarding hurts the users by forcing them to be at the mercy of the vendor and disallowing them from modifying the program to suit their own needs. For instance, the EAC information processing centre used the following software packages that are of the CSS type: MS 2000 Server and MS Windows NT, Win XP Professional, MS Windows Professional, MS Win 98, Office 2000 Suite, SUN Systems and TRIM software. Maintaining the use of such software was expensive and continued to make the EAC dependant on the provider and developer. It also posed considerable challenges when it came to software compatibility, system integration and interoperability. On the other hand, open source software (OSS) is software for which the source code is freely and publicly available, though the specific licensing agreements vary as to what one is allowed to do with that code. The availability of the source code and the right to modify it is very important. It enables the unlimited tuning and improvement of a software product. It also makes it possible to port the code to new hardware, to adapt it to changing conditions, and to reach a detailed understanding of how the system works. This is why many experts are reaching the conclusion that to really extend the lifetime of an application, it must be available in open source form. EAC needed to embrace OSS and promote its development in the sub-region.

Donors assisted EAC headquarters in acquiring CSS, which still poses challenges associated with it. In future, the EAC should specify the kind of software assistance it needs from the donors. It would be a good idea if the EAC looked into the option of developing and using OSS besides the CSS. Such action would promote local software development and at the same time create jobs and wealth in the sub-region. Despite the assistance that was given by the donors to the EAC headquarters, it was observed that effective sharing of best practices as well as skills transfer through consultancy was poor. Considering the ICT components that benefited from the supportive hardware, software and communication, most of which were proprietary – such outcome is expected. Lack of ICT policy spelling out what is expected of the donors could have contributed to the poor result. Also lack of capacity at the EAC headquarters to absorb and therefore enable skills transfer could be among possible contributing factors. Though the problem of scarcity of a skilled technical human resource in developing countries is serious, adopting policies that encourage mobilisation and sharing of the few in the sub-region would be a great step towards fixing the problem. In view of this, the EAC supported the concept of a regional-industry higher education partnership concept. Therefore the EAC expressed the desire to promote the following: centres of excellence in various fields including ICT, harmonisation of education systems in partner states, and support for a practical/industrial-oriented education system.

Three ICT initiatives that were found at EAC headquarters had supported hardware, software and communication tools out of the six that needed similar donor involvement and support (see Fig. 2). The situation at EAC headquarters appeared more desperate for the donors when some of its budget for ICT components such as training and consultancy were supposed to be financed by mainly donors who were still undefined. That situation could be avoided through EAC headquarters putting in place an ICT policy and mechanisms that promote ICT investment. However, the ICT components that were budgeted, needed to be well understood and their associated risks known, if they are to attract sponsorship from donors, private sector and any possible investor.

Since EAC headquarters and its autonomous institutions had adequate information about the costs of different aspects of ICT adaptation and utilisation, they could use this information to justify and attract FDI, and ICT investments by sub-regional governments, donors and the private sector. In the case of the EAC headquarters, there were only six donors who offered assistance, which was not enough to meet the ICT demands. To be able to use the information on costs of ICT adaptation and utilisation in prioritising ICT initiatives, taking into consideration all identifiable risks, an option-based ICT investment decision index (IDI) has been developed. Use of IDI would be easily adopted on the basis of two factors: first, the top-level decision-making style of EAC headquarters that involved a systematic search for opportunities and anticipation of problems; and secondly, the operations at EAC headquarters were mostly controlled by information systems. The EAC headquarters had stated that it systematically considered the costs and benefits of options to ensure that specific goals were achieved efficiently. The EAC headquarters emphasised effectiveness, long-term planning, and careful screening of investments in order to minimise risks, which IDI supports.

Option-based ICT Investment Decision Index (IDI)

The approach we present arises from the fusion and application of the research done by Benaroch (2002) on the option-based methodology for managing IT investment risk and that of Alleman J. et al. who developed an investment criterion incorporating real options. This was necessitated by the fact that policy-makers and CEOs are experiencing a lot of difficulties when it comes to making decisions related to ICT investments. IDI is expected to provide a simple and reproducible ground upon which decisions can be based, instead of relying on instinct and gut feeling (see Fig. 3). A decision is arrived at after going through five steps. The first three steps ensure that risks associated with all identifiable investments are known and understood. Step IV computes IDI for each investment. Step V applies the decision criterion to provide and interpret IDI to the policy-makers and CEOs in the form of a simple Do Not Invest, or Wait and Watch, or Invest Carefully, or Invest. A do-not-invest decision means forfeiting that option, perhaps due to the numerous risks involved, the lack of sufficient benefits, if any, and its unsustainability. An invest decision means there is a great future, the necessary capacity is available and the risks associated with investment are identified, understood and can be handled. A wait-and-watch decision should be execute if the investor has no competitor envisioned. The invest-carefully decision has different roadmaps that implements it, which are stated and explained in Table 20.3.

Table 20.3: Invest Carefully Decision

Decision	Roadmap	Basic Conditions Required
Invest Carefully	Develop in Stages	• Modular and stepwise development approach possible • Development steps have varying risks levels • No requirement on order of development of modules
	Pilot/Prototype	• Reduced scope of investment possible • There is need to study certain risks
	Outsource	• Investment does not involve core business processing and capabilities of the organization • Need to concentrate on the core business of the organization • Skilled human resource is lacking
	Lease	• If investment resources can be leased.

In the case of EAC headquarters where adequate information on the cost of different aspects of ICT adaptation and utilisation exist, applying, stock option theory (Mairav, 2000), the assets' current value (S), time to expiration (G), exercise price (K), volatility (Q) and the risk-free rate (r) could be identified; consequently, the Investment Decision Index (IDI) d can then be computed. Hence, knowing S, K and Q could provide enough information to make sophisticated decisions under uncertainty once expressed in the form of a decision-making index d. Therefore this can be very useful to policy-makers and chief executive officers (CEOs) as an indicator for basing on their investment decisions.

Benefits of IDI

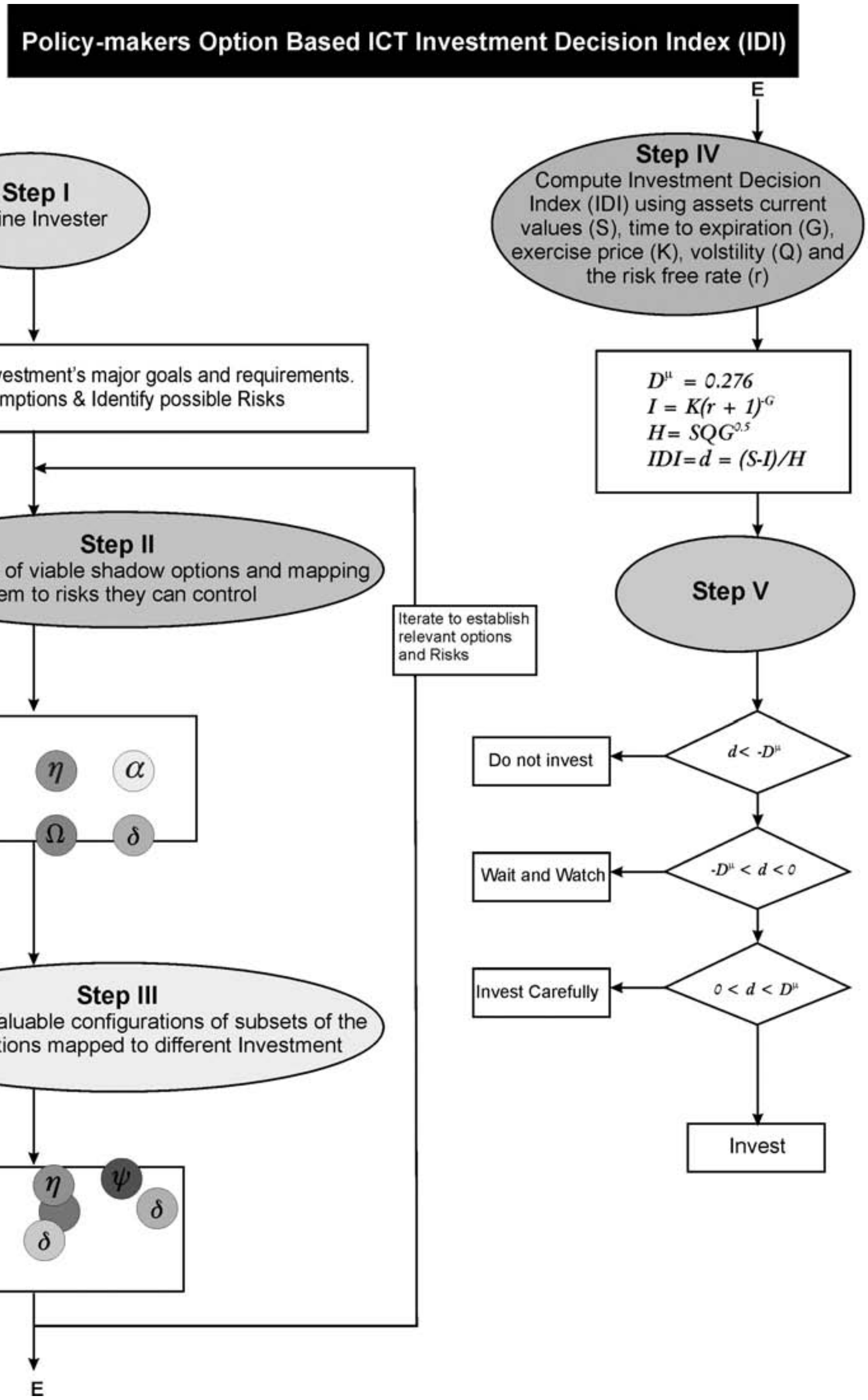
In order for governments, private sector and financial institutions to support ICT initiatives and project investments, they need to be structured. They also need to have been analysed and therefore use of IDI would ensure to a greater extent that the risks involved are qualified and understood. The Africa Development Bank (ADB) could act as an information source on some of the key parameters that go into the formation of IDI. If ADB appreciates the benefits of using IDI, it could make it mandatory regarding all ICT initiatives it approves for funding that they apply IDI in their selection of viable, feasible and sustainable initiatives. Use of IDI would enable ADB to fulfil its roles effectively such as the mobilisation of funds and direct foreign investments in Africa, encouragement of regional co-operation through initiating development and funding of regional projects so as to enhance integration, and encouragement of private-sector involvement in infrastructure development (Urua, 2004).

If financial institutions appreciate the use of IDI as a decision-support method that takes into consideration possible risk factors that are quantified and understood, application of IDI in identifying feasible ICT initiatives would convince financial institutions and development partners to fund such initiatives. This is because the possible risks would have been identified in advance, understood, and the best option selected, before any financial request and commitment are made. Therefore, the perennial problem of financial limitations would reduce.

Kenya and Uganda are members of COMESA. One of the COMESA ICT policy objectives is to create an integrated market that will attract investment (Dafalla, 2004). Increase in private sector investment and foreign direct investment (FDI) is among the key benefits expected from the COMESA ICT policy. Creating an integrated market alone is not sufficient to attract investments into ICT sector that embeds a lot of risks. This requires that mechanisms and methods that consider risks, which can help establish feasible ICT initiatives that can be translated into real investments, need to be developed. Therefore, IDI as a method and a tool for arriving at feasible and real investment can greatly contribute towards the realisation and exploitation of the COMESA ICT policy objective of creating an integrated market. IDI can contribute as follows to enable:

- financial institutions make decisions to support ICT initiatives
- policy-makers and CEOs commit themselves and institutions on ICT initiatives
- attraction of FDI into ICT initiatives
- exploitation of an integrated market
- promotion of development through facilitating good decision-making
- indirect promotion of access to ICT services
- promotion of adoption of new technologies

Fig.20. 3: Policy-makers' Option-based ICT Investment Decision Index (IDI)



Key ICT Policy Actors

It is important to note that the key actors in ICT policy formulation can in broad terms be categorised into four, namely: government, the private sector, civil society and academia. A general observation made seems to find academia making their contribution last of all or not at all. In our view, academia is best placed to understand what is best for its country through research and should be at the forefront. Taking the case of Kenya, the government view of ICT policy came first, the private sector and civil society came second, leaving academia in the last position. The Ministry of Planning and National Development together with IDRC, took the initiative to organise and conduct an ICT policy research whose findings were to be factored into the final national ICT policy. We need to see not only government contributions and suggestions backed up with research, but also those of private sector and civil societies. Most of the sub-regional and national ICT conventions, conferences and workshops had no presentations based on research. Over 80% of the presentations were from the private sector, civil societies and vendors without any indication of support from research or collaboration with academia. This trend needs to be reversed if a useful and reliable way forward has to be charted from such gatherings.

E-governance Framework

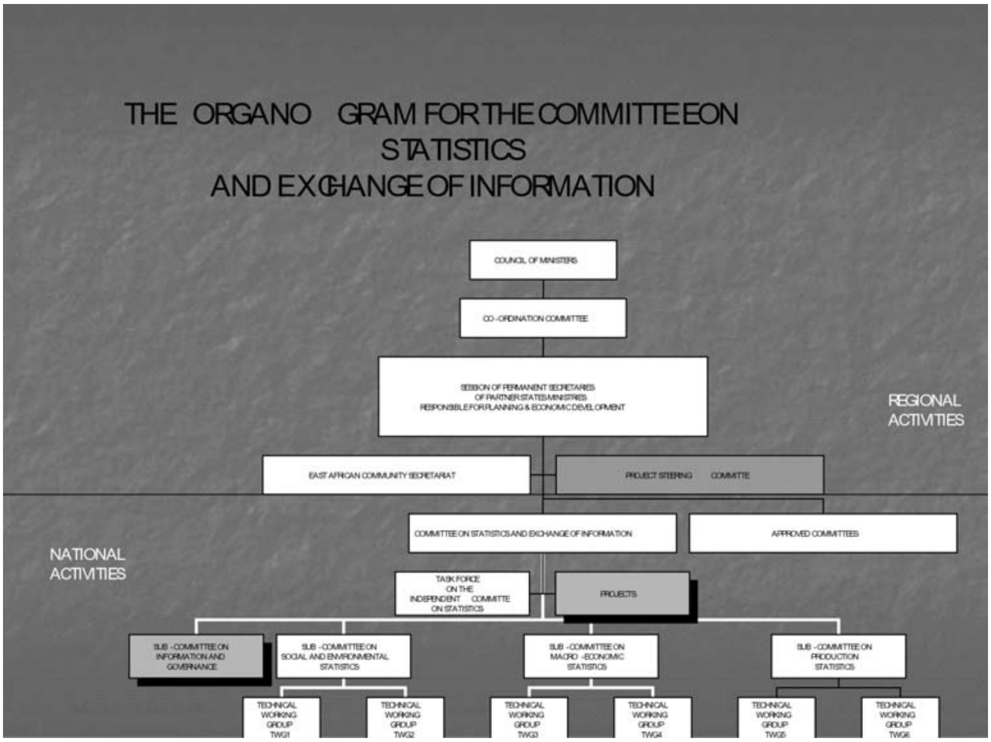
E-government is defined as delivery of government services and information to the public using electronic means, whereas e-governance goes beyond this to allow direct participation of constituents in government activities.

The high failure rate of information systems of well over 50% the world over is one reason why many researchers are currently taking a more holistic approach to corporate ICT as the failure implies low returns on ICT investments, affects business continuity and eventually tarnishes the image of the technology. The public sector in developing countries, having less capital at its disposal for ICT investments, cannot afford such liabilities as such failures would also affect public confidence. The e-governance model is an attempt to bring some degree of coherence to planning and developing public sector ICT projects so that the drivers (policy-makers) who understand the processes they wish to automate are not at the mercy of the technical specialists or the marketing agents. The model enables the decision-makers to be masters of the process, precisely because the information architectures, information-system architecture, data architectures and the ICT delivery system architectures (hardware, software and network) emanate for various classes of end-users, determined by security and access rights considerations, including the wider society.

The e-governance model developed is generic. In considering the EAC, the impact is sub-regional. Moreover, if the EAC adopted this model, it would assist further in its ICT strategy, and this could have a significant effect on the ICT best practices in the partner states since EAC data is aggregated national data.

The generic e-governance model is applicable at the EAC. Since in some applications the statistical data emerges from the partner states Kenya, Tanzania and Uganda, and is collated at the EAC, all are beneficiaries as the partner states provide the input and the EAC system produces the deliverables. Furthermore, the partner states are affected by the quality of the decision based on the integrated information. See Fig.20. 4 on the possible areas of applications. However, with a unified, generic view of EAC processes to be automated, the EAC Organo Gram structure below (which is a time-honored public-service way of dealing with data) may well have to be reviewed and the processes re-engineered to bring about greater effectiveness and efficiency.

Fig 20.4: EAC Organogram for Committee on Statistics and Information Exchange



The following holistic and stepwise approach to reformation is suggested: the EAC must first re-identify its information needs that will help it achieve its organisational reform objectives. The kind of information needs will determine the role of IT and specify the accompanying information systems. The reform objectives can be categorised into four phases: automation, optimisation, reengineering and transformation (Heeks, 2003). Each phase is derived from the type of change sorted. The automation phase involves changing from manual operations to IT operated via the deployment of information systems. As a result the same things are done but with greater efficiency, faster and more cheaperly. The optimisation phase involves changing applications by rationalising data structures and weak processes. Under optimisation, the information systems cost and personnel are closely controlled to ensure better ways of doing the same things. The reengineering phase is where redesigning data structures and work processes changes the organisation. Here, information systems are coordinated in such a way that the same things can be done in radically different and better ways. Finally, the transformation phase implies changing the organisation by completely transforming data structures and work processes so as to produce new things.

The EAC had a project of establishing the EAC statistics database (Henrik, 2002). The project was carried out in year 2001-2002. The purpose of the project was:

- To facilitate the development of regional statistics
- To initiate the production and dissemination of regional statistics
- To make recommendations and implementation plans for the future

Each member state had its own National Bureau of Statistics. There were no automated means of delivering these statistics to the EAC secretariat. By deploying a powerful IBM database web server at the EAC Secretariat running the Windows 2000 server, MS Internet information server and the PX Web statistical dissemination software system, and delivering PX for data entry and conversion at the national statistical offices (and other data producers), the EAC has implemented the automation phase. The automation phase ensured that statistical survey data is typed into the computer and tabulated by computer and not by hand. The EAC, after it successfully automated the manual process, embarked on the optimisation phase where it was expected that the survey forms and data entry screens would be simplified and the regional offices fitted with networked computers, which enable direct entry of data by field staff instead of central entry by a pool of clerical staff at EAC headquarters. In order to realise optimisation, The EAC deployed PC Axis software at the EAC secretariat for merging and elaborating the data from the partner states. Data harmonisation had not been completed by the time the project stalled. If the EAC succeeds reviving the project and taking it through the remaining phases, that is reengineering and transformation, then we should expect that during the reengineering phase, survey questions will be redesigned to provide the information that is needed by the bureau and its clients. The computer systems of the separate sectoral analysis departments will also be redesigned and linked to ensure availability of all data sets across the whole sub-region and there will be minimum duplication of information between departments or sectors. It is expected that a new central analysis department will be created to analyse the cross-sectoral trends.

In the last phase, which is transformation, the EAC statistical database is expected to become the EAC Statistical System that will now operate as an agency for statistical services for the entire sub-region. In this capacity, the agency can provide income-generating statistical services for foreign and local private firms. These services can include annually-updated CD-Roms of sub-regional and national data sets; access to certain sub-region and national data sets via the Internet; and an on-line analysis of services for the provision of customised trend analysis and reports. Developing the EAC Statistical System will obtain great support, for instance, from the already forming National Statistical System in Kenya. Kenya, as a sub-regional member state, has realised the importance of having a properly coordinated bureau of statistics that provides accurate, consistent and timely statistics. Only quality statistics can enable tracking of progress being made towards meeting development goals and targets on poverty reduction, job creation, housing, agricultural production, health, education, transport and communication, among others (Central Bureau of Statistics, 2003).

The establishment of the proposed EAC Statistical System would contribute to the development of the economic and social integration of EAC partner states, especially through improvement of the EAC secretariat's ability to monitor and evaluate the impact of the decision made by the EAC Council of Ministers. Emerging trends and factors responsible for any deviations would easily be monitored and remedial measures designed in time.

Figure 5 shows the information systems that were in place at the EAC headquarters. The Monitoring Council Decision System (MCDS) Adlib, can be seen supporting the entire process activities (Lucy, 1997). Table 5 shows MCDS sectional process activities mapped onto their corresponding section architectures of the generic e-governance model shown in Fig 20.6.

Fig 20.5: EAC Headquarters Information Systems

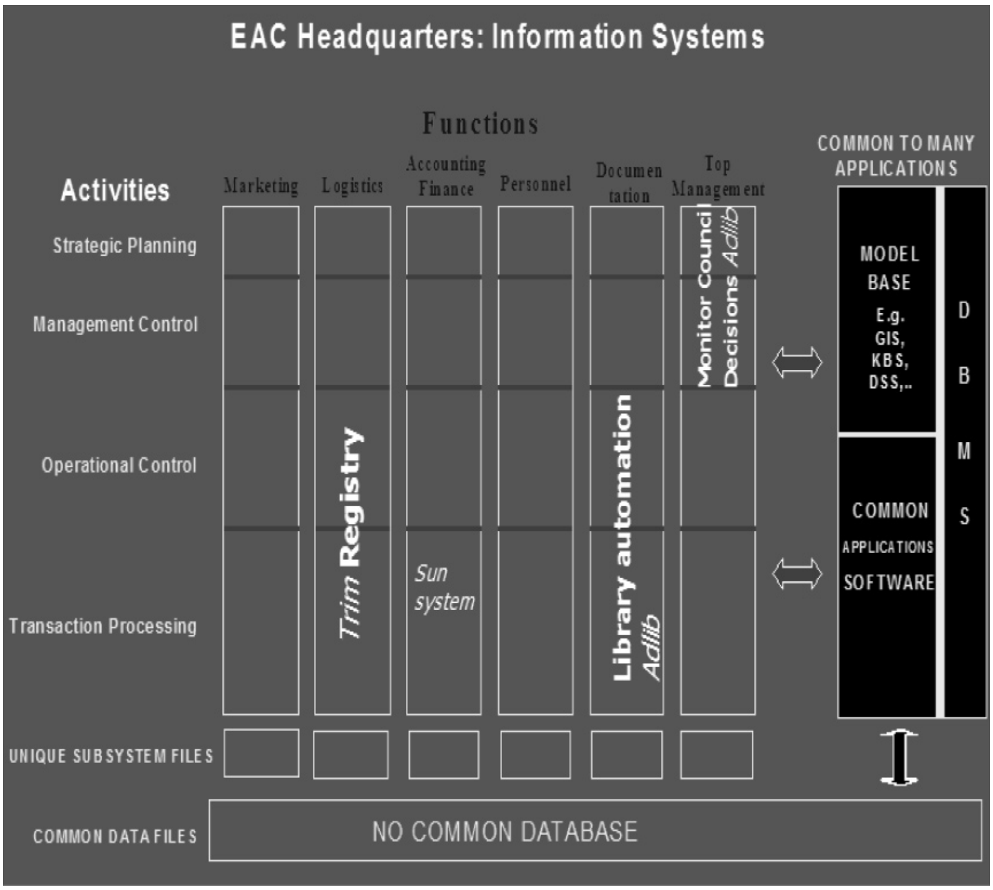
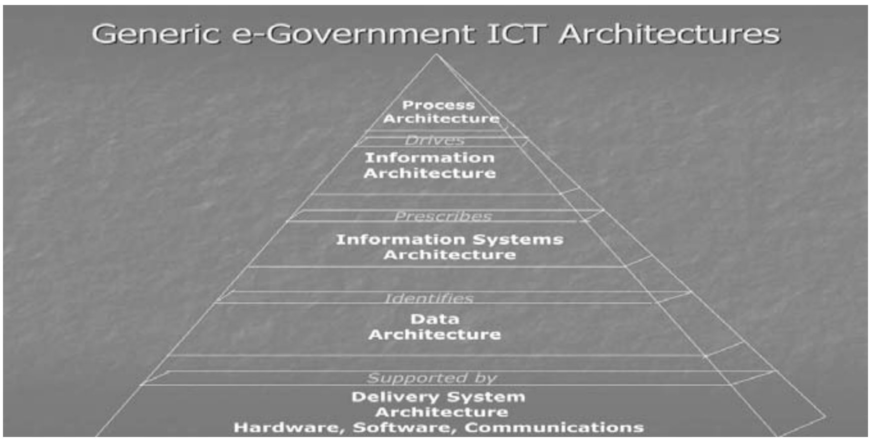


Table 20.5: Mapping Organisational Process Sections of the MCDS on the Generic E-governance Model

Organizational Process	MCDS	Generic e-governance Model
Strategic Planning	Monitor Council Decisions	Process Architecture
Management Control	Track Minutes of Council meetings	Information Architecture
Operational Control	Customized *Adlib* (Library System)	Information System Architecture
Transaction Processing	Extraction of Council Decisions	Data Architecture
	LAN, Customized Adlib, client server configurations	Delivery System Architecture (Hardware, Software and Infrastructure)

Fig.20.6: Generic E-governance Model



Going through the various architectures of the e-governance model, a data architecture will facilitate a database from which will be produced not only pre-specified reports but also adhoc reports and queries. The current categorisation of production, macro-economic, social, environmental and governance (planned) information, as it now appears to be (see Fig.20.4), may well have to change or be restructured to reflect new generic, integrated and modular design paradigms. Furthermore, once the generic e-governance model is adopted by the EAC, the applications can be outsourced to the private sector provided the blueprint below is followed, in particular the development of stages iii), iv) and v) below which are prescribed by stage ii) immediately above, and which in turn is driven by the processes of EAC.

i) What processes should be automated in e-governance? Process architecture.

ii) What information is needed to accomplish these processes? Information architecture.

iii) How are the processes and information related? Information systems architecture.

iv) How is the data managed? Data architecture.

v) Which hardware, software and networks are required? Delivery system architecture.

Derived Policy Statements for EAC

The following EAC sub-regional ICT policy statements have been suggested after carefully studying the EAC sub-region member-states' national ICT policies, COMESA ICT policy, and the ICT status of the EAC headquarters and its autonomous institutions. These statements can be considered when formulating the EAC sub-regional ICT policy, which is currently ongoing.

1) The EAC will promote and enhance the development of qualified personnel for smart policy-making, regulation and management of information resources and services, including education and training.

2) The EAC will encourage ICT investment and adoption based on evaluation that take into consideration all risk factors and apply the best option (Urua, 2004).

3) The EAC will promote partnership with the private sector and development partners to stimulate use of ICT and the development of ICT infrastructure in the sub-region.

4) The EAC will support the review of existing laws and regulations in order to support the ICT industry and enact new laws that take into consideration Internet governance and the convergence of telecommunication, broadcasting and information systems.

5) The EAC in collaboration with its member-states and key ICT stakeholders will develop and establish an appropriately designed scheme of service for different cadres of ICT personnel in order to secure their retention and promote innovation.

6) The EAC will promote utilisation of all installed ICT infrastructure to be optimally utilised and synchronised.

7) The EAC will encourage its member-states to annually allocate funds equivalent to a reasonable proportion of their GDP for ICT deployment, diffusion and universal access in partnership with the private sector and development partners.

8) The EAC will participate and support COMESA ICT initiatives in order to maximise the benefits of increased capacity and low cost (Osakonor, 2004).

9) The EAC will encourage adoption of e-applications based on proven conceptual frameworks.

10) The EAC will promote sharing of sub-regional information and data through the provision of timely and quality statistics. Quality statistics would help monitor development goals, poverty alleviation, job creation, housing, agricultural production, health, education, trade, communication, transport and emerging trends, among others (Central Bureau of Statistics, 2003).

Conclusion

Owing to the fact that real-world technology investments usually embed multiple interacting options, policy-makers and CEOs experience difficulties in making reliable and sound decisions. The IDI concept presented in this paper, besides the benefits stated earlier, could enable them to control the balance between the risk and the reward characteristics of ICT investments. However, the IDI model needs to be tested. We recommend that required data be collected and the model applied.

The EAC headquarters should consider establishing an EAC Statistical System, particularly for the purpose of building capacity to monitor and evaluate the impact of the decisions made by the EAC Council of Ministers.

Now that key information systems at the EAC headquarters such as MCDS mapped well on the developed generic e-governance model, we recommend that the EAC headquarters and any other organisation should be encouraged to adopt this model on condition that they are able to identify the organisational processes and their respective architectures addressed in the model.

The EAC secretariat together with the regulatory authorities are conducting a study on the Harmonization of the Regional Communications Regulatory Strategy. However, it is important to note that capacity-building for regulation has remained elusive. What we mean by capacity-building in this case is the identification and implementation of institutional and management processes that make regulation effective and efficient (CRC Policy Brief, 2005). In order to achieve this, the regulatory authorities in the EAC sub-region should strive to plan and manage regulatory processes to ensure at the very least, that they meet the commercial standards demonstrated by the ICT private sector, if regulatory regimes are to satisfy the needs of both customers and suppliers, and are sensitive to the EAC sub-regional economic interests.

Acknowledgement

The authors are grateful to the United Nations Economic Commission for Africa (UNECA) for funding the Software Research in E-Government: A Pilot Project for East Africa. It was during the implementation of this project that the authors of this paper felt the effect of operating in an EAC sub-regional ICT vacuum, which culminated into the writing of this paper. They also recognise the roles played by the following institutions: the Inter-University Council for the East Africa (IUCEA), the East African Community (EAC), University of Nairobi (UoN), Makerere University (MAK) and the University of Dar-es-Salaam (UDSM). Their contributions provided a solid base in terms of data upon which this paper has been built.

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Appendix

The President of The Republic of Uganda's Opening Speech 9 August 2005

His Excellency Yoweri Kaguta Museveni

Your Excellencies
Hon. Ministers present
Vice-Chancellor, Makerere University
Distinguished participants,
Ladies and Gentlemen.

I must, first of all, express my profound pleasure at being invited to participate in this important first Annual International Conference and Workshop on Sustainable ICT Capacity in Developing Countries.

During the last century, the developed world changed from an agricultural society, where manual labour was a critical factor, to an industrial society, where the management of technology, capital and labour provided a competitive advantage.

In the last decade the information era was born. This is where ICT systems became the driving force of the economies of the developed countries.

Increasingly, delivery of and access to updated information is becoming a key ingredient of success in all sectors of development. Although the internet has been identified, and continues to be a powerful channel for information delivery and sharing all over the world, its full use has not yet reached the bigger majority of the developing world's population.

Extensive and fundamental change is the natural order and to wake up to that reality is to understand that all organisations and individuals, without exception, must lead the change or be led to extinction. Manifestations of change are all around us, whether in computers, telecommunications or biotechnology. We believe very strongly that the Internet has the potential not only to revolutionise the way government operates, the way it performs, but also to revolutionise the relationship between citizens and their governments and to give people a chance to participate in ways that have not been possible before.

Today a new society, I am told, is emerging where knowledge is the primary production resource, instead of capital and labour. This society is called the knowledge society. The knowledge society is powered by innovative capacity and it relies heavily on ICT to create and maintain the knowledge infrastructure and to develop human resource and enhance its productivity.

The government, which I lead, has not yet arrived at the stage of being a knowledge society.

It is my strong desire and my government's intention that we should run where our counterparts in the developed world used to crawl. By this I mean we should leap into the knowledge society. We should create knowledge and deploy it in all sectors like agriculture, industries, healthcare, poverty eradication e.t.c. My presence at this conference is a testimony that I want this society created in this country.

We in this country cannot afford to ignore the impact of the digital divide as it divides the "haves" from the "have-nots". Those who do not have the opportunity to access or develop ICT skills are increasingly excluded from the knowledge economy, jobs and government processes, leaving them disempowered. It is a known fact that ICT gives us the means and opportunity to break down the walls of division and the barriers of isolation by putting the equipment, as well as the opportunity, directly into people's hands. We can break down the barriers that prevent people from realising their potential. I call upon you at this workshop to debate and come up with an agenda on how ICT can be used in poverty eradication. The people need specific answers to the following questions:

1. What are the areas that hold great potential for using ICT for poverty eradication?
2. What are the strategies that should be adopted for using ICT for poverty reduction?
3. How can the poor be provided with access to ICT-based information and services and how can they be empowered to use ICT for their livelihood?
4. What could be the role of community internet access in poverty eradication and how could such access be funded?
5. How can the local community be involved in managing and adopting ICT for poverty eradication?
6. What should be done to provide a local language to interface with ICT to help the poor?

ICT can contribute to income generation and poverty eradication. I have heard of a number of success stories that bear testimony to the use of ICT in poverty eradication. This workshop should create a framework for successful diffusion of ICT. The ability to utilise ICT by our countries will greatly facilitate the process of dealing with issues of social equity, and help in addressing the needs of disadvantaged people. The government has put in place a policy framework and gone to great length to develop infrastructure for connectivity. We have also removed taxes on computer equipment and software imported into the country. Plans are in place to attract investors to start more ICT-related industries through the Presidential Investors Round Table (PIRT) whose ICT working group has made several recommendations, most of which have been implemented.

My government encourages and supports broad partnerships at global, regional, national and local levels to develop ICT infrastructure and the production of a skilled workforce.

I know that the risks of embracing ICT are high but so are the rewards. I have seen in both the local and international media that at times ICT promotes immorality and also affects our cherished cultures. You the scholars and technocrats can help us eliminate these vices. We need to use the positive power of ICT to address economic and social divides.

In conclusion let me state that the information society is about understanding problems and looking at possible solutions that technology makes possible. Technology has opened up many new doors to rich sources of information and knowledge. We must ensure that all our citizens enjoy the benefits and opportunities that an inclusive people centred information society offers.

I congratulate and commend the Makerere University Faculty of Computing and Information Technology on hosting this first Annual International Conference and Workshop on Sustainable ICT Capacity in Developing Countries. The Uganda Government is committed to ensuring that whatever resolutions and commitments are made at this gathering bear fruit.

I now declare this conference officially opened.

For God and My country.

Glossary

a backup is a copy of software or data.

ad hoc reports are issued in reply to a special request, in contrast with periodical reports.

Advanced Research Projects Agency is a US Department of Defence agency responsible for initial sponsorship of the Internet.

an application program is a set of computer instructions written in a programming language, the purpose of which is to provide functionality to a user.

an audit is a regular examination or check of systems, their inputs, outputs, and processing.

an audit trail lists all changes made to a file for checking or control purposes.

analogue is information represented as a continuously changing physical quantity, such as a radio signal.

application controls are designed to protect specific applications.

an application portfolio is the collection of corporate IT applications, sometimes including those under development.

artificial intelligence (AI) is a sub-field of computer science concerned with symbolic reasoning and problem-solving. Artificial neural network (ANN) is a computer technology attempting to build computers that will operate like a human brain. ANN programs can work with ambiguous information. Artificial intelligence techniques enable computer-based systems to respond in similar ways to intelligent human beings.

an asynchronous transfer mode is a network communication technique capable of handling high bandwidth multimedia information applications, including video.

an automatic teller machine is a device for delivering cash and carrying out other transactions for authorised customers using, say, a bank or credit card.

backbone is the long-distance, high-capacity and -speed network that links the major Internet computer nodes.

bandwidth is an indication of the amount of information a telecommunication channel can carry (usually measured in bits per second).

batch processing processes inputs at fixed intervals as a file and operates on it all at once; interactive (or on-line) processing operates on a transaction as soon as it occurs.

behaviour-oriented chargeout system sets IS service costs in a way that encourages usage consistent with organisational objectives, even though the charges may not correspond to actual costs.

best practice benchmarks identify activities and methods that the most effective organisations use to operate and manage various IS functions.

biometric controls are security controls that involve unique physical or behavioural characteristics of people, such as fingerprints, voice, the face structures or the iris.

bit (bi)nary digi(t) is used in a mathematical system that recognises only two states, typically represented as “0” or “1”.

broadband telecommunication medium is like optical fibre, which can cope with the large volumes of data required for multimedia applications.

bulletin board system is a computer system allowing users of an electronic network to leave messages that can be read by many other users.

business pressures are forces, such as global competition, in the organisation’s environment that create pressures on the organisation’s operations.

business process is a collection of activities that take one or more kinds of inputs and create an output.

business process re-engineering (BPR) is a methodology for introducing a fundamental change in specific business processes, usually supported by an information system. Business systems planning (BSP) concentrates on identifying problems and related decisions, based on business processes and data classes (an IBM methodology).

business process re-engineering is an pproach to restructuring organisations by optimising the processes needed to meet specific goals, which often requires changing existing departmental boundaries.

byte is a number of bits (usually eight) used to represent an alphanumeric character.

CCITT is an international standards-making body representing telecommunications operators, suppliers, and other interested parties.

CD-ROM (compact disc-read only memory) is a secondary digital storage medium that uses laser-made pits in plastic represented bits.

cellular radio is a mobile-telephone service which divides the areas covered into small cells to assist in managing the network efficiently.

central processing unit (CPU) is the “brain” of a computer controlling all computational, input, output, and wage activities.

centralised computing puts all processing and control authority within one computer to which all other computing devices respond.

centralised IS refers to the corporate information systems department which controls the shared IT, such as corporate infrastructure, from a central location.

channel systems is a network of the materials and distribution system within an organisation, and between the organisation and its suppliers and customers.

chargeback systems treat the MIS function as a service or utility charging organisational sub-unit for JIIS - with the objective of recovering MIS expenditures.

chargeout (*see* **chargeback**).

Chief Information Officer (CIO) is the director of a department in a large organisation, analogous to **Chief Knowledge Officer**.

circuit switching is a way of linking systems and devices on a network by directly connecting transmission circuits, as with traditional telephone exchanges.

client/server architecture is a type of distributed client server where end-user PCs (clients) request services or ignated processors or peripherals (servers).

coaxial cable is a transmission medium used for cable networks, with a bandwidth narrower than optical fibre but broader than copper wires.

code of ethics is a group of ethical behaviour required by organisations or by professional societies.

collaboration is defined as the mutual efforts between individuals or teams who perform related activities in order to accomplish them.

common carrier is a telecommunications network supplier which carries communications from others.

competitive advantage is an advantage such as lower cost or quicker service delivery.

computer conferencing is a group discussion based on the exchange of electronic messages on a computer network.

computer integrated manufacturing is the use of computers and networks to support all aspects of the manufacturing process.

computer-aided software engineering is a set of methods, techniques, and tools which seek to apply engineering rigour to software development.

cross-subsidy is the use of revenues from a profitable activity to support unprofitable ones, for instance to support telecommunications in remote areas.

cultural imperialism is a strong influence by one country or group of countries through the domination of electronic media, production and distribution.

cyberspace is a term indicating the virtual universe created by digital information flows.

cycle time reduction refers to the reduction of the time required to execute a task or produce a product. It is usually done by using information technologies.

data are raw facts that can be processed into accurate and relevant information.

data communications is the process of exchanging data or information electronically.

data conferening refers to data sent along with voice and/or video.

data encryption is encoding data so that they cannot be understood unless they are decoded; it is used to protect data from unauthorised users.

data integrity is the accuracy and accessibility of data.

data mart is a subset of the data warehouse, usually originated to a specific purpose or major data subject.

data mining is the process of searching for unknown information or relationships in large databases using tools such as neural computing or case-based reasoning.

data quality (DQ) is a measure of the accuracy, objectivity, accessibility, relevance, timeliness, completeness, and other characteristics that describe useful data.

data tampering is deliberately entering false data, or changing and deleting true data.

data visualisation refers to visual presentation of data and information by graphics, animation, or any other multimedia.

data warehouse is a repository of historical data, subject-oriented and organised, integrated and from various sources, that can easily be accessed and manipulated for decision support.

database is a collection of files serving as a data resource for computer-based information systems.

database management system (DBMS) is a software program (or group of programs) that manages and provides access to a database.

decentralised computing breaks centralised computing into functionally equal parts with each part essentially a smaller, centralised sub-system.

decision room is an arrangement for a group DSS in which terminals are available to the participants.

decision support system (DSS) is a computer-based information system that combines models and data in an attempt to solve semi-structured problems with extensive user involvement.

decryption is the restoration (uncoding) of scrambled data into the original format using some key.

Delphi method is a qualitative forecasting methodology using anonymous questionnaires done in several iterations to find consensus.

dial-up access is connecting to a network by dialling rather than being connected to it permanently.

differentiation (of product or service) is a strategy of gaining a competitive advantage by providing a product (or service) of the same cost and quality as a competitor, but with some additional attribute(s), that makes it different from the competition. A digital signature is added to electronic messages usually encrypted in the sender public key.

digital compression refers to techniques which enable large amounts of information to be sent using fewer bits.

digital is represented by strings of "1"s and "0"s, such as data used by digital information and communication.

direct satellite broadcasting is the transmission of television programmes directly from a satellite to an antenna TV set.

disaster avoidance plan is a comprehensive plan to avoid a controllable catastrophe in the corporate information systems. A disaster recovery plan is a plan to operate an IS area after a disaster (such as an earthquake) and to restore the functioning of the systems.

distributed computing breaks centralised computing into many semi-autonomous computers that may not be (and usually are not) functionally equal.

distributed processing (*see* **distributed computing**) **document management** refers to the automated management and control of digitised documents throughout their life cycle.

download is to retrieve an electronic document or software file across a network.

drilldown is the ability to investigate information in increasing detail, e.g. to find not only total sales, but also sales by region, by product, or by salesperson.

edutainment is the delivery of education on line in combination with some entertainment. It combines learning and fun.

electronic banking (see **cyberbanking**).

electronic bartering is the electronic exchange of commodities and/or services between business and business or business and consumers.

electronic benefits transfer (EBT) refers to the transfer of direct payments made by the government to recipients' bank accounts or smart cards.

electronic bulletin boards are public-access electronic mail message centres where authorised people can leave messages for everyone to read (e.g. interest groups on the Internet).

electronic cash (e-cash) is a computerised stored value that can be used as cash. It is stored on a smart card or on a computer's hard drive.

electronic catalogues refer to vendors' catalogues available on line. Electronic certificates are provided by a trusted third party, verifying that specific public encryption keys belong to specific individuals.

electronic cheques (e-cheques) enable payments to be made with electronic rather than paper cheque s.

e**lectronic commerce (e-commerce)** is the exchange of products, services, information, or money with the support of computers and networks. It is business done on line.

electronic communities refers to groups of people with similar interests who use the Internet to communicate or collaborate.

electronic credit cards allow on-line payments with the characteristics of regular credit cards (e.g. payment within 30 days).

electronic data interchange (EDI) is a computer-to-computer direct communication of standard business transactions between or among business partners.

electronic data interchange is the ability to exchange information, such as orders and invoices, between users and providers electronically.

electronic democracy refers to the application of electronic voting system democratic processes.

electronic funds transfer (EFT) is the transmission of funds, debits and credits, and charges and payments electronically between banks and their customers.

electronic mail (e-mail) is computer-based messages that can be electronically manipulated, stored, combined with other information, and exchanged with other computers.

electronic mall is an on-line shopping centre with many (sometimes thousands) stores on one Web site.

electronic markets are the networks of interactions and relationships where products, services, information, and payments are exchanged.

electronic purse (or **wallet**) refers to the device that enables the storage and distribution of e-cash.

electronic retailing refers to on-line selling of products or services to individuals; it is similar to regular retailing.

electronic surveillance refers to the tracking of people's activities, on-line or off-line. It is often done with the aid of computers (e.g. monitoring e-mail).

encryption is the scrambling of data so that they cannot be recognised by unauthorised readers.

ends/means analysis (e/m analysis) determines information requirements based on desired ends (effectiveness) and the available means (efficiency) to achieve the ends. Enterprise-computing (or enterprise-wide systems) are information systems that are used throughout the enterprise.

end-user computing is the use or development of information systems by the principal users of the systems' outputs or their staffs.

enterprise resources planning (ERP) is an integrated process of planning and managing of all resources and their use in entire enterprises. It includes contacts with business partners.

enterprise software is an integrated software that supports enterprise computing. Most notable is SAP R/3, People Soft etc.

enterprise-wide system is one that encompasses the entire enterprise. It is implemented on a company-wide network.

entities are people, places, or things about which we want, collect, store, and maintain information.

ergonomics is the science of adapting machines and work environments to people.

ethics is a branch of philosophy that deals with what is considered to be "right" and "wrong".

ethnography is a social science method for analysing group behaviour through observation, for example by observing a work environment when new technology is introduced into it.

ethnomethodology is a form of ethnography employing a range of systematic techniques for recording and studying group behaviour.

executive support system (ESS) is an executive information system that includes some analytical and communication capabilities. **Executive information systems (EIS)** are specifically designed to support executive work.

expert system is an artificial intelligence technique for developing software incorporating human expertise in a particular subject.

file transfer protocol is a standard for exchanging computer files across the Internet.

flexible manufacturing systems refer to the application of information and communication technologies to tailoring production relatively easily to different customer requirements.

Fordism refers to rigid, routinised assembly-line work processes, based on Taylorism, which Henry Ford introduced in the early twentieth century to build cars.

global business drivers are entities that benefit from global economies of scale and add value to a global business strategy.

geographical information systems use spatial data such as maps, and can combine this data with other text, images and symbols.

graphical user interface uses icons and pointer devices to simplify users' interaction with a computer, as in Microsoft Windows and Apple Macintosh systems.

group DSS (GDSS) is an interactive, computer-based system linking solutions to semi-structured problems by enabling decision-makers to work together as a group.

groupware tools is a generic term for several computerised tools that aim to support people working in a group setting.

hacking refers to accessing a computer-based system unlawfully.

heuristic design or **prototyping** is an approach to systems development that exploits advanced technologies for using trial-and-error problem-solving.

hidden unemployment refers to cases in which people are considered fully employed but actually work only part of the time.

hierarchical model relates data by structuring data into an inverted "tree" in which records refer to a senior field and any number of subordinate fields (i.e. one "parent" and several "children").

hierarchical organisation is a traditional multilevel structure, like a military command, with each level supervising the level below it.

high-definition television refers to television pictures with a high resolution involving the presentation of more information on a screen to give sharper images than traditional lower-resolution images. This requires higher bandwidth networks.

hyperlink is the process of automatically moving from a certain Web page to another by clicking on a highlighted word or icon.

Hypertext Mark-up Language (HTML) is a programming language that uses hypertext to establish dynamic links (*see* **hyperlink**) to other documents stored in the same or other computers on the Internet or intranets.

icons are pictures of features or functions that can be graphically "selected" for execution.

imperfect information is information that improves your knowledge, but does not tell you the results for sure.

increasing returns is a concept in economics that points to increased benefits with the volume of operation (the larger, the better).

inference engine is the part of an expert system that performs a reasoning function.

information and communication technologies are all the different kinds of electronic systems used for broadcasting, telecommunications, and computer-mediated communications.

information architecture is a conceptualisation of the manner in which information requirements are met by the system.

information content is an approach to identifying strategic information systems by the importance of the information to the organisation.

information economics is an approach to cost-benefit analysis that incorporates organisational objectives in a scoring methodology to assess more accurately the value of intangible benefits.

information economy is an economy in which the processing and transmission of information is a prime activity.

information engineers are specialists in IT architecture design.

information infrastructure is the physical arrangement of hardware, software, databases, networks, and so forth. It is the provision of underlying network capabilities to support a variety of services based on computing and telecommunications capabilities.

information is data that are processed or operated on by a computer.

information privacy refers to privacy issues related to the use of information systems, such as invasion of privacy in databases.

information requirements are those items of information needed by information systems users for decision-making.

information service provider is an organisation, group, or individual who creates and packages information content carried by electronic networks.

information sharing refers to users permitting each other to view the information in their possession.

information society refers to the increasing centrality of ICTs to all forms of social and economic activity.

information superhighway is a national information infrastructure to interconnect computer users.

information systems controls are used to counter computer hazards (such as crime and human errors).

information technology (IT) is the technology component of an information system (a narrow definition), or the collection of the entire system in an organisation (broad definition used in this book).

information technology architecture is the field of study and practice devoted to understanding and planning information systems components in the form of an organisational infrastructure.

information technology is computer-based techniques that are designed to store, process, manage, and transmit information.

input device is a computer system component that accepts data from the user (e.g. a keyboard or mouse).

input/output (I/O) device transfers data into or out of a computer.

inputs are the resources introduced into a system for transformation into outputs.

integrated CASE tools support prototyping and reusable systems components, including component repositories and automatic computer code generation.

integrated circuits are interconnected layers of etched semiconductor materials forming electronic transistor circuit units with "on-off" positions that direct the electrical current passing through them.

integrated digital services network is a service using digital techniques throughout the network.

intellectual property refers to the right of individuals and companies to receive royalties for copyrighted original work such as writing books, composing music, or developing software.

intelligence support systems are intelligent systems designed to support knowledge workers.

intelligent agents are expert or knowledge-based systems embedded in computer-based information systems (or their components).

intelligent systems include a knowledge component, such as an expert system or neural network.

interactive marketing (intermarketing) is an interactive customised relationship between vendors and buyers for advertisement and sales transactions.

inter-marketing is a new interactive style of marketing, allowing personal contact with customers and providing marketing organisations with greater ability to understand the customer, market, and competition.

internal IS structure is the organisational structure of an information systems department.

Internet is an international 'network of networks' offering electronic database services to millions of people. **Internet** is a self-regulated network of computer networks connecting millions of computers all over the world.

Internet kiosks enable people who do not have computers to access the Internet from public locations.

inter-organisational information systems (IOS) refer to information systems between two or more organisations that support an efficient, routine flow of transaction-processing data.

intranet is a corporate network that functions with Internet technologies, such as browsers and search engines, using Internet protocols.

IT outsourcing is using outside vendors to create, maintain and re-engineer IT architectures and systems.

IT planning is the organised planning for IT infrastructure and applications portfolios done at various levels of organisation.

job content refers to the elements of a job as reflected in a job description.

job stress refers to the stress experienced by individuals while performing their job.

Just in Time is the use of information and computer technology for ordinate deliveries from suppliers to ensure that a minimum of material inventory is needed to support production processes.

knowledge base is a collection of facts, rules, and procedures organised in one place.

knowledge discovery (*see* **knowledge discovery in databases**)

knowledge discovery in databases (KDD) refers to the process of extracting knowledge from volumes of data in databases (e.g. in data warehouses).

knowledge is the understanding, awareness, or familiarity acquired through education or experience.

knowledge workers are people who use knowledge as a significant part of their work responsibility.

knowledge-based organisations are organisations that capture, store, and utilise knowledge as a major activity with the help of IT.

labour productivity is the ratio of the value of outputs to quantity of labour required to produce these outputs.

laser printers are no-impact printers that produce high-quality printed output.

legacy systems are older systems that have become core business operations and may still be capable of meeting business needs; they may not require any immediate changes or they may be in need of re-engineering to meet new human needs.

liberalisation is the opening up of public telecommunications competition.

logical design refers to the design of an information system based on the user's point of view.

long-range planning is a corporate or IT plan usually spanning five years or longer.

Lotus Notes is an integrated groupware software package, which also provides application developers with an environment for quickly creating cross-platform client/server applications.

machine learning is a method by which a computer learns from past experiences (e.g. from historical data).

marketing transaction database (MTD) is an interactive marketing database oriented towards targeting messages and marketing in real time.

mass customisation refers to the production of a very large quantity of customised products, such as computers (e.g. by Dell Computers).

material requirements planning (MRP) is a planning process (usually computerised) that integrates production, purchasing, and inventory management of interrelated products.

metadata are data about data, such as indices or summaries.

metamalls refer to on-line supermalls that serve several on-line malls by providing them with unified services, such as search engines.

metric benchmarks provide numeric measures of IS performance relative to other numerical factors such as organisational revenues, CPU capacity, etc.

micro payments refer to small payments (a few dollars or cents) for products or services purchased on the Internet.

microcomputers are the smallest and least expensive category of general-purpose computers; they are also known as **micros** and **personal computers**.

milestones (or **checkpoints**) are established to allow periodical reviews of progress so that management can determine if a project merits further commitment of resources, if it requires adjustments, or if it should be discontinued.

minicomputer is a relatively smaller, cheaper, and more compact computer that performs the same functions as a larger, mainframe computer, but to a more limited extent.

model-based management system (MBMS) is a software program to establish, update, and use a model base.

modem is a device that modulates and demodulates signals.

Moore's law indicates that the power of a microprocessor will double every 18 months while the cost stays at the same level.

mosaic is a simple graphical user interface, which has influenced interface designs of many other information networks.

multifactor productivity is the ratio of the value of outputs to the value of the inputs – including labour, investments, materials, etc. – used to produce these outputs.

multimedia database data and procedures are stored as objects containing various multimedia (e.g. video).

multimedia is the integration of text, video and audio computer and telecommunication systems. It is the combination of at least two media for input or output of data; these media can be audio (sound), voice, animation, video, text, graphics, and/or images.

narrowband is a telecommunication channel with relatively small volumes of data, such as copper wire telephony.

natural language processor (NLP) is a knowledge-based use interface that allows the user to carry on a conversation with a computer-based system in much the same way as he or she would converse with another person.

netiquette is the rules of conduct over the Internet, especially in newsgroups, chat rooms, and bulletin boards.

network computer (NC) is a network-based terminal, similar to a "dummy" terminal in a mainframe, that allows communication and use of information on the network, but it does not have a CPU.

network effects are the support that leading products in an industry receive from their large user base and the complementary products marketed to these users.

network is a telecommunications system that permits the sharing of resources such as computing power, software, input/output devices, and data.

networked computing is a corporate information infrastructure that provides the necessary networks for distributed computing. Users can easily contact each other or databases and communicate with external entities.

networked enterprise comprises one seamless network, thus extending the corporate contacts to all the entities a company does business with.

neural computing is the technology that attempts to achieve knowledge representations and processing based on massive parallel proccessing, fast retrieval of large amounts of information, and the ability to recognise patterns based on experiences.

nominal group technique (NTG) is a group dynamic procedure to mimic the process of people working in a group.

object-oriented database refers to a database that is organised and managed using an object-oriented approach for data presentation and management.

object-oriented development is based on interchangeable software components (objects) that model the behaviour of persons, places, things, or concepts in the real world.

object-oriented programming (OOP) models a system as a set of cooperating objects.

office automation systems (OAS) are used to increase the productivity of office workers and the quality of office work.

on-line analytical processing (OLAP) is the processing of data as soon as transactions occur.

on-line data entry inputs data directly to and is immediately used by a computer.

on-line transaction processing (OLTP) is a transaction processing system, created on a client/server architecture, that saves money by allowing suppliers to enter the TPS and look at the firm's inventory level or production schedule.

operating system software supervises the overall operation of a computer, including such tasks as monitoring the computer's status, handling executable program interruptions, and scheduling operations.

optical character reader (OCR) is an input device that scans textual data.

optical scanners scan text and graphics forms for input to a computer system.

option valuation is the process of assigning a value to future benefits that could result from a current investment.

organisation transformation is a radical change in an organisation involving structure, culture, and the manner in which business is conducted.

organisational decision support system (ODSS) is a network DSS that serves people at several locations.

organisational learning is the process of organisations coping with major changes such as BPR. Such learning can be facilitated by knowledge bases.

output device is the part of a computer system that produces processed data or information.

outputs are the completed products or services of a system.

outsourcing is acquiring IS services from an external organisation rather than through internal employees.

packet switching is a method for coordinating small packets of information rather than a single continuous stream and then reassembling them at their destination.

parallel conversion is a process of converting to a new information system by using the old and new systems concurrently until the new system is demonstrably stable and reliable.

parallel processing is executing several processing instructions at the same time (in parallel) rather than one at a time (serial sequential processing).

pattern recognition is the ability of a computer to classify input items to a predetermined category by matching each item's characteristics with those of a stored category.

peer-to-peer network relationships stress processing on an equal basis among all processors, sharing devices and data on a mutual basis.

perfect information refers to information that enables a user to predict results with complete certainty (the yield from a certificate of deposit).

periodical reports are routine reports executed at predetermined times (in contrast with ad hoc reports).

personal information manager (PIM) is a software package for a manager's personal use exhibiting the features of project management software and desktop organisers.

phased conversion is switching an old system to a new system in several phases.

physical design is the process of translating the logical design of a system into the technical design.

pilot conversion is switching from an old system to a complete, new system in parts of an organisation, one part at a time.

Plain Old Telephone Service refers to the basic voice-only telephony service.

political economy is the overlap and interaction between economic and political power in the context of prevailing control structures.

post-audit refers to the auditing conducted on information systems after their implementation and use.

post-Fordism refers to the new forms of work organisation which move away from the automated mass-production line of Fordism.

preferred reading is the interpretation which a producer of media content or software would like the audience or user to follow.

price-to-performance ratio indicates the relative cost, usually on a per-MIPS (millions of instructions per second) basis, of the processing power of a computer.

primary storage (or **main memory**) stores data and codes for the CPU.

privacy policies are organisational policies designed to protect individuals' privacy.

private automatic branch exchange is a system located on a user's premises which links phones inside the organisation and connects them to the public network.

private key refers to a security encryption/decryption code that is known only to its user/owner.

privatisation is the opening up of the public telecommunications supply industry to private ownership.

process innovation is stepping back from a process to inquire into its overall business objectives, and then effecting creative and radical change to realise order-of-magnitude improvements in a way that accomplishes objectives.

processor (computer) is a device that processes inputs into outputs.

productivity paradox is the seeming contradiction between extremely large investments in IT in the economy, in contrast to indications of low productivity growth in the sector that have received the largest IT investments.

programme evaluation and review technique (PERT) is a planning and control tool representing the network of tasks in diagrammatic form required to complete a project, through establishing sequential dependencies and relationships among the tasks.

project planning is the fourth stage of the model for information systems planning, providing an overall framework within which the system development life cycle can be planned, scheduled, and controlled.

protocol is the detailed definition of the procedures and rules required to transmit information across a telecommunications link.

prototyping is an approach to systems development that exploits advanced technologies for using trial-and-error problem-solving.

PTT is a monopoly public telecommunications operator, generally owned by a national government.

public key is the code of a certain individual that is distributed to authorised people so they can encrypt or decrypt messages with it.

public switched telephone network is a telecommunication network available to the public.

public telecommunication operator is a supplier offering telecommunications infrastructure capabilities to individuals and companies.

push technology delivers only the information users want : their preference profile.

quality of life is the measure of how well we achieve a measurable standard of living.

random-access memory (RAM) is a digital storage or memory that can be directly written to and read.

rapid application development (RAD) is a method that enables the rapid construction of information system applications by using special tools.

read-only memory (ROM) is a digital storage or memory that can be read directly.

requirement analysis refers to the stage in a system cycle where the goals (outputs) of a system are rated against the needs of the users.

response management is the strategy of responding to competitors or market developments rather than being a leader. Return on investment (ROI) is the percentage return computed by ROI= net revenue / required investment.

reverse engineering is the process of converting the code, files, and databases of legacy systems into components that can he used to create new (usually client/server) applications.

risk management is the process of determining the potential risk associated with a project or a problem and considering this risk of cost-benefit analysis.

robot is an electromechanical device that can be programmed to do automatc manual tasks.

robotics is the science of using a machine (a robot) to perform complex manual functions without human intervention.

role ambiguity refers to the possibility of the creation of unclear or fuzzy job descriptions as organisational changes occur. This may confuse the employees.

R's (3) of re-engineering refer to the key activities of re-engineering organised into three phases: redesign, retool and re-orchestrate. The total cost of ownership is a formula for calculating the cost of owning and operating a PC.

sales automation software is the software used to automate the work of salespeople.

sales-force automation refers to the hardware and software used by salespeople, usually in the field, to execute some of their tasks (e.g. using wireless computers to generate proposals at clients' sites).

self-directed teams take their own decisions and have authority (and responsibility) to execute specific tasks.

sensitivity analysis studies the effect of a change in one of many input variables on a proposed solution.

server is any system or process that provides data, services, or access to other systems for clients.

service level agreements (SLA) are made between the IS department and users to specify what, when, and how IS services are expected to be rendered.

share of voice is a measurement of cross-media ownership based on the proportion of total media consumption rather than technologically defined markets, such as newspaper circulation or television audience shares, on their own.

smart cards are storage media the size of a credit card that contain a microprocessor capable of storing and processing information.

social shaping of technology is a research discipline which acknowledges the importance of global and local social and economic forces in determining the outcomes of technological innovation.

software agents are autonomous software programs that execute mundane tasks for the benefit of their users; they are also known as **intelligent agents**.

software is instructional coding that manipulates the hardware in a computer system.

spamming refers to indiscriminate distribution of messages (e.g. junk mail) without considering their appropriateness.

span of control is a measure of the number of employees who report to one supervisor or manager.

speech recognition is a process that allows us to communicate with a computer by speaking to it.

speech understanding is the ability of computers to understand the meaning of sentenccs, in contrast with recognising individual words.

steering committee is composed of key managers representing major functional units within the organisation to oversee the IS function, to ensure that adequate planning and control processes are present, and to direct IS activities in support of long-range organisational objectives and goals.

strategic alliances are business alliances among companies that provide strategic benefits to their partners.

strategic information systems (SIS) are information systems that provide, or help to provide, a strategic advantage.

strategic planning, the first stage of the planning model, aligns IS strategic planning with overall organisational planning by assessing organisational objectives and strategies, setting the IS mission, assessing the environment, and setting IS policies, objectives and goals.

supply chain describes all the activities related to the acceptance of an order from a customer and fulfilling it. In its extended format, it also includes connections with suppliers, customers, and other business interests.

support activities do not add value directly to a firm's product or service under consideration but support the primary activities that do add value.

symbolic processing uses symbols, rather than numbers, combined with rule of thumb (or heuristics) to process information and solve problems.

synchronous (real-time) communication means that messages sent at a certain time are received immediately, almost simultaneously.

system development life cycle (SDLC) is a model for developing a system based on a traditional problem-solving process with sequential steps and options for revisiting steps when problems appear.

system development refers to the structuring of hardware and software to achieve the effective and efficient processing of information.

system is a set of elements that act as a single, goal-oriented entity.

system software is a set of instructions that act as the intermediary between the computer hardware and application programs.

tariff re-balancing is the shifting of the basis of telecommunication charges to reflect the direct costs of each service, without allowing for cross-subsidies.

Taylorism is a way of organising work which emphasises routinisation as a means of optimising productivity; originally developed by engineer F. W. Taylor in the late nineteenth century but also often employed in modern computer-based automation.

telebanking is an interactive networked service allowing transactions with banks to be undertaken from home.

telecommuting generally refers to all types of electronic highspeed long-distance voice and data communication, usually through the use of common carriers.

teleconferencing is a meeting involving people in different locations communicating through electronic media by use of telephone or computer systems.

teleport is a site-specific telecommunication infrastructure, such as a station link to a satellite, associated with related land and development.

teleshopping is the ability to order goods and services from home through an interactive network.

teletext is the service transmitted by television signal which allows call-up of a wide variety of information on a TV screen.

television licence is required in some countries for the use of television, such as in the UK, where the public service BBC is funded from licence fees.

telework is the use of an electronic network to enable individuals to work from home or a decentralised work centre.

total quality management (TQM) is an organisation-wide effort to improve quality and make it the responsibility of all employees.

transaction processing system (TPS) processes an organisation's basic business transactions such as purchasing, billing, and payroll.

trend analysis is the analysis of performance over time, attempting to show future direction using forecasting methods.

Turing tests, named after the English mathematician, Alan Turing, are designed to measure whether a computer is intelligent or not.

universal service is the provision of a minimum set of telecomunications services to all households.

user interfaces facilitate communication between a user (a person) and an information system and may be tailored uniquely for an individual.

validation ensures that a system meets documented and approved system requirements established during the design stage.

value added networks are networks that add communications services to existing common carriers.

value analysis facilitates decision-making in situations where intangible benefits are important, by evaluating benefits and costs through an initial prototype prior to development of a complete system.

value chain model (by Porter) shows the primary activities that sequentially add value to the profit margin. Also shown are the support activities.

value systems in Michael Porter's value chain model include producers, suppliers, distributors, and buyers (all with their own value chains).

V-chip is an electronic device that can be installed in a TV set to block out 'objectionable' material, which is detected by a rating code in the television signal.

video mail refers to the ability to transmit photos, pictures, and documents among conversing people, including conferencing.

video teleconferencing is teleconferencing with the added capability of the participants to see each other as well as documents or other objects.

video conferencing is teleconferencing involving video communication.

video-on-demand is an interactive network service which allows one to view a video whenever one wishes.

videotex is a computer-based network service which delivers graphical information, typically as pages of information.

virtual corporations may operate from various locations, usually through telecommunications, without a permanent headquarters.

virtual IS organisation is a team-based IS organisation that includes vendors and other business partners.

virtual organisation is an operation involving many individual firms in different locations using electronic networks.

virtual reality is a pseudo-3D interactive technology which provides a user with a feeling that he or she is physically present in a computer-generated world.

Virtual Reality Mark-up Language (VRML) is a platform-independent standard for virtual reality (VR).

virus is software that can damage or destroy data or software in a computer.

visual interactive modelling (VIM) is a method of modelling situations for problem-solving where users can interact with the system and the results of their action are displayed.

visual interactive simulation (VIS) is a VIM where simulation is used as the problem-solving tool.

visual recognition refers to the computer's ability to interpret scenes; it is also known as **computer vision.**

voice mail is digitised spoken messages that are stored and transferred electronically to receivers. It is the ability to store spoken messages on a network for subsequent retrieval by the recipient.

voice recognition is the ability of a computer to understand the meaning of spoken words.

voice synthesis transforms computer output into voice or audio output.

vulnerability (insecurity) refers to a system's exposure to potential hazards, either intentional or accidental.

wand readers are hand-held optical readers for scanning data.

waterfall method refers to the process of system development where work flows down from one stage to the next only after it is completed.

"what-if" analysis seeks to determine the effect of changing some of the input data on solutions.

wide area network is a telecommunications network that extends beyond individual buildings or campuses.

wide area networks (WANs) are networks that generally span distances greater than one city and include regional networks such as telephone companies or international networks such as global communications service providers.

work group refers to two or more individuals who act together to perform a task.

workflow systems use group support software for scheduling, routing, and monitoring specific tasks throughout an organisation.

World Wide Web is a system which allows information sites around the world to be accessed via the Internet through the mosaic interface.

WYSIWYG (what you see is what you get) means that material displayed on a computer screen will look exactly – or almost exactly – as it will look on a printed page.

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