The impact of networking and information technology on Saudi Arabian and British universities

This item was submitted to Loughborough University's Institutional Repository by the/an author.

Additional Information:


Metadata Record: https://dspace.lboro.ac.uk/2134/27905

Publisher: © Abdulghafoor Abdulfattah Bukhari

Rights: This work is made available according to the conditions of the Creative Commons Attribution-NonCommercial-NoDerivatives 2.5 Generic (CC BY-NC-ND 2.5) licence. Full details of this licence are available at: http://creativecommons.org/licenses/by-nc-nd/2.5/

Please cite the published version.
This item was submitted to Loughborough University as a PhD thesis by the author and is made available in the Institutional Repository (https://dspace.lboro.ac.uk/) under the following Creative Commons Licence conditions.

![Creative Commons License](https://i.imgur.com/12345678.png)

**Attribution-NonCommercial-NoDerivs 2.5**

You are free:

- to copy, distribute, display, and perform the work

Under the following conditions:

**Attribution.** You must attribute the work in the manner specified by the author or licensor.

**Noncommercial.** You may not use this work for commercial purposes.

**No Derivative Works.** You may not alter, transform, or build upon this work.

- For any reuse or distribution, you must make clear to others the license terms of this work.
- Any of these conditions can be waived if you get permission from the copyright holder.

Your fair use and other rights are in no way affected by the above.

This is a human-readable summary of the Legal Code (the full license).

[Disclaimer](https://creativecommons.org/licenses/by-nc-nd/2.5/)

For the full text of this licence, please go to:
http://creativecommons.org/licenses/by-nc-nd/2.5/
<table>
<thead>
<tr>
<th>VOL. NO.</th>
<th>AUTHOR/FILING TITLE</th>
<th>CLASS MARK</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0 JUN 1995</td>
<td>BUKHARI, A. A.</td>
<td>Loan copy</td>
<td>25 JUN 1999</td>
</tr>
<tr>
<td>28 JUN 1996</td>
<td></td>
<td>25 JUN 1999</td>
<td></td>
</tr>
<tr>
<td>28 JUN 1996</td>
<td></td>
<td>25 JUN 1999</td>
<td></td>
</tr>
<tr>
<td>27 JUN 1997</td>
<td></td>
<td>8 MAR 2000</td>
<td></td>
</tr>
<tr>
<td>26 JUN 1998</td>
<td></td>
<td>28 MAY 2000</td>
<td></td>
</tr>
</tbody>
</table>
The Impact of Networking and Information Technology on Saudi Arabian and British Universities

by

Abdulghafoor Abdulfattah Bukhari

A Doctoral Thesis
Submitted in partial fulfilment of the requirements for the award of
Doctor of Philosophy
of the
Loughborough University of Technology
1994

Supervisor: Professor A. Jack Meadows
Department of Information and Library Studies
Loughborough University of Technology

© by Abdulghafoor Abdulfattah Bukhari, 1994
Abstract

As a result of the growing use of computers and continuing improvements in communication technologies, there has been an accelerating growth of LANs on-campus and WANs between campuses. The developed countries, such as the USA and UK, are developing high-speed networks to establish a powerful national information technology infrastructure. A developing country, such as Saudi Arabia (SA), is now considering how best to provide comparable national network services.

The aim of this thesis is to study the impact of networking and information technology on the SA academic environment, together with some comparison with UK experience. Particular emphasis is placed on development plans for high-speed network services. The network systems that exist in the USA and UK, along with the development of NREN and SuperJANET procedures, are investigated. The overall intention is to apply the practical experience gained by these two countries to generate a set of design principles that can be applied to universities in SA.

To explore requirements, surveys were conducted during the years 1990, 1991 and 1992. These involved questionnaires and interviews. The first survey covered the user side, whilst the second involved the management and organisational sides. The questionnaire involved the investigation of how staff and students were reacting to their changing IT environment. The interview questions were put to computer centre management staff to focus on how use of technology may be shaped by the university to increase information handling activities on the campus.

The study indicates that a number of complex issues arise on SA university campuses due to the implementation of campus-wide network systems. Three factors especially are fundamental: (i) made of access to IT activities, (ii) organisational IT structure, and (iii) user training. The findings suggest that new planning is essential to support and develop effective network campuses in SA universities.
ACKNOWLEDGEMENTS

First and foremost, grateful thanks go to Professor A Jack Meadows, Dean of Education and Humanities, my supervisor, for his help, advice, guidance, support, supervision and continuous encouragement for this thesis to be completed. Also thanks go to Professor A Jack Meadows and Dr. Jane Meadows for their friendship with my family and me.

I am also most grateful to Dr. R P Sturges, my Director of Research for the great amount of time, help and support he has given me during this work.

My thanks are due to Mr Neil Hamilton and Mr Roger Gladwin (University of Liverpool) and to Mrs Margaret Millington (University of Surrey) for their assistance in distributing the questionnaires, and to Mr Fytton Rowland for his advice on this topic.

I also thank Mr D Hogg (Director of the Computer Centre) and Mr R Thirlby (Network Manager) at Loughborough University of Technology for their valuable time and help in providing me with the necessary information I needed for my work.

I would like also to thank Mrs Inese Smith for helping and reading through references and bibliography for correction.

Thanks are also due to Professor Abbas S Tashkundi (King Abdulaziz University), who was my supervisor during my field work in SA, for his support in the work. Also thanks go to Dr. Hasan M Felemban for his advice and contribution in distributing the questionnaires and also for arranging time to meet interviewees at King Abdulaziz University. I am also grateful to Dr. Mohammed S Ashoor, Dean of Libraries at King Fahd University in SA, for his help in arranging time with interviewees on the university campus.

Finally, I am extremely grateful to my wife for her continuous shared responsibility, support and help to finish my study, and also for creating a good atmosphere while I was working at home. My thanks are also due to my mother and father, particularly my father, who encouraged me to finish my study.
To my wife Z. M. Bukhari, my children
and my parents
# Table of Contents

1 Introduction 1
   1.1 General introduction 1
   1.2 Aims 7
   1.3 Objectives 8
   1.4 Hypotheses 11
   1.5 Reason for undertaking the work 11
   1.6 Reason for comparing SA and UK 12
   1.7 Structure of the thesis 15

References 18

2 The development of the educational network system 20
   2.1 Introduction 20
   2.2 Background on Saudi Arabia (SA) 21
   2.3 Microcomputer network development 23
   2.4 Local Area Network (LAN) development 24
   2.5 Wide Area Network (WAN) development 26
   2.6 National network development in the USA 27
   2.7 Organisational structure 34
   2.8 User level integration 36
   2.9 National network development in the UK 36
   2.10 Organisational structure 44
   2.11 User level integration 46
   2.12 National network development in the SA 48
   2.13 The convergence of information services 53

References 64

3 The effect of IT on the educational system 70
   3.1 Introduction 70
   3.2 Organisation 70
3.3 Information systems
3.4 Structure
3.5 Teaching/learning
3.6 Research
3.7 Information provision
3.8 Copyright
3.9 Training

References

4 Methodology
4.1 Introduction
4.2 Guidelines for the research
4.3 The research model
4.4 Methods

References

5 Results of responses to questionnaire
5.1 Introduction

SA side
5.2 Information-handling via computers
5.3 Use of computers
5.4 Advice on computers
5.5 Discussion

UK side
5.6 Information-handling via computers
5.7 Use of computers
5.8 Advice on computers
5.9 Discussion

✓ Comparative results
5.10 Information-handling via computers
5.11 Use of computers
5.12 Advice on computers

-ii-
7 Devising and implementing a plan for academic networking in Saudi Arabia

7.1 Introduction 300
7.2 On-campus networking development 301
    7.2.1 Merging of library, academic and administrative computing 301
    7.2.2 Development of "electronic campus" 302
7.3 Situation of the UK Universities 307
    7.3.1 Aston University 308
    7.3.2 External experience 309
7.4 Situation of the SA universities (1991) 310
7.5 Factors affecting on-campus network 312
    7.5.1 Physical factors 313
    7.5.2 Organisational factors 327
    7.5.3 User factors 329
7.6 On-campus network design 331
    7.6.1 Physical design 331
    7.6.2 Organisational design 337
    7.6.3 User design 340
7.7 Implementation
  7.7.1 Physical changes
  7.7.2 Organisational changes
  7.7.3 User changes

7.8 Cost estimate

7.9 Between-campus networking developments
  7.9.1 USA experience
  7.9.2 UK experience

7.10 Situation in SA

7.11 Factors affecting between-campus network
  7.11.1 Physical factors
  7.11.2 Organisational factors
  7.11.3 User factors

7.12 Between-campus network design
  7.12.1 Physical design
  7.12.2 Organisational design
  7.12.3 User design

7.13 Implementation
  7.13.1 Physical changes
  7.13.2 Organisational changes
  7.13.3 User changes

7.14 Cost estimate

References

8 Overview, conclusions and recommendations

8.1 Introduction

8.2 Academic view

8.3 Management view

8.4 Conclusions

8.5 Recommendations

List of Figures and Tables

Figure 2.1 NSFNET network operation centres in the USA
Figure 2.2 NREN supercomputer network operation centres in the USA
Figure 2.3 JANET wide area network operation centres in the UK 39
Figure 2.4 SuperJANET wide area network operation centres in the UK 43
Figure 2.5 GULFNET wide area network operation centres in the SA 50

Figure 3.1 Forms of multimedia model 96
Figure 3.2 Outline of the training system 121
Figure 3.3 Relationships between training and selection decision in the training system 122
Figure 3.4 Learning system development model 124
Figure 3.5 Connection of a professional training centre 127

Figure 4.1 Basic model of university information system (IS) 148
Figure 4.2 Basic model of university IT integrated components 148
Figure 4.3 Research model 150
Figure 4.4 Project duration time and period of fieldwork 165

Figure 5.1 Staff versus number of computer activities 171
Figure 5.2 Staff versus number of computer activities 191
Figure 5.3 Total computer activities used by respondents in the UK and SA 201

Figure 6.1 KSU networks layout 218
Figure 6.2 FDDI, IBM and LAN interfaces 220
Figure 6.3 KAU organisational committee structure 259
Figure 6.4 KSU organisational committee structure 260
Figure 6.5 KFU organisational committee structure 261
Figure 6.6 NU organisational committee structure 264
Figure 6.7 LU organisational committee structure 265
Figure 6.8 LUT organisational committee structure 266
Figure 6.9 National computer conferences hosted in SA since 1974 274

Figure 7.1 Organisational IT structure 307
Figure 7.2 On-campus high-speed network performance 333
Figure 7.3 University organisational IT committee structure 338
Figure 7.4  Gantt charts compared with PERT diagrams for star-up and running-up situations of IT planning activities that can be accomplished on university campus.

Figure 7.5  Network model for use in cost estimate.

Figure 7.6  Information system organisational structure.

Figure 7.7  Between-campus ATM pilot configuration connections.

Figure 7.8  Multi-service network.

Figure 7.9  Between-campus organisational structure development.

Figure 7.10  Gantt charts compared with PERT diagram for IT planning activities that can be accomplished between campuses.

Table 5.1  Percentage of staff who used a computer for each activity.

Table 5.2  Percentage of the different sciences who used a computer for each activity.

Table 5.3  Percentage of the science and engineering staff who used a computer for each activity.

Table 5.4  Percentage of activities carried out on each type of computer.

Table 5.5  Percentage of the science and engineering staff who used different computers for each activity.

Table 5.6  Sources of advice about computerisation.

Table 5.7  Percentage of the science and engineering staff who used advice for computer activity.

Table 5.8  Percentage of staff who used advice for computer activity by the different sciences.

Table 5.9  Percentage of staff who used a computer for each activity.

Table 5.10  Percentage of staff who used a computer for each activity.

Table 5.11  Percentage of staff who used different computers for each activity.

Table 5.12  Percentage of activities carried out on each type of computer.

Table 5.13  Use of computers in the different sciences.
Table 5.14 Percentage of people who used advice for computer activity
Table 5.15 Percentage of people who used advice for computer activity by different sciences
Table 5.16 Percentage of staff in three surveys who used IT for the indicated activity
Table 5.17 Percentage of staff in three surveys who used different computers for each activity
Table 5.18 Source of advice about computerisation in three surveys
Table 6.1 Universities' budget systems (Government support)
Table 7.1 Development cost for ATM switches
Table 7.2 Trunk transmission rates in Europe and N. America
Table 7.3 Development costs for between-campus ATM switches
Glossary List of acronyms and transcription or definition of the acronyms

Appendices

Appendix I Computerisation of information questionnaire
Appendix II University computing director interview
Appendix III Departmental computing representative interview
Appendix IV KACST staff interview
Appendix V Details of the people interviewed in SA and the UK during the course of this research project
Appendix VI Development plan in the SA
Appendix VII IT policy development

Bibliography
Chapter 1

Introduction

1.1 General introduction

Information Technology (IT) has been widely discussed as having the potential to change radically higher education. Mainframe computer systems, microcomputers, local area networks (LANs), wide area networks (WANs), personal workstations, plans, policies, etc., have been discussed in higher education. Networking strategy for advanced information technology is perhaps the most recent activity being discussed to integrate higher education aspects of computing with high-speed network performance. These discussions consider how new technology is changing the pattern of higher education and giving rise to resource-sharing consortia that will result in significant institutional change [1].

In a time of rapidly expanding development in all areas of information technology, new educational applications are continually being considered. For example, in the seventies the primary use of computer resources was limited to the centralised computing environment. The use of computing technology was limited to the large data file, as in number crunching and statistical manipulation. The mainframe computer and wide area networking were the used for these activities. The mid-eighties witnessed the development of a variety of information
technologies that offered the prospect of establishing different computing technologies on the university campus. Among those technologies were microcomputers and local area networking. Microcomputers have become an important tool for campus users to accomplish their work. Local area networks involved sharing computer resources and facilitated communication among those microcomputer users. It allowed users to share common databases, experimental design, teaching courses, library and other information resources, as well as to communicate with each other through the various network technologies such as e-mail and other communication activities. These two tools together extended the possibility of bringing in integrated computerisation activities in which significant improvement and rapid expansion of the communication system on-campus and between-campuses have occurred.

The beginning of the nineties has seen more advanced information technologies implemented and used in universities. There has been a growing trend towards the integration of voice, images and data over wide-area broadband networks to support a wide variety of digital services. The existence of ISDN (Integrated Service Digital Network) and its technological development in digital switches, such as SMDS (Switched Multi-megabit Data Service), and digital transmission mode, such as ATM (Asynchronous Transfer Mode), have brought about a broad consensus favouring increased effort to promote greater communication and collaboration between users which is at the same time fast and reliable. For instance, in
terms of networking, IT provides a range of communication possibilities as regards size, speed, capacity, etc. In terms of teaching/learning systems, IT provides new multimedia systems such as video, sound, graphics, etc. and makes it possible to present different media activities simultaneously, so as to make teaching/learning systems more effective. In library and research work, CD-ROM is another area of IT that can help researchers towards easy searching. Accordingly, wide area networks (WANs) and local area networks (LANs) have become a primary channel for network users to communicate text, data, e-mail, voice, video, etc., on a national scale [2].

These new information and communication technologies, as well as being computing tools, are fundamentally changing the university campus environment. The heart of this environmental transformation is rapid technological change in the field of information networks. An information network has been defined by Etheridge and Simon [3] as "a combination of IT-based components that is designed to meet the requirements for connecting a variety of forms of information, such as voice, data, text, image or any combination of these forms, within or between organisations." To meet these requirements, teaching/learning, research, library, and even university organisations are all changing on their campuses to more electronic forms, so as to enhance all university campus activities and further provide high-speed network performance on-campus and between campuses.
These transformations are constituting a challenge to the whole educational system [4].

Much of this challenge is based on the changing environment. Many plans and strategies in the past were based upon the existence of technological development, itself, and not on user demand. Today, the picture is different. User demand is an important part of planning and strategies for campus network system development. It is possible to say that today's users are different from past users. In the USA and UK, for example, the experience of computing in the educational system over the last fifteen years, where the technology has been developing all the time on the campus, has raised users' level of expectation of integrated computerisation and networking. Today, all users want to use e-mail to exchange information on a single or multilateral basis, and they want to use networks to provide facilities to make information of all kinds available to, or to receive it from, a worldwide community [5]. Some want to use images, graphics, video and audio and so on. Today's technology must produce the technology that meets user demand. 'Technology-push' is being increasingly replaced by 'demand-pull'. Consequently, IT strategy and planning development in the university campus organisation has seen it necessary to focus institutional planning effort more on the need of scholars and students and less on the technological infrastructure to help accomplish a campus-wide collaboration and consensus for implementing network IT strategy on the large complex campus [6].
It seems, as Makey [7] indicates, that the technology needs to be viewed in a new way. Serious attention needs to be given to equipping the system in a way which is relevant to the educational endeavour. The most important key component is how to use today's technologies worldwide to develop national infrastructures to enhance the education system as a whole. Thus the important thing is how university campuses can deal with technology developments to meet users' demand. In addition, how can universities cope with the technology and demand to enhance the entire campus. In the past, technology was pushing forward what was available on the campus. Today the technology exists and is available everywhere on the campus. The question is more how to use this technology to provide effective educational systems.

In the developed countries, especially the USA and UK, the balance is more on the users' demand side, with users sometimes waiting for the technology to catch up. Forward planning steps have been taken to use advanced technology to build up a powerful national network IT infrastructure around the countries so as to supply users with the technology they require. In the USA, for example, the recent agreement on NREN (National Research and Education Network), which is an extension of NSFNET and Internet network systems, and in the UK the recent development of SuperJANET (Super Joint Academic NETwork), which is the extension of JANET MK II and JANET network systems, are examples of linking
universities and other organisations with high-speed network performance.

In the developing countries, such as Saudi Arabia (SA), there is an interest in IT development (computerisation, networking and communication facilities) planned for the entire country. In last two decades in SA, as the report of the Fifth Development Plan (1990-1995) [8] explains, the introduction and application of advanced technology in various sectors of the economy is expected to add greatly to the development process in SA. The government has promoted efforts to apply advanced technology for the removal of inherited resource constraints and the maximum exploitation of national capabilities. The development of the petrochemical and oil refinery industries by using high technology systems in the various parts of SA is a good example of building a powerful IT infrastructure around the country. The introduction of the computer in the educational system is widespread. Individuals now enjoy the benefits of high quality, high performance, and services utilising the latest technology. Furthermore, in response to the increasing demands for rapidly developing high technology performance, a telecommunications network has been installed for the transmission of data, telex, etc., based on PSPDN (Package Switched Public Data Network). Recently, the telephone company added ISDN (Integrated Services Digital Network) services to provide a digital long distance transmission network and a video conference service between major cities within SA and between SA and other countries [9]. These achievements have resulted in the
development of a sophisticated infrastructure that is similar to those existing in the industrial countries such as the USA and UK.

These technological developments have not left SA without problems. Most of these IT networks developments were either within industry, or the academic environment and no communications existed between them in terms of networking facilities. The development of computerisation and networking has so far been on the technology push side, rather than on the users' demand side. It is hoped that this will soon diminish and user demand for a sophisticated national high-speed network system development will soon increase. To meet these requirements, the lack of a detailed IT strategy, plan and organisational structure for industry, university and government is a major drawback.

1.2 Aims

The purpose of this work was to investigate the provision of network systems in the SA academic environment. Particular emphasis was given to the educational development plan for a high-speed network system involving images, video and data services. The work of the development plan has been considered in terms of three basic factors: (i) access to IT activities, (ii) organisational IT structure and (iii) the user training.

The overall intention was that the practical experience gained from developed countries, especially the USA and UK, would
generate a set of design principle considerations that would be applicable to future high-speed network development in developing countries, especially SA. Whether the USA and UK are appropriate models will be examined later. User demand for this kind of network activity is seen as the ultimate goal, and this raises a number of questions for the designer of the system. Whether user demand can lead, or follows technological capabilities, will also be discussed later.

1.3 Objectives

The more specific objective of this work is to contribute to a better understanding of the issue of how use of IT affects information handling and channels of communication in campus-wide network information systems at universities in Saudi Arabia (SA). A comparison will be made with university computerisation and networking in developed countries, especially the United Kingdom (UK). It is hypothesised (see below) that barriers to computerisation and networking have been encountered and partly solved already in developed countries, so that the result of a comparison will be to provide guidelines, ideas, and insights for introducing better computerised information system services in Saudi Arabian (and comparable) universities. The development of computerisation and networking systems in the USA will be considered briefly to provide additional input.
In order to draw conclusions from past experiences and to make suggestions for future policies, a much deeper understanding is needed about the nature of computer/IT diffusion in SA universities. When the study is put in this perspective, its objectives can be articulated as follows:

1- Identification of trends in IT-related information handling amongst users. These trends will be examined in the context of existing IT resources in academic departments and the university computing centre. This objective can be seen from an academic user point of view as encompassing the following points:

. To determine what kinds of information activity are employed by various types of academic user and how their requirements can be satisfied.

. To determine what kinds of computer and networking are being used.

. To see where advice on computing is being obtained.

. To consider how the quality of information-related education and training programmes in universities can be improved.

2- Identification of those elements which constitute the necessary infrastructure for the employment of information technology. These elements will be looked at in terms of 'technology-
push' and 'demand-pull' on the university campus. This objective relates to management planning, since it examines:

1. What are the pressures on a university's strategy for the development of networks on the campus.

2. What role information technology can play (or fail to play) in the development plan for campus-wide network information systems.

This objectives will be viewed in the light of a world-wide trend away from a central (mainframe-oriented) campus organisation to a distributed environment.

3. Development of a conceptual model relating to good organisational network practice, the smooth flow of information, adequate access to information resources and appropriate sharing of resources.

This objective will help contribute to a better understanding of how IT affects information handling and channels of communication for users of the campus system.

These related objectives examine the importance of the relationship between user needs, information technology (and to, a lesser extent, other technology) and organisational structure.
1.4 Hypotheses

General deficiencies in the on-campus implementation of IT, often found in developing countries, will be investigated in SA as an example. It is proposed that the following hypotheses apply to the development of campus-wide network information systems in such a country:

. Lack of a proper IT committee structure within the university can lead to an inadequate distribution of resources in the implementation of an IT strategy.

. Lack of a communication infrastructure hinders the coordination and collaboration of users within, and outside, the university.

. Lack of skilled personnel in the management and operation of campus-wide network information systems affects the implementation and utilisation of successful systems.

. Lack of information-related education and training facilities is a major factor in slowing the implementation of computer usage within the academic community.

1.5 Reason for undertaking the work

Recently, a number of universities in Saudi Arabia have become engaged in the development of campus-wide computerised
network integrated systems. The question of how far the universities of Saudi Arabia have successfully moved from a mainframe-oriented campus to one with integrated computerised systems is therefore an important focus of attention. In other words, to what extent have integrated systems already been established within these academic institutions? Do the academic staff integrate all their work onto a single computer? What changes does computerisation bring about, both at the level of the individual and in the academic department? Can people communicate with each other via networks within the department, between departments, within the university and between universities? What are the basic problems of introducing and expanding computerisation within the academic sector? To provide answers, research was carried out in Saudi Arabia to study what is currently happening at the universities in the area of campus computerisation. Similar research was also taken in a few selected UK universities for the purpose of a comparative study.

1.6 Reasons for comparing SA and UK

Although neither country can necessarily be regarded as a 'typical' example, it is reasonable to see a comparison between SA and the UK as being a comparison of a developing country with a developed country. The intention in carrying out this comparison is that developing countries, in general, and SA in particular are worth to be studying developed countries for guidelines and
insights into the introduction of computers and networking, not least in the academic arena.

If useful guidelines and insights are to be drawn from a comparison between SA and the UK, it is important that there should be sufficient in common between the two countries that it is possible to envisage a British-style system arising in SA. In offering this possibility, the following points should be taken into account:

. The government of SA regards the importation of Western (UK and USA) technology and techniques as important for its rapid economic development, and the introduction of technology into SA has been increasingly encouraged by successive government five-year plans.

. SA is a wealthy country (unlike other developing countries; where lack of financial resources hampers rapid adoption of IT) and its large financial resources allows it to introduce IT at whatever rate seems appropriate.

. GULFNET has been developed to link universities, research centres and other organisations to provide effective IT and networking facilities.

. SA universities are developing advanced IT and networking facilities (ISDN, fibre optics, etc.,) on their campuses.
These factors may be compared with the situation in the UK:

. There has been a long-term policy of centralised encouragement of the use of computers and networking by UK universities.

. The JANET system is similar to the GULFNET system in SA, but the UK is now progressing beyond this with the introduction of SuperJANET.

. SuperJANET (the upgrading system of JANET) has been developed to provide a high-performance multi-service network for academic and other users in the UK.

. UK universities are already using advanced IT and networking developments (ISDN, fibre optics, ATM, etc.,) to provide effective high-speed networks on their campuses.

This listing of factors suggests that, as regards academic networking, there is sufficient similarity between SA and the UK to make a comparison worthwhile. At the same time, developments in the UK are a stage beyond those in SA. Hence, the comparison may provide insights for SA in moving to this next stage. The existence of a previous study of the UK position (in 1986) makes it possible to look at trends in the UK and so to consider whether similar trends might be expected in SA.
In the case of SA and UK, the main difference currently lies in the development of the SuperJANET system in the latter country. This SuperJANET development (to be discussed later) may give insights into the appropriate organisation of IT and networking needed to upgrade the GULFNET system in SA. However, though the technological capability is certainly there, other factors (e.g., volume of network usage) differ. The significance of such differences when comparing SA and the UK will be considered later.

1.7 Structure of the thesis

There are eight chapters in this thesis. They cover the following topics:

Chapter 2 discusses the relevant background to computing technology. It introduces issues relating to the physical, organisational and user environments. These relate to the characteristics of network developments on the university campus and between university campuses. Practical experience in the USA and UK in the development of national network systems is considered. The background on SA in terms of problems, objectives and other factors is presented.

Chapter 3 reviews the literature concerning the effect of IT on the educational and research environment, including users' activities, networks and organisational issues.
Chapter 4 introduces the methodology used for this research. The questionnaire method, interview process and analysis of university organisational structure have been used for studying and understanding how technology is introduced, used, managed and operated in the campus setting.

Chapter 5 examines the questionnaire responses. It describes how academic users (scientific staff) in UK and SA universities have reacted to the use of IT in their daily work activities. This is to see whether the results support the likelihood that trends in SA will parallel those occurring in the UK.

Chapter 6 analyses the interviews. These have been undertaken to examine how senior staff of computer centres and academic departmental computing representatives are reacting to IT needs across the campus. It is particularly concerned with how technology can best be utilised to provide better information services across the campus. Interviews from both the UK and SA sides are presented.

Chapter 7 looks at a possible development plan for academic networking in SA. It examines campus-wide IT strategy in UK and SA universities. The physical, organisational and users' issues in the implementation of new systems are presented, along with the design and implementation of a network model as part of a five-year IT strategy plan in the SA. IT policy development in the SA is outlined in Appendix VII.
Chapter 8 presents an overview, conclusions and the recommendations derived from this study. It covers both the academic and management sides and draws baseline conclusions for planning and designing campus-wide network systems in SA. It also makes recommendations in this area.

A glossary is provided at the end of the thesis. It includes lists of acronyms and definitions of the acronyms for the purpose of clarifying technical terms in IT (computing and networking).
REFERENCES

(Details of publishers are included in the bibliography at the end)


Chapter 2

The development of the educational network system

2.1 Introduction

During the 1970s the main impact of IT on a campus related to the central computing facilities, more especially the mainframe computer [1]. IT in the present sense (i.e. computers plus networks) began to make an impact during the mid-1980s as microcomputers and LANs spread out over the campus. This technology reshaped the campus environment and enabled users to communicate with each other and to access information in an increasingly effective and efficient way. More recently, developments in computer communication technology (such as B-ISDN, ATM and SDMS) have seen rapid changes in the LANs and WANs environments, so that plans now relate to effective communication on campus to the national and international network infrastructure between campuses [2].

Most universities in the developed countries, especially in the USA and UK, have already started to use these new technologies and are planning to make extensive use of better high-speed network services for academic staff, scientists and researchers. The development of NREN in the USA and SuperJANET in UK are good examples, and will be discussed later.
This background chapter consists of three parts. The first part provides background on the networking environment in SA. The second part involves examination of how the microcomputer, LAN and communication facilities have been developed in the academic arena. The third and final part explains how national high-performance computing network systems have been developed in the USA and UK in response to apparent academic needs. Emphasis is also given to the organisational structure, to see how university organisations are dealing with information network facilities on their campuses.

2.2 Background on Saudi Arabia (SA)

Saudi Arabia (SA) is now approaching the era of high-speed national network development. This is due to the current (1990-1995) government development plan. The plan envisages the establishment of a good network communication system between universities, industries and government organisations to increase co-operation and collaboration between them. The government has identified both the need and the demand and has recognised the importance of developing an effective communication system between universities and other organisations in terms of research, development, consultation, advisory services, experience and so on. Thus one of the main objectives of the government (during the Five Year Development Plan 1990-1995) is to provide an effective network communication system between SA sectors (see Appendix VI for more details of the development plan).
On the academic side, also, universities are trying to utilise the latest technology to develop high quality and high-speed network performance. For example, King Saud University (KSU) is in the process of developing an integrated information systems to link all campus mainframes and microcomputers via fibre optics cabling to provide high-speed networks [3]. On the user side, also, universities are experiencing an increasing (from scientists, engineers and researchers) demand, and so are realising that development of an effective network communication system is essential. They know that the existing campus network, though offering many useful facilities (e.g., LANs), is not really geared towards satisfying all the needs of academic users. This is due to the large and growing number of experienced Saudi academic staff (appointed from postgraduate students returning from abroad), the existence of overseas (non-Saudi) staff and the creation of more faculty departments which depend on microcomputers and networks for their work. Thus the users of the network system are increasing and will require an effective and efficient network system.

A recent study [4] indicates that microcomputers in SA may be as widespread as calculators by the end of this decade. It is estimated that PC sales there jumped from $7 million in 1982 to $35 million in 1985, and commentators are saying that the microcomputer revolution together with advances in telecommunications is causing a major transformation of SA society [5]. Correspondingly, the SA government is trying to establish a national network...
infrastructure to link universities, industry and government. The government's goals are: to advance the leading edge of networking and services to cover industry and government sites, and to increase network access to the education and research community. Competitive operation in this changing and challenging environment requires effective management and utilisation of all the resources at the disposal of an organisation [6].

This background indicates the need for a national network development plan in the SA. A key component of the development plan programme is to ensure the availability of high-speed network products that provide the users with the facilities that they require. Fulfilling this demand for high-speed network development on the university campus and nationally between campuses needs an effective plan involving a range of people and organisations, allocation of enough funding and a five-year development plan (to link in with the five-year national development plan in SA). Such a plan could start to be implemented from 1996.

2.3 Microcomputer network development

Microcomputers/PCs were adopted in academic departments a long time before networks appeared on the campus. When networking first arrived on the university campus, the computer centre and some departments developed their own networked systems. This led, as Becker [7] has pointed out, to a centrally
located computer service, as the mainframe computer was the centre-piece of any computing environment. All peripheral devices such as printers, terminals and even modems were connected directly to this computer. Users were able to connect to the mainframe via their terminals and were able to share data and communicate via these central network systems. When microcomputer networking spread on the university campus, the demand grew from a simple terminal-host connectivity to a complex microcomputer/PC file server connectivity with the ability to share data remotely [8]. In fact, with the development of microcomputers and networking in the academic area, former mainframe applications have become available on the desktop. In parallel with the growth of PCs in the academic area, there has been a steady increase in the use of workstations (multi-purpose applications) by scientists, engineers and researchers. This has, in effect, decentralised the IT environment on the university campus. The ability to connect microcomputer workstations with internal or external network systems has increased communications between staff, researchers and students.

2.4 Local Area Network (LAN) development

The local area network is a relative newcomer to the world of computing, experiencing phenomenal growth in the last seven years. The impetus for local area networking relates particularly to when Xerox, Digital and Intel introduced Ethernet to the academic computing community during the 1980s. Each interested
department started to build up its own network system, so that various LANs architecture and topology occurred on the campus. This type of network is usually centred on a small site, such as an office block or part of a university campus. There was rarely effective planning across the whole campus for developing a unified network system. This was due to the technology and telecommunication environment at that time, where the capacity, size and data traffic volume of networks were not enough for providing and connecting the whole campus with fast and sophisticated network systems. Therefore, the impact of IT and networking was on individual department rather than on the entire campus. Reardon [9] has pointed out that network developments have tended to be constrained by the limits of telecommunications technology. Certainly dramatic progress was made, but the transmission speed and capacity in the link to the wider area network were always low.

This state of affairs meant that the mid-1980s saw the development of LANs rapidly and WANs slowly. These two systems have been separated in their development because of their respective capacities and characteristics. Now, however, a WAN can work as fast as many LANs. Recent telecommunication technology and PCs of high capacity open up new prospects for WAN technology that appear to promise better and more effective network systems for the needs of the entire campus as well as between campuses.
2.5 Wide Area Network (WAN) development

Wide area networks (WANs) were originally set up for military defence purposes and universities used them for research-related activities. Today, WANs are being used for many purposes and not necessarily for research purposes only. As was mentioned earlier, the LAN's ability is limited geographically; so there is a need for a powerful WAN system technology to complement the LANs environment. Recently, in parallel with the development of local area networks, wide area networks have started to upgrade their telecommunication channels to connect local area network systems in compatible and efficient ways. The recent development of fibre optics cable and the very recent development of B-ISDN (Broadband Integrated Service Digital Network) for high rates of bits in the range of a Gigabit per second (billion bits per second) have improved the speed and power of both local and wide area networks. This has enabled wide area networks to develop upgrading systems to connect these local area networks in a very high-speed wide area network. Telecommunications technology has developed ATM and SMDS telecommunications systems to be compatible with the transmission speed of LANs. Today, various national and international organisations have developed network standards, such as B-ISDN, ATM and SMDS, that allow a variety of computing equipment to be connected together in a network.

It appears, therefore, that the wide area network today does not greatly differ from the LAN, except that it is much more
widespread geographically. The availability of multi-megabit capacity has itself changed the architecture of the information network in current network systems [10]. Thus the importance of the wide area network lies in its ability to connect efficiently many local area networks.

2.6 National network development in the USA

In the USA, the national network system began early in the 1970s, but its main expansion started in the 1980s. During this time, the Federal government has initiated a number of important programmes related to national networking. Recently, it has initiated the development of a national high-speed network, known as NREN, by upgrading the Internet system.

The Internet system

The Internet is a loosely organised system of interconnected computer networks in the USA, and it links over one hundred thousand computers nation-wide and overseas [11]. It originated with the development of ARPANET as an experimental network established in the 1969 by DARPA (Defence Advanced Research Projects Agency). This was the first prototype packet-switched telecommunications network and served as early backbone for the Internet system [12]. Its purpose was to allow geographically dispersed researchers to share scientific data and computing resources by using the TCP/IP protocol system. This development
led to a set of rules which allowed scientists, researchers, engineers, and educators to send messages between different types of computer and from one network to another.

In the 1980s, due to the success of TCP/IP and other advances in the network and telecommunication areas, the number of networks attached to ARPANET grew to approximately 60 [13]. This significant portion of the total network traffic services used by academic researchers changed the concept of the Internet management. In recognition of this demand for more network services, DAPRA looked at shifting the provision of the Internet service from the Department of Defence to the academic area. In 1985, the National Science Foundation (NSF) took over the co-ordination and development of the Internet. It began to establish national supercomputer centres and designed a high-speed telecommunications backbone, known as NSFNET, to provide access to the centres for the scientists and engineers in a variety of disciplines.

The NSFNET system

As a result of the activities of the National Science Foundation, interest in data networks for higher education and research grew rapidly. Consequently, networking became much more visible on university campuses. For example, before 1984, three sites - Purdue, Minnesota, and California State Universities were established as supercomputer operation centres. During 1985, NSFNET selected...
four more sites to establish national supercomputer centres: the University of California at San Diego, University of Illinois at Urbana - Champaign, Cornell University and the John von Neumann Centre at Princeton in New Jersey. A fifth site, Pittsburgh University, was added in early 1986. Four more sites - Ohio, Texas, Alabama, and San Diego Universities - were added up to the end of 1989. The sites of these NSFNET centres are shown in Figure 2.1. Each site serves its academic community, research institutions, and other organisations within and between the states. (For example, the John von Neumann supercomputer centre provides nodes to Pennsylvania, Massachusetts, New York, Rhode Island, Colorado, and Arizona.) This growth in the number of centres reflected the increasing activity on campuses.
I. Co = Colorado, Colorado State University
II = Illinois, University of Illinois
In = Indiana, Purdue University
Oh = Ohio, Ohio State University
Pa = Pennsylvania, Pittsburgh University
Ny = New York, Cornell University
Ns = New Jersey, John von Neumann Centre
Te = Texas, Texas University
Al = Alabama, Alabama University
Ms = Minnesota, Minnesota University
Sd = San Diego, University of California

Figure 2.1. NSFNET network operation centres in the USA
Services

Most of these NSFNET operating centres provide services to universities, national laboratories, non-profit institutions, government research organisations and private companies doing government-supported research and education. Researchers and educators currently use the centres for a variety of functions: e-mail for exchanging messages, file transfer for transmitting papers and data, graphic and image file transfer, on-line bulletin boards for posting queries and participating in discussions, remote access to computerised databases, and on-line newsletters and journals for sharing news and research results. In addition, the services also provide on-line access to a variety of remote information resources and other research and education tools such as library catalogues and databases and commercial and government information services.

The NREN system

NREN was initiated as part of the NSFNET system development (it stands for National Research and Education Network). It has been defined by Hall [14] as the union of all existing networks - from departmental networks up to the national backbones and international networks. It is the primary resource for providing an information infrastructure for the collection of IT and services for the higher education and research community. During 1988, the National High-Performance Computer Technology Act defined the
government's role in high-performance computers. It proposed the creation of a high-capacity (45 Mb/s backbone) fibre optic network to link and broaden access to supercomputer centres throughout the USA. An important goal was to enhance the economic competitiveness of the USA by facilitating communication between scientists and engineers improving research productivity, speeding up the rate of technology transfer between the research and manufacturing sector, enabling scientists and researchers in different disciplines to engage in large-scale remote collaboration, and encouraging educational activities. The NREN initiative has increased the number of nodes so as to increase users' ability to handle their information needs more effectively and more efficiently. Figure 2.2 shows the distribution of nodes for the NREN.

The plan to create NREN had three stages. The first stage involved upgrading and interconnecting existing agency networks into a 1.5 Mb/s national networking testbed. The second stage was to integrate national networks into a 45 Mb/s backbone by 1993. Finally, the third stage is to implement a technological leap to a multigigabit NREN starting in the mid-1990s.
Co = Colorado, Colorado State University
IL = Illinois, Argonne Centre
In = Indiana, Purdue University
Oh = Ohio, Ohio State University
Pa = Pennsylvania, Pittsburgh University
Ny = New York, Cornell University
Ny = New York, Ithaca Centre
Ns = New Jersey, John von Neumann Centre
Te = Texas, Texas University
Al = Alabama, Alabama University
Ms = Minnesota, Minnesota University
Sd = San Diego, University of California
Mg = Michigan, Michigan University
Ca = California, Palo Alto Centre
Ma = Massachusetts, Cambridge University

Figure 2.2. NREN supercomputer network operation centres in the USA
Costs

Funding of $600 million was provided by the FCCSET (Federal Coordinating Council for Science, Engineering, and Technology) committee to achieve the NREN programme. This is based on a five-year plan extending from 1991 to 1996. Preliminary planning estimates suggested that the first year of the programme would require $150 million, which would then grow to an incremental annual level of $600 million by the fifth year.

2.7 Organisational structure change

The impact of campus-based IT and network facilities has been partly to reshape university organisational structure in US universities. For example, the traditional organisational head, the Director of Computing, is being systematically changed in favour of individuals who are more involved with planning and setting institutional policy than in technical detail [15]. This is one small example of the fact that the structure of organisations tends to adapt to, and to follow, changes in information technology capabilities [16].

As another example, several universities in the USA have recently started to develop new organisational IT committee structures within their campuses. For example, at Scranton University in North-Eastern Pennsylvania, the position of Assistant Provost for
Information Technology was created as a new IT function within the university structure. The holder of this position functions as the Chief Information Officer (CIO) of the university and is responsible for administration and academic computing [17]. Included in this hierarchy structure are the Media Resource Centre (a division of the Library responsible for video services), the Library, and other departments providing network or technology-related services. We see here a convergence between the information-providing services.

Penrod, Dolence and Douglas [18] identify new types of Chief Information Officers who are now being appointed in higher education in the USA. There are high-level ports (Vice-President) which combine control of computing services and information services on the campus. Such a Vice-President for Computing/Information Services reports directly to the President/Chancellor of the institution, is an executive officer, sets policy both for the division and for the university. The rationale for this development is that the previously separate activities of the computer centre, the library and the audiovisual services are increasingly converging, and need to be organised and planned for together. This development is by no means universal yet in the USA, but the trend is very evident (and has been widely discussed). Moreover, the new integrated appointments carry much more weight in campus decisions than the older separate appointments customarily did.
2.8 User level integration

The NREN technology [19] provides multi-tasking activity support to integrate user activities. It provides scholar-to-scholar communications to integrate research interests; instructor-to-student communications to integrate interactive education across the USA in terms of text, image or voice; user-to-user government information; user-to-library/database to access library materials from homes, offices and schools; user-to-international database to enable users to exchange information and communicate with other countries.

Based on these requirements, the Federal government has developed a user policy goal to allocate a certain percentage (8%) of NREN total budgeting for education and training purposes [20]. This was to identify and address a number of social and behavioural issues related to the integration of communication facilities into the working lives of network users.

2.9 National network development in the UK

In the case of the UK, the development of a national network plan started in the early 1980s. In 1979 the Joint Network Team (JNT) created a single unified network from several existing separate networks. Several funding agencies supported the JANET initiative: the Science and Engineering Research Council (SERC), the Natural Environment Research Council (NERC), the Agricultural and Food
Research Council (AFRC), and the Computer Board for Universities and Research Councils (subsequently the Information Systems Committee of the Universities Funding Council). Their work led to the establishment of JANET in 1985 to support and serve a large and increasingly diverse campus user community [21].

The JANET system

The development of the JANET system has resulted from the needs of scientists, engineers, and researchers all over the UK for more an effective communication facility to communicate with each other in more efficient ways. It has been developed as a private X.25 packet switched network that interconnects over 100 sites in the community. At the majority of sites, local area networks (LANs) are connected to JANET, allowing off-site access to the host computers and terminals connected to these networks.

JANET was developed to merge the old regional networks in the widely spread SERCNET. Much of the data traffic operated between sites and their regional centres, or between sites within a region [22]. The core switches of the JANET were interconnected at speeds up to 512 Kb/s using multiplexer operator on telecommunications circuits whose raw bandwidth was 2 Mb/s. But, in recent years, as the user traffic has increased due, in part, to links with external organisations (e.g., industrial research laboratories, libraries, publishing houses, etc.) and with the availability of advance IT in
communication, the JANET system has changed significantly, including the development of JANET MK II.

The JANET MK II system

JANET MK II, a major upgrade of the existing JANET, started in the early 1990s. The plan was originally approved by the Information Systems Committee of the Universities Funding Council to provide 2 Mb/s switched connections to the majority of the UK universities [23]. The objective behind developing a national network system such as the JANET II was (1) to have the JANET system as a powerful supercomputing network operation available to cover all UK areas in ensuring communications to remote users, and (2) to provide a national organisation of advanced research computing to promote collaboration with foreign countries and within industry. Today, the majority of institution sites are served by LANs, which are interconnected by the JANET wide-area backbone, creating a single homogeneous network.

Network operation centres

The Network Operation Centres (NOCs) are shown in Figure 2.3. These are located at: Bath University Computing Services, the Queen's University Belfast, University of Cambridge Computer Laboratory, Daresbury Laboratory, Edinburgh University Computing Service, University of London Computer Centre, Manchester University Computing Centre, and Rutherford
Ba = Bath, Bath University Computing Services
Be = Belfast, Queen's University Belfast
C = Cambridge, University of Cambridge Computer Laboratory
L = London, University of London Computer Centre
D = Daresbury, Daresbury Laboratory
E = Edinburgh, Edinburgh University Computing Service
M = Manchester, Manchester Computing Centre
R = Rutherford, Rutherford Appleton Laboratory

Figure 2.3. JANET wide area network operation centres in the UK
Appleton Laboratory. Each institution has a line to the nearest of these network operation centres. These centres have been chosen to cover most areas of the UK by providing significant enhancements to the network trunk link capacity between all sectors.

The links between the NOCs run at 2 Mbps, 1 Mbps, and 512 Kbps, and the links between the institutions and NOCs are 2 Mbps, 64 Kbps, 19.2 Kbps or 9.6 Kbps. The experience of the JANET system has been generally similar to that of the NSFNET developed in the USA in terms of adding bandwidth to sites to enable them to undertake much more activity than was previously possible.

A range of external gateways connect JANET to other important networks, including the US Internet, the European Academic Research network (EARN), the World-wide UNIX Network, and the UK Public Data Network [24]. In addition to this, EARN-RELAY provides a gateway between JANET and EARN in Europe, BITNET in USA, (now merged with CSNET and operated by CREN), NETNORTH in Canada, and GULFNET in the Middle East (operated by KACST in Saudi Arabia).

Services

There are many information services that can be accessed through JANET. Over 70 UK library on-line public access catalogues (OPAC) can be accessed. File transfer facilities are available to, and from
end systems on the Internet. E-mail (X.400) is a new service available to the new international standard for mail called ISO/IEC 10021 MOTIS (Message-Oriented Text Interchange System). The Directory Service (X.500) is a new world-wide service which is available for loading and maintaining data. It provides data stored on many distributed directory databases via networks. This service helps to search for information anywhere in the world without users having to learn another set of commands. The JANET service also provides the Bulletin Board for Libraries (BUBL) which is designed specifically to provide information of interest to librarians who use JANET. It is increasingly being used by non-librarians - lecturers, students, and so on - for the guidance it provides on finding and using library-related resources and services on JANET and beyond.

The SuperJANET system

The Information Systems Committee of the Universities Funding Council announced in 1991 the development of SuperJANET. The aim is to provide site interconnection networks at speeds in excess of 100 Mb/s and also the provision of video services for the mid-1990s. The SuperJANET initiative started in 1989 as an upgrading of the JANET II system. The project is aimed at converting the JANET II system into a 'multiservice' network, offering much higher performance. Such a network should allow a new class of distributed data processing applications to be run routinely over a wide campus user base.
The main objective of SuperJANET development is to create more LAN-to-LAN connectivities around the UK by increasing the speed of communication. It is to maximise the number of sites connected and offer a range of access speeds to meet different site requirements. This will allow the interfacing of high performance LANs to WANs and also the provision of video services. This will help the academic community to use pictures, graphics and voices in their teaching courses. It will also help them to communicate with each other in distance learning, electronic publishing, library document distribution, and multimedia information services. It is said that SuperJANET will bring about networked teaching and e-mail with video content.

Today, SuperJANET is made up of the most powerful supercomputing network operation centres in the UK. A provision of 140 Mb/s capacity used by those sites indicates rapid transmission rate. It is expected a minimum of 45 sites will be connected during 1993. Figure 2.4 shows the network operation centres in the UK.
Figure 2.4. SuperJANET wide area network operation centres in the UK
The impact of IT and networking on campuses can be reviewed from the differences of network development sites in Figures 2.3 and 2.4. In Figure 2.3 eight sites were developed as network operation centres whilst in Figure 2.4 fifteen sites developed. This differences in sites indicate that use of networking is growing fast between campuses.

Costs

Provision of 20 million (UK pound) has been made for a state-of-the-art optical fibre network operating at up to 622 Mb/s and with enhancement potential. The funding of 5 million (UK pound) provided by the (former) University Funding Council covers the operation up to 1994. The remaining 15 million (UK pound) funding which extends the operation up to 1997 is being sought from the new Funding Councils and has yet to be ratified. The total funding for the SuperJANET of 20 million (UK pound) is based on a five-year plan.

2.10 Organisational structure change

As with the USA, the proliferation of microcomputing and networking facilities on the campus has resulted in a greater uncertainty regarding areas of responsibility. In consequence, the idea of merging library, academic, and central computing information services has been accepted - though not necessarily implemented - in most UK universities. Establishing a separate
organisational IT committee structure has also been approved. This has led to the appearance of a new senior position, such as Pro-Vice-Chancellor for IT or Director of IT. The incumbent chairs an Information Systems Committee and must have a good grasp of the institutional needs [25]. This new responsibility has placed a premium on establishing how best to support a network strategy throughout the entire campus. Aston University and many others have established a good IT infrastructure around their campuses by responding in this way to new pressures. Thus at Aston University, the Director of LIS was appointed as the University's first Pro-Vice-Chancellor for Information Technology, in addition to her LIS responsibilities. This post was given university-wide responsibility for the development of an IT strategy for academic and administrative matters.

IUCC, CTI and MAC

The Inter-University Committee on Computing (IUCC) was an independent organisation developed many years ago in the interest of UK universities. It was established to provide an effective computing network communication infrastructure between universities in the UK. It was intended to help universities overcome their computing problems, by seeing how they could benefit from IT development to enhance their computing/information services on the whole campus (for teaching, research, and administration). The existence of IUCC and its sub-committees has helped UK universities not only in terms of financial planning,
but also in other respects. For example, the development of training programmes and purchasing policies by IUTC (Inter-University Training Committee) and IUPC (Inter-University Purchasing Committee) sub-committees, respectively, has helped ensure greater efficiency.

The existence of the CTI (Computing in Teaching Initiative) programme for improving teaching and learning activities inside and between universities, and the existence of the MAC (Management and Administrative Computing) initiative for the purpose of improving administrative computing programmes are other examples of national initiatives to aid universities in their transition to an IT-based campus culture.

A survey by Work [26] showed (as of October 1991) that there were 22 campus-wide network information systems in UK universities. They were in full operation, providing staff, students and researchers with the benefit of a networked 'virtual campus', permitting easy access to the resources of the community as a whole.

2.11 User level integration

Since IT started to exist on-campus, several trends have begun to create a user demand for a high-speed network to be developed in the UK academic environment. One theme has been the trend in many areas of research and education towards the increased use of
images in computing and communication. Applications, such as distance learning, remote control of experiments and computer collaboration between users, has called for multi-media communication activities. This emphasis on multi-media, including the requirement to support picture, video, voice and data traffic, suggests that high performance alone is not enough. Thus SuperJANET is expected to provide support to a wide range of network research and development activities in addition to providing a high quality service to an expanding user community.

The development of Pathnet in medical practice, especially in the field of histopathology, is a good example of this. Recently, the Department of Pathological Science, University of Manchester, and the Department of Pathology, University College London, have developed the Pathnet high-speed network to transfer visual images (e.g. diagnosis of the patient's disease and its particular treatment by the clinician, X-ray images, endoscopic images, etc.) via a camera and SuperJANET network to appropriate experts [27]. Pathologists at each end will be able to swap images and discuss relevant features. Pathnet offers the opportunity for a more universal provision of pathology expertise. It is of use not only for consultation with experts, but also by non-pathologists and in providing assistance for countries limited provision of pathology services. It is also of use for training purposes. Developments of this sort can be paralleled in the USA, and reflect the similarity of IT trends in the two countries.
2.12 National network development in the SA

As was the case in the USA and UK, the SA government started to plan for a national network infrastructure in the mid-1970s, although the actual development plan started in 1985. During the mid-1970s the government decided to establish a central campus site to support research and development (R&D) projects in SA. In 1977, the Saudi Arabian National Centre for Science and Technology (SANCST) was established as an independent organisation supporting science and technology [28]. Its aim was to facilitate the application of national science and technology policies to all sectors in SA universities, research centres, and government organisations.

In the early 1980s, the government felt that SANCST should expand its responsibility to become involved in developing a national network infrastructure to serve all SA sectors as well as other Arab Gulf Countries (AGC). In 1985, the name SANCST was changed to King Abdulaziz City for Science and Technology (KACST). It was expected to be responsible for the formulation of national science and technology policies and for the coordination and promotion of applied scientific research in SA [29]. The development of a regional network, known as GULFNET, was started. Thus, the government's concern was to establish a wide area network system in KACST in order to provide an IT infrastructure to facilitate the exchange of data, information handling and messages between scientists, engineers, and other researchers in SA.
GULFNET system

In 1985, GULFNET (the first Middle East computer network for the academic and research community in Arab Gulf Countries) was established as a central node at KACST. Its objective was similar to JANET's, to provide a wide variety of computer network support services to the academic and research community in Saudi Arabia and other Arab Gulf Countries. The network was established with the assistance of IBM and links various computer centres of major universities and research organisations through public leased telephone lines. A computer in each member institution provides a connection to the principal node at KACST. At the present time, there are 14 universities and research institutions in Kuwait and Saudi Arabia connected to GULFNET and a few more are expected to join shortly. These universities and institutions are shown in Figure 2.5.

GULFNET is similar to BITNET in the USA and EARN in Europe in conceptual design and in certain other characteristics. (It has selected the same technology as that used for BITNET and EARN).
1. SAKACS, King Abdulaziz City for Science and Technology
2. SAKSU, King Saud University
3. SAIPA, Institute of Public Administration
4. SAGCC, Gulf Cooperation Council
5. SAMOH, Ministry of Health
6. SAKFSHRC, King Faisal Specialist Hospital and Research Centre
7. SAKFUPM, King Fahd University for Petroleum and Minerals
8. SAKFU, King Faisal University
9. SAKAU, King Abdulaziz University
10. SAIRTI, Islamic Research and Training Institute
11. SAUQU, Um Ulqura University
12. KUKISC, Kuwait Institute Scientific Centre
13. KUKISC, Kuwait IBM Scientific Centre
14. KUKU, Kuwait University

Key code:  SA = Saudi Arabia    KU = Kuwait

Figure 2.5. GULFNET wide area network operation centres in the SA

Chapter 2

Network Background
Connected organisations

At present there are fourteen organisations representing universities, research institutions and government organisations connected to the GULFNET as shown in Figure 2.5. In the near future these organisations will increase due to the return of postgraduate students from the USA and UK after the completion of their degrees. These students have been sent by the government to the developed countries, such as the USA and UK, to get their higher degree studies in various fields, especially in science, engineering and technology. The government's plan for the educational system is to increase the proportion of academic teaching staff who are Saudi citizens. More than 20% of staff in different disciplines in the SA universities are foreigners. These returning postgraduate students, who number several thousands, with experience in using computers and networks during their study programmes abroad, will join the teaching staff at different universities and government organisations. It is already clear that they will want to use computers and networks for communication activities in the SA. Also several industrial companies will join GULFNET, since one of the government's objectives during the Fifth Development Plan (1990-1995) is to provide effective collaboration and communications between universities and industries.

Therefore GULFNET will face problems unless an extension is properly planned. The large number of scientists, engineers and
researchers in the SA will need a fast and efficient network to communicate with each other in an effective way, and also to interact internationally with colleagues elsewhere who have access to high-speed networks.

Services

GULFNET provides the following services: interactive messaging, file transfer, sending notes and keeping track of correspondence, user directory access to KACST's databases, conference system, newsletter, bulletin board facilities, and answering service. A multi-purpose user-friendly e-mail system was designed to allow transmission of pre-defined form(s) from one node to another. Users of KACST's information services utilise this facility to send their request for on-line searching. KACST, for its part, conducts searches on national and international databases and transmits the search results to requesters through the network. The principal node at KACST has also installed a server machine on its computer, called NETSERV, which contains information on the network, location of nodes, users' names and addresses, procedures to communicate with each other and general advice on how to use the network facilities. All users of the network can access NETSERV by entering a command line. These services are provided free of charge to all researchers without regard to their location and affiliation. GULFNET facilities are utilised by KACST to receive search requests and to transmit the search results.
Organisational structure

Although the advance of IT and network development started some time ago on SA campuses, the traditional organisational structure with a Director of Computing is still the norm in SA universities. The idea of merging the various types of information activity that occur on campus has not yet come to the force. An important reason for this (as will be demonstrated later) is that the role of networking does not dominate in SA as it does in the UK and USA. It is appropriate, therefore, to look at the reasons why the different service activities in universities - the computer centre, the library and audiovisual services - are converging organisationally in the UK and USA, and so to establish whether similar pressures are at work in SA.

2.13 The convergence of information services

We have already seen how the UK and USA developed high-speed networks in order to provide better information services to all campus users. We have also seen how university organisation and the users' level of integration has changed.

The university computer centre faced the challenge of mediating new information services to users from the start. This challenge dates from the mid-1960s when many university computer centres started to install mainframe computers to provide central university services (e.g., time-sharing) for researchers to share...
resources across all university subjects [30]. Although a significant amount of teaching support was provided, this related mainly either to research or to computing [31]. Up to the 1970s, the computer centre's facilities provided the only system available for users to take advantage of. Thus the main central facility in the university was the mainframe and the impact of IT was centralised. Many computer centres were heavily involved in centralised provision of this type [32].

The mainframe strategy remained until new developments in networking and data communications began to deliver computing resources to the users' place of work in the mid-1980s [33]. This added a further central facility in the form of a data network and increased the need for connectivity and bandwidth. This, in turn, led to the possibility of radically new service applications. At the same time software development moved the computer centre further from computing services and towards information communication services. Software now comes in packages, which means a move from programming towards a service philosophy, especially as regards communication services. Thus the computer centre is now less a pure computing facility and more as information communication facility. This does not mean that the role of mainframes has entirely disappeared. For instance, software packages on mainframes, such as SPSS and file sharing, still provide for the needs of larger users. But microcomputers and networks have opened up new opportunities for the expansion of the use of IT which the mainframe could never provide [34].
These new developments have made the computer centre accept a move to more decentralised functions, such that the centre is less interested in computers and more interested in information. This brings it much closer to the library.

As with the computer centre, the university library also started using computers to provide information services to its users a long time ago. It started to develop its own systems at the end of the 1960s through the provision of circulation systems, then moved to online cataloguing systems and finally, to integrated library systems [35]. Much of this systems development was within the library as a means to link internal activities. Hence the use of the computer in the library was organised separately from the computer centre. However, recent trends in advanced IT and networking development have opened up a number of new possibilities and created many new demands on libraries [36]. These new electronic information services have made the library very interested in a future 'electronic library' or 'virtual library'. Such a library, being based on an access policy, will be greatly concerned with communication and the remote provision of information services. This means that the library is moving towards the same range of interests as the computer centre in terms of providing effective information communications.

With the emergence of new multimedia for storing, accessing and transmitting information in electronic form, audiovisual centres
are also becoming concerned to a large extent with the development of effective electronic handling of images. The increase in available networking bandwidth - the development from JANET to SuperJANET - means that images can now be handled on networks in a way that was not possible before. This means that the audiovisual centre is becoming more like the computer centre and the library in providing information via remote electronic communication rather than in a distinctive way.

All these factors are bringing together what were previously seen as separate organisational entities. Consequently, there is a new 'convergence' of computer centre, library and audiovisual centre to deliver related services to the same people via more effective electronic communications. Sutton [37] has commented: "It is certainly true that there is common acceptance of the principle that there should be no 'private networks' in the university - a single communications strategy should address as far as possible all needs and provide a common service resource for these three main strands of service."

This convergence is now affecting university organisation at all levels. At a national level, the Computer Board was established in 1970 to be responsible for an overview of the funding of all computing equipment [38]. As universities moved from the traditional mainframe environment towards distributed network communication systems, the Computer Board initiative was integrated with the Information Systems Committee of the UFC.
The new board reflected the carrying together of networked information: it was well positioned to support campus-wide strategy and policy in relation to the convergence of library, computer centre and audiovisual information services.

In the 1990s, several universities have started to develop new positions of Director of IT on the campus to formulate a policy for providing effective information communications in the light of this convergence. Ford [39] points out that universities today increasingly need an IT presence at the top management level because the whole business is now becoming increasingly complex and competitive. It seems that modifications in the organisational structure of universities are necessary to deal effectively with the information changes occurring on the campus.

The user side has also changed due to the growth of networked information services. These have enhanced users' abilities in using various kind of information activities (e.g., electronic mail, online searching). Traditional computing are relatively less favoured by campus users today: skill and knowledge have started to shift from computer programming to information communication. It is coming to be accepted that the most important thing in the convergence mentioned earlier is the need for developing effective training programmes so that users can communicate and handle information successfully. The challenge today is in the development and provision of professional training programmes to help users make more effective use of IT services.
In the UK, for example, several such programmes have been developed in recent years [41], largely targeted at various types of users (academics, students and administrators).

What all these developments mean is that the impact of IT on the university campus is changing the forms of networked information service, organisational structure and users' communication. It is, in effect, making the university reshape its environment to a more electronic form, in the light of the convergence of the information services.

From the practical point of view, the developed countries have already started to experience the changes mentioned above. Appropriate models for such a system are being developed in the form of an organisational IT structure [42] to provide effective coordination between people on the campus. The convergence of library, audiovisual and computing services is developing under this umbrella. The Computer Board, the Research Councils and the Information Systems Committee [43] have discussed the impact of IT on universities and have noted the importance of developing organisational structure in the light of the spread of IT and networking across the whole of higher education. In some institutions, recent organisational changes have exploited this 'convergence' of library, academic and computing information services under a single managerial system of IT [44]. Aston University, for example, moved to this system and appointed a Director of IT to merge the previously different services. The aim
has been to achieve organisational and managerial integration between the library and other services as the best way of ensuring their functional integration and improved coordination in planning over the entire campus.

On the user side, teachers, students, researchers, etc., are working with various kinds of computers (e.g. microcomputers, mainframes, workstations) and communications activities (e.g. e-mail, online search, distance learning). This community needs reliable information service facilities so that use of IT and networking can be effective in teaching/learning and research systems. For example, Newcastle University and a number of American Universities have developed the WINE (Workstation Integrated Network Environment) system to enable users to construct distributed information applications on workstations [45]. At London University, LIVE-NET (London Interactive Video Education Network), which is a broadband fibre optic video and data network linking the major schools of the university, has been developed to provide effective information communication services between campus users [46]. Queen's University has developed a Centre for Computer Based Learning with the aim of providing effective use of computers in teaching/learning systems [47]. This means that several universities in the UK have developed and are developing campus-wide networks to provide users with effective teaching-related information services. Clearly, these developments need to be coordinated at the national level. In this regard, the UK has pioneered the development of CTI
(Computers in Teaching Initiative) and ITTI (Information Technology Training Initiative) to provide new ways of improving learning [48].

In developing countries, more specifically in SA universities, there is a similar interest in the use of advanced IT and networking facilities to provide effective information communication services. The introduction of the computer in the SA educational system is widespread, and facilities are beginning to follow the UK pattern. For example, King Saud University (KSU) is moving toward an integrated computer communications network services by using advanced IT such as fibre optics and ISDN technologies [49]. At present, the Faculty of Medicine has video terminal capabilities for teaching purposes, but these terminals are not yet connected nationally to allow other universities to benefit from them. King Fahd University (KFU) is using advanced IT to provide an effective e-mail communication service to link all campus users and to enhance teaching/learning systems [50]. At King Abdulaziz University (KAU) there is a similar development. The university is using advanced IT to develop a high-speed network information service on the campus. It is now investigating the use of video in the Faculty of Medicine, but the use is limited at present to the students in class only: it is not yet connected nationally. The libraries at these universities are also changing. They are already putting their activities on computers and developing OPACs and CD-ROM network. More generally, the government has initiated strategies and plans for developing advanced technology in
various sectors of SA to improve information services (as was mentioned in the previous chapter).

All these facts indicate that there is a movement in SA universities away from a mainframe oriented system and towards more integrated information systems. In the near future, these systems within different universities will need to be connected nationally to provide effective IT and networking infrastructure throughout the country. All the signs are that we can expect a similar convergence in SA and a similar impact upon organisations there.

Technology-push and demand-pull

Most of the information technology services developed in universities were thus originally separate. The computer centre developed its own information services, as did both the library and the audiovisual services. The reason for this was the limited technology available at that time. The limitations of this technology both restricted its use, and determined how it was organised. To take an example outside the universities, Prestel (viewdata system for obtaining data via TV) was put up by BT because they thought there would be a demand. In fact, there was not. The technology push was simply neither well-timed, nor properly supported. Again the original development of JANET mistook where the demand was. It was thought that the demand was for file transfer when it was actually for e-mail. So in this instance, it was not purely a case of technology push, but they
mistook what the demand was for. Another example is CD-ROMs. The libraries thought that there was a demand for CD-ROMs and they installed several individual CD-ROMs in their libraries. In fact, they, too, mistook what the demand was for. People liked CD-ROMs, but did not want to look at them in the library: they wanted them networked. All of these examples are of technology push which did not understand user needs.

Today, one can see that demand-pull in the UK is often more significant than technology-push. The reasons are: users now have more skills and knowledge about using computing systems than before due to their experience; there is increasing use of networked information services within the user community; users demand enhanced means for exploiting their research, teaching and administrative activities; the increasing availability of broadband digital networks in attracting users; decreases in the price of IT equipment are making purchases more acceptable to individuals and organisations.

The development of SuperJANET is a good example. Its early growth has been to enhance information services, remote consultations, group communications and teaching/learning: these applications have developed from the needs of a large user community and will help to ensure that users' needs are satisfied at an early stage [51]. In addition, the creation of the new position of the Director of IT within the UK universities is another good example of the demand-pull situation. This position was
developed to meet users' demand in providing effective information communication services in the light of converging library, computer centre and audiovisual technologies.

In SA, there is some demand-pull. For example, some scientists want wide-band facilities to transfer information, but the number of people involved is not large enough to merit provision on their demand alone. Technology-push is therefore more important at the moment. In the near future, the demand is expected to increase with the increasing number of users. Demand-pull should then become more significant than technology-push. In terms of the comparison between SA and the UK, it means that SA is moving in the same direction as the UK in organisational terms, but probably the process is slower in SA than in the UK because there are fewer users involved, and so demand-pull is less.

All this implies a need for more user training in SA, as has already been divided in the UK. The convergence of systems in both countries requires more user training. The difference between the UK and SA as regards technology-push implies that a somewhat different approach to the encouragement of training may be needed in the two countries in the immediate future.

Putting all these factors together, it can be concluded that SA is moving in the same direction as the UK, but not necessarily at the same speed. However, more user training is certainly required to achieve progress both in SA and the UK.

Chapter 2 -63- Network Background
REFERENCES

(Details of publishers are included in the bibliography at the end)


3. Al-Tamim, F. *Towards integrated computer communications network at King Saud University*, 1990, pp. 4-8.


Chapter 2 -64- Network Background


13. Ibid., p. 9.


Chapter 2 -66- Network Background


32. Spratt, ref. 30, p. 4.

33. Spratt, ref. 30, p. 5.

34. Hartley, ref. 31, p. 19.


conference held at University of College of Wales, Aberystwyth, 3-5 April 1990, 1990, pp. 30-33.


43. Ibid., p. 28.

44. Joint Funding Councils' ref. 36, p. 29.


46. Joint Funding Councils', ref. 36, p. 70.

47. Joint Funding Councils', ref. 36, p. 27.


Chapter 2 -68- Network Background

49. Al-Tamim, ref. 3, p. 6.


Chapter 3

The effect of IT on the educational system

3.1 Introduction

As a result of recent progress in various aspects of IT (involving various combinations of video, data, graphics, etc.) in educational systems (teaching, research and administration), high-level network services and communication tools are becoming essential parts of higher education in developed countries. The first question to be asked about this concerns the organisational structure. This can be seen as a system-related question: university organisations are viewed here as systems that focus on planning, strategy, decision, policy, training, etc., to produce effective use of IT on the entire campus.

This chapter discusses the impact of IT on the educational system by looking first at the university organisation, second at educational matters, and finally at the training environment.

3.2 Organisation

A central task facing organisations is how to apply new IT capabilities to develop greater co-operation and co-ordination among their employees. This requires individuals and/or groups to work together within the organisation system to achieve specific
goals. One way of viewing the organisation and its effective management and co-operation is to represent the organisation as a stable system of individuals who work together to achieve common goals through a hierarchy of ranks and decisions [1]. This can be extended to consider it as a system of overlapping and interdependent groups [2]. Other ways are to look at it as a collective group of individuals who are capable of fulfilment beyond the capacity of individuals acting alone [3], or as a group of people who are arranged in a structure and with an identifiable objective [4]. Thus Redding [5] and Newstrom and Davis [6] have discussed an organisation as a whole system that uses an organisational relationship of individuals and groups to achieve an objective.

In the university context, this human activity system looks rather different from the other organisations indicated above. For example, a university organisation differs from an industrial organisation, whose aim is the production of goods and services, and which is subject to the overriding condition that it must make a profit. It differs because the university's product is teaching, researching, learning and developing knowledge, and this cannot be added together into a sum total of profit or loss. Livingstone [7] has remarked that the traditional assumption sees the university organisation as fundamentally a community of scholars. In particular, a university does not have a single objective. It actually has two major objectives - the discovery of knowledge (research) and the dissemination of knowledge (teaching). In addition to
these two objectives, it must also run an administrative system. The administrative system is perhaps similar to other organisations, though university infrastructures often differ. Consequently, when we look at information in the university we are dealing with three different types of information that often flow and are handled in different ways.

**Network organisation**

Most traditional organisations have supposed a centralised structure. Networking stresses decentralisation. Centralised organisations may now need to change in order to fit into the structures imposed by information technology systems [8]. A new approach must recognise how human characteristics operate within a decentralised network organisation [9].

It is already clear that IT can fundamentally change the way work can be done, can integrate functions at all levels within and between organisations, and present new strategic opportunities for organisations as they reassess their missions and operations [10]. The obvious example within a university organisation relates to the merging of computing, library and administrative systems.

**The system concept**

A system, in this particular case, implies separate components put together to achieve organisational goals. The term 'systems' can be
used in many contexts. In the university organisational context, for example, we can speak of administrative and departmental systems. In teaching/learning, we can speak of communication systems, etc. Definitions of (system) in the literature differ, but in all cases indicate that the system as an assemblage of components. Thus Senn [11] defined it as an array of components designed to accomplish a common objective of supporting organisational activities. These include day-to-day work, communication of information, management of activities, and decision making. Harrington [12] defined a system as a collection of parts interacting with one another in an integrated and dependent relationship to produce the organisation. These definitions indicate that systems are characterised by their component parts, environment, boundaries, input/output, goals, objectives and many other entities. Thus the systems approach to the study of organisations proceeds from the premise that a system is composed of a series of definite components brought together to achieve optimal efficiency as a whole.

It is useful to apply this concept to the university organisation. The main objectives of the university organisation, as mentioned earlier, are teaching, research and administration. These represent the major systems. Within these systems, are other systems. Libraries and computing centres, for example, can represent lower-level systems which link administration, teaching and research activities. The components of these systems may be students, faculties, staff, books, and so on. The components may be linked
by different types of information system to provide the necessary impetus to allow the entire organisation to accomplish certain objectives.

The nature of system and sub-system can vary in an organisational context. For example, the administrative system is a sub-system of the university's whole system. But it can also be referred to as a system itself, because it deals with many interrelated components (such as financial, budgeting, planning and personnel). Equally, the teaching system may be considered as a sub-system of the university's whole system, because it is within the university organisation; but it can also be referred to as a system if we relate it to its components (classrooms, instruction, blackboards, computers and so on).

3.3 Information systems

Information systems integrate system components, in this case teaching, research and administrative systems. These information systems relationships can be represented by means of network information flows, such as information that is sent to departments either directly or via the faculty. Newstrom and Davis [13] have noted that, as advanced technology spreads in organisations and work is broken into smaller parts, new integration is required to put them back together again to make a whole organisation system. This can be expected to be necessary for the organisational structure of universities.
3.4 Structure

In the earlier history of computing, a single computing centre did not necessarily serve both the academic and administrative needs of the university [14]. Now, as a result of networking, there has been a movement to reunite all computing under one organisational structure. One reason for this is the recognition that these different IT resources need full management attention. Without management's basic understanding of the nature of the IT problem, it is difficult to obtain the necessary resources for the development and distribution of computer resources on the campus [15]. The organisational implications are that IT services are no longer concerned with individual services, such as the library, administration, teaching, research, etc., but with the university as a whole [16].

Woodsworth [17] notes that the effect of network IT on university organisation has been to place increased emphasis on centralised co-ordination and decentralised integration of planning and goal setting on the campus. Harrington [18] considers technology as of primary importance in influencing the structure and functioning of an organisation, whilst Holtham [19] has emphasised the need to understand the appropriate organisational model in determining and identifying all the interrelationship activities adequately. All these suggest that IT has put pressure on the university organisation to focus decentralised institutional planning efforts on the whole campus-wide information system.
A further change has appeared in the user environment, where intensive training programmes and better information services have been introduced to increase users' ability and knowledge in dealing with this new network environment. Two elements can be identified here: a) the computer centre staff who manage and operate the computing systems, and b) the university users (academic staff, students, etc.) who use the computing systems. Elbert [20] has remarked that computing managers have to educate themselves in data communication and network facility. Managers who work with data traffic networks now encompass multiple sources of network services and equipment, such as audio and video. Thus computing managers (IT professionals) should have a practical understanding of the systems aspects of IT networks. Rosevear [21] has commented that courses which can offer multimedia IT training products and services can provide professional development and skills to manage and operate IT equipment within the campus effectively. So training programmes relating to advanced network technology now need to be developed, based on a good planning strategy and providing the necessary steps towards developing skilled and experienced people. Initial training should include general awareness of what network information technology can do, how it is organised within the campus, and in general terms how it is used by the different services. In summarising these factors, Ewart [22] indicated that the university campus should be looked at as an information system, including [23] all areas of computing organisation.
(computer centre, library, academic computing, etc.) into one division of information system and services.

3.5 Teaching/learning

Today the impact of IT is more due to the spread of networks and the availability of advanced communication systems, which are much more pervasive. As the technology is developed and spread over the whole campus, the university's infrastructure is becoming a collection of multiple technologies, involving staff, library, electronic databases, e-mail and so on [24]. This development of technology is opening up an opportunity for learners to use today's technology to get instant access to information from any place, at any time and in any format they want.

The pervasiveness of the emerging networked technology has now changing teaching/learning systems more than ever before. It is affecting how people on campus (teachers and students) access, gather, analyse, present and transmit information of many kinds. This has made it more possible for students to study when and where it suits them. They will be less restricted by library opening hours, schedules or classroom. This change, as Richardson [25] says, will increasingly require people to know how to use the system and to handle information activities effectively. Communication skills and training will be essential to enhance the learner's ability in this learning system.
The new networked environment has changed the way courseware has developed for teaching/learning purposes. Interactive text has come back into prominence with the increased use of computer-assisted learning in recent years [26]. Much courseware is being produced in formats that better involve graphics design and layout. Furthermore, interactive video has appeared as the latest and (to date) most sophisticated audiovisual communication system for individual use [27]. See [28] points out that in today's technology implementing a quality educational system requires a change in the way teaching is traditionally delivered. He emphasises two basic factors which need to be considered in the new system of teaching/learning - comprehension and communication. In the first instance, the application of knowledge, skills and activities to comprehension is changing because technology is providing various kinds of access to information. In the second, multimedia technology is changing the way learners will access, process and communicate the information they comprehend. Thus the new strategy for technology, changing the teaching/learning style, is to see all knowledge and skills, all machines, all equipment, all manuals, all software, etc., as comprehension and communication processes, not as products. In these terms, there is a need to put these technologies directly into students' hands, so that they can train seriously for the job, the world, and the lives they will lead tomorrow [29]. From the practical point of view, adopting these strategies is not easy, and, although institutions are already moving along this pathway, it will remain difficult.
In the USA, universities started to face these technological challenges in their teaching systems some years ago. As Erhmann [30] points out they began to change their campuses to attain a limited, but vital set of institutional objectives - a sufficiently up-to-date curriculum, adequate access and an affordable, supportable budget. Since 1985, funding of almost $10 million/year has been invested in a programme called the Annenberg/CPB Project, devoted to the developing video, print and computer software for curriculum use, to the demonstration of new technology as applied to educational problems, and to research on technology in higher education. It was developed because people felt that many types of software developed in the past in colleges and universities were not distributable in a form which presented information to students in an orderly instructional fashion [31]. Ehrmann further indicates that the courseware was in limited and crude (not upgradeable) software packages that were not particularly likely to revolutionise anything. They were acceptable to faculty members who wished to use them to make marginal improvements in current courses. Today, learners need widely available, highly developed software for instructional use, including WP, spreadsheets, communication packages, the Internet, etc.

In 1990 the EDUCOM programme for Educational Uses of Information Technology (EUIT) began to talk of the need for effective development of computer courseware to be widely used on and off-campus [32]. This so-called "worldware", which
includes all activities mentioned above, now exists in US universities. Today's curricula are becoming dependent upon the use of such worldware. Universities recognise that:

. worldware can assist important changes in the curriculum, even though it has no curricular content,

. what matters most are uses of technology that influence the student's whole course of study, and worldware is flexible enough and relevant enough to make such change possible, and

. if such curricular improvements come from independent choices made by faculty members and students, the cumulative effect can be significant and yet remain invisible to university administrators and to national experts on education.

Due to these developments, campuses are now experimenting with courses using several different technologies to give learners on and off-campus a rich and well-structured information experience, e.g. a combination of live or taped video for lectures, audio-conferencing for small discussions, and e-mail for discussion and transfer of homework [33]. All these developments mean that campuses in the USA are changing their computer-based learning environments in order to survive and grow in this decade.

In summary, we can conclude that universities in the USA are trying to develop good teaching/learning systems by providing: (i)
a rich information environment (e.g. enabling students to work individually and/or in groups, to gain skills), (ii) making education more accessible for all learners (at any place on the campus and at any time), and (iii) establishing more shared resources and tools across organisational boundaries (sharing libraries and laboratory equipment in the broadest sense with other colleges, universities, government, etc.).

In the UK, similar strategies are now being developed. Universities are trying to develop effective teaching systems to meet campus users' needs. The development of SuperJANET, linking all UK universities with each other in a more advanced and effective way, should produce rapid and easy communication for staff and students in those institutions. Links into worldwide networks are opening up opportunities to transfer technology-based learning programmes between institutions. In this regard, Rowland [34] says that the availability of advanced communication technologies and networks is changing the direction of teaching systems so that:

- There will be subject-centred groups of teachers who will communicate over the network.

- Communication between teachers and between students on a worldwide basis will be normal and courses will be available on a logging-in basis to all people.
Graphics and images databases will be available over wide-band networks and will be used heavily in teaching.

The networks will make multimedia material available everywhere.

All lessons will be much more flexible with network access available in the classroom.

In the UK, the CTI organisation has highlighted various needs that must be met if effective teaching/learning systems are to operate. Among these needs are:

- an effective quality control filter for courseware,
- better distribution and support mechanisms for courseware,
- discipline-based courseware development centres promoting standards of good practice and offering comprehensive support service for developers,
- encouragement of multi-institution courseware development projects,
- effective campus-level support in all universities for computers in teaching and learning and guidance on strategies for exploiting the potential of multimedia in education, and
a programme of research into the effectiveness of computers in teaching.

All this means that a new direction in teaching systems is being considered, and that learning technology will assume a greater importance in the coming years. In view of this, a recent report [35] from the Advisory Council on Science and Technology to the Cabinet Office has stated that new learning technologies, such as interactive video systems, compact discs and computer-based learning, should be used for greater productivity in Higher Education Institutions, especially with increasing student numbers. This, they recognise, would require funds to be available for a software development.

The systematic gathering and dissemination of information and resources for computer based-learning carried out by the CTI centres is a good example of this approach [36]. The funding of five million pounds committed by the UFC's (now Information Systems Committee) Teaching and Learning Technology Programme in 1992/1993 in support of projects that will "develop the integration of new technologies into the mainstream of teaching and learning in higher education" [37] was a good start in experimenting with new changes. Today, the output of these project developments is apparent in a variety of ways. For instance, a recent CTI report [38] indicates that, at local level, universities (through CTI Centres) are examining the provision of facilities and support for computer-based teaching to provide
integrated services among, and in some cases across, disciplines. Such services must be of high quality, adapt to the specific educational and computing needs of the disciplines, cope with the traditions of the disciplines, and have credibility with academics. In view of this project development, universities are beginning to apply computer-based course material at the local level to provide effective teaching systems. Developments have included - suitable hardware access for staff and students, a software and courseware library, a source of technical advice for mounting and adapting software, resources for the production of material within the discipline to suit course programmes, creating of a policy to encourage the reusability of materials and the development of Computer Management Learning (which concentrates on managing the learning process rather than contributing to the course materials) within the individual institutions.

In another example, the CTI reports cooperation between institutions to integrate facilities into a national system. This need is called for because teaching systems are expanding on and off-campus, and this cannot be generally provided at the local level. Response to these needs lies in cooperation between campuses. It has been [39] recommended that:

"universities provide local support and coordination which meshes into a national discipline-based activity. At the local level the Computer Centre activities should be well integrated with the work of the departments and faculties,"
the Staff Development Unit, the Library, Computer-Based Learning Unit, Audio-Visual Unit and the research programmes of the Education Faculty, the Computer Science Department and related departments. At the national level the CTI should be encouraged to stimulate and support Computer Centres, Libraries and special units in their support of computer based teaching and learning."

On the evidence of these developments, which have already taken place, there is increasing scope for improving the management and delivery of CAL services to increase students' learning activities in the local and national context. Currently, the lack of high quality courseware is seen as a major blockage to the uptake of CAL in universities. Early uses of computers in teaching suited the limitations of the technology, but subsequent development has provided a wide range of different kinds of computer-based course materials, offering students opportunities to choose from alternative modes of representation and to explore databases containing multimedia materials. Thus CTI has expanded its planning activities to include an element of courseware development to cover as wide a range of educational software as is necessary and to provide for the needs of all disciplines. The list includes - software for tutorials (including demonstration/example materials), simulation software, distance learning materials, software tools, and multimedia materials [40]. These CAL developments differ from previous ones in that today's CAL must provide tools not only to enhance teaching activities, but also to
make learners re-think how learning is achieved and how courses are structured. Today's CAL development must cater for a more flexible and integrated system and one which needs greater knowledge to operate.

In view of this, it is noteworthy point that, in the USA especially, the term 'instruction' (a generic term for computer-assisted instruction (CAI)) tends to be used in a more global sense, for any type of teacher/learner interchange, whereas in the UK the term 'learning' is being used as a preferred generic term for computer-assisted learning (CAL) [41]. Although they look similar, in that both systems use computers for teaching/learning, conceptual base is rather different. In today's technology, it seems that the word 'learning' is a more appropriate term to use than 'instruction', because use of computers can assist in many diverse ways. Many examples of these different learning activities have been mentioned previously.

All these developments mean that UK universities are experiencing rapid change in their teaching with increasing emphasis on information technology and information management. The CTI's national subject centres, with their concentration on innovative teaching methods, and also the Information Technology Training Initiative (ITTI) projects with their products, are examples of current support for improved learning that should form part of a new infrastructure for innovation in education.
These developments of shared electronic educational resources and new networked forms of large-scale teaching will require new organisational structures and the creation of a supporting infrastructure at both the national and international level [42]. In view of this requirement, some universities in the UK, such as those at Aston, Belfast and London [43], have already moved towards organisational integration of their educational support operations: moving distance learning, multi-media instruction, etc., into the same division of the university as the information services [44]. SuperJANET will extend the scope, allowing faculty and students to use computer-based tools and resources for teaching and learning via networks and remote terminals [45]. Remote courseware delivery will also allow students working at home to access a rich base of learning materials directly on and off campus [46]. A recent survey [47] conducted in UK universities indicates that courseware development, use of commercial software and of computer-based learning programs are one of the important changes now in progress on campuses.

In SA, a new trend in teaching/learning is appearing. The Ministry of Education this year has announced the approval of the government to include a computer course in the High School curricula as a basic course to be studied within the teaching system. This does not mean that computers have entered high school only recently. The private schools have already been using computers for some years. The government has also developed a plan (see Appendix VI) for enhancing student and staff skills in
computing system in Higher Education. This trend indicates that there is a new direction in teaching system in SA.

In the UK the use of IT started in the 1960s. However, the limits of technology at that time allowed the teaching system to grow only slowly, as mentioned earlier. None of the developments in technology had a significantly strong impact in changing traditional teaching approaches in a fundamental way. The other reason for this slow development was that the users were not interested in using computers. This was again due to technology availability. This means that in the past technology was not a problem since its presence or absence did not have a significant effect on the teaching/learning environment.

Now the situation is changed. We have seen how the UK universities have radically changed their teaching and learning systems through the use of modern technology. This means that the presence of technology has become important in the teaching system. The pressure came from the users side. The increasing number of students enrolled in the university and their demands for effective teaching pushed universities to consider highly developed educational systems.

Comparing the UK with the SA situation a similar effect will occur. There will be a substantial proportion of students coming straight from school, with some basic skills in IT and computing, who will require modified courses and conditions and not need to start
from the very basic level. So the future system of the university will not just have increased in size, it will have diversified, creating additional requirements. Furthermore, availability of today's technology and availability of sufficient funding will make it an easier and faster development.

All these factors indicate that the UK teaching/learning systems can be used in SA. This does not mean that same criteria, implementation and development will be used in SA, but the experience will guide development stages to be considered in the design and implementation of new teaching system through using modern technology, at least in the organisational form. The development is not easy and cannot be carried out within days or months. SA needs to develop specific teaching/learning policy statements which may take some time.

In summary, the UK teaching applications can be useful in the SA situation, but to introduce these there should be a larger number of users. This may slow down the process of implementation for some years, but it will grow fast later on when a large number of students will be coming from school, and their demand for IT teaching/learning will increase. Thus universities in SA must from now start to plan an effective educational system policy development. The important issue in this area is conducting research and experiment - developing CALs in different subject areas, standardisation in software packages, etc. It is good practice to coordinate with the developed countries, such as the UK, to
gain insights in this matter. This may help universities in SA to find out what problems exist in teaching/learning system and how these problems can be solved. In this case examination of what has happened in the UK will remove some problems, particularly since at present, UK universities are experimenting and developing researches and projects in teaching/learning areas.

Open learning

"Both open learning and distance learning are terms that have been in common use in education and training circles over the last twenty years, along with close relatives such as flexible learning, supported self-study, resource-based learning and so on" [48]. Paine [49] has stated that open learning is a broader concept than distance learning. Distance learning deals with students separated physically from the learning centre, whilst open learning focuses and concentrates on developing a flexible learning centre. However, definitions have varied and there are no agreed definitions for open and distance learning. The following describes some of the definitions that have appeared in the literature. Lewis and Spencer [50] defined open learning as the provision of flexible courses to meet individual requirements, so attempting to remove barriers which prevent attendance at traditional courses. This implies a learner-centred model. Dixon [51] defined it as learning opportunities that both aim to give access to knowledge and skills otherwise unavailable, and give learners the optimum degree of control over their learning. Paine [52] has described
open learning as focusing on access to educational opportunities and student-centred learning. The student can thus choose how, when, where and what to learn as far as possible. Finally, Hold and Bonnici [53] have defined it as a multi-faceted concept, which attempts to reduce, if not eliminate, a number of the barriers to certain groups of students participating in formal education. It also attempts to provide students, on entering various courses of study, with the best possible chance of successfully completing their chosen learning experiences.

These definitions indicate that most educational systems have elements of both openness and distance, whichever way they are designed, as Hodgson [54] has noted. He further pointed out that confusion or blurring often arises because of the names that institutions or organisations adopt. The Open University (OU) in the UK is a good example.

For most people, open learning implies that the learner's work is organised around self-study materials - the packages [55]. As Lewis and Spencer [56] have pointed out: ".... in nearly every case specially prepared or adapted materials are necessary." Within today's new technology (ISDN, ATM, etc.), such facilities as Windows, Icons, and Pointer are used to manage the computer screen so as to make open learning activity easier. The use of video, graphics, sound, etc., at high speed and simultaneously is another learning method that helps to make the open learning environment more effective.
All these means that new technology opens up new areas for the open learning environment. What is needed, as Paine [57] has said, is to alter traditional education and training and herald the wider acceptance of the open learning principle. Such a principle can contribute to openness [58] by:

- enabling more people to learn by economising on the amount of teacher time required.
- using a variety of media appealing to different learners.
- enabling learners to study when and where they choose.
- enabling them to work at their own pace.
- setting learning activities in the learner's home, community or workplace.
- giving learners responsibility for their own progress.

Distance learning

Distance learning quite simply means that the students and teacher are at a distance from one another, with little opportunity for face-to-face contact [59]. Definitions have again varied, but all refer to the use of communication materials, such as print, video, audio and so on. Perry and Rumble [60] defined distance learning as when the learner and the teacher are not face-to-face, so that in order for two-way communication to take place between them, a medium such as print, radio or the telephone must be used.
Kaye [61] contrasting it to traditional classroom or campus-based education, described distance education as characterised by a clear separation of the majority of teaching and learning activities. Teaching is to a large degree through various technologies (print, audio, video, broadcasting, computers), whilst learning generally takes place on an individual basis through supported independent study in the student's home or workplace. Finally, Rowntree [62] has defined distance learning as learning at distance from one's teacher, usually with the help of pre-recorded, packaged learning materials, but with the learners still being guided by the teachers.

Distance education has been in existence for many years. But learning processes formerly proved neither effective nor efficient due to the limitation of communication technology development at that time. Most of the forms of distance education, as Sewart, Keegan and Holmberg [63] have indicated, were identified by the technical media they used. This view has been endorsed by Srisanan [64], who has mentioned that, in the past, there have been different experimental approaches to distance education teaching, but printed materials were the most efficient instructional medium used for that purpose. Correspondence education was originally such a single medium system, but is now supplemented by such media as radio and television. In 1970, the Open University in the UK introduced audio support for distance learning delivery in the form of audio-cassettes and telephone tutorials [65]. In the USA, the city of San Francisco developed an
electronic university network system for the purpose of distance learning by providing audio and telephone based systems [66]. In general, between 1960 and early 1980 the use of educational technology was in the form of print materials, audio and telephone line systems. Today the use of information technology has extended to involve more materials or media.

Four key concepts have been stressed by Van den Brande [67]. They are: openness - in terms of meeting changing and differentiated learning needs; flexibility - in terms of adaptation to individual needs and learning modes and providing full interactive facilities with tutors or other learners; decentralisation - both in terms of reaching people in remote areas, and of unimpeded access to study facilities at a distance; multimedia training - a definition based on the prevalent instruments and techniques. The advantage of these new technologies, as Van den Brande further describes, is that they can be made more readily accessible to the students and more economical. NREN technology development in the USA is a good example. Ehrmann [68] has noted that the strategy's central elements involve the use of worldware computing conferencing, and networked partnerships to create an educational environment that is exceptionally strong in project-based learning, exceptionally accessible to the learner off-campus, and exceptionally cost-effective. This means that universities, especially in the USA and UK, are trying to develop a national information infrastructure strategy to enhance teaching/learning activities with the introduction of new
technology. One of these important technologies is multimedia systems, and the other is the development of applications for the computer system itself (e.g. Hypercard/hypermedia of Apple Macintosh).

Multimedia

Multimedia permits the integration of texts, graphics, digital video images, digital audio and sound synthesis as shown in Figure 3.1. This is a model developed by Barker and Tucker [69] to represent the multimedia capabilities of hypertext. Today's technology (such as ISDN) makes it possible to access and manage a wide variety of media in ways which were not previously possible. As an example, Clark [70] has noted that a high quality picture, which previously could not easily be transmitted because of its high information content can now be transmitted in eight seconds via ISDN technology. Furthermore, recent developments in information technology through digital video (ATM and SDMS) have made the learning environment more effective. In this regard, Botto [71] has remarked that video-conferencing allows you to see your colleague in a Window on your screen and allows participants to talk face-to-face as if around a table. Voice-mail, for instance, can record
Figure 3.1. Forms of multimedia model
sound, providing a voice-computer link. Thus with today's new technologies, the management of multimedia is giving the opportunity to provide new services, which include not only numerical data and text, but also other information such as video and images.

The advantages of computer-based media over the other media mentioned in Stewart's model are indicated by Jones and Winne [72]. Computers have the capability for visual display and graphics, feedback and record keeping, exploration, networking, direct manipulation and interaction, access to common databases and focusing on specific parts of the material. In the area of support, Paine [73] pointed out that new technology has many uses. Microcomputers and modems, electronic boards, bulletin boards and electronic mail are all cheaply available. This means that a student has access to the learning system twenty-four hours a day. It also means that certain pieces of information, such as tests or further reading, can be downloaded from a computer located in a learning centre onto a student's own micro. Students are also able to communicate with each other in a way hitherto impossible. Furthermore, in terms of interface systems, the level of compatibility which has emerged between the Macintosh and the PC provides a most significant opportunity for teaching and learning systems. Microsoft, for example, has committed itself to the MacroMind animation file commonly associated with the Macintosh. As a result, the Macromedia engine incorporated within Multimedia Windows is able to play MacroMind animation
files directly [74]. SuperJANET technology development in the UK is a good example of a new service that can support an academic teaching/learning environment. All kinds of multimedia services will be usable on the SuperJANET system and will reach all major sites in UK HE institutions by the year 2000 [75].

All these examples indicate that new technology is being developed in higher education to ensure an efficient learning system and extend the range of subject and skill areas with which education can cope. Thus, the impact of multimedia computing technology on teaching/learning is becoming clear now that the computer is no longer solely confined to WP, database and spreadsheets, but is likely to involve video and images. Particular attention is now being paid to Computer-Assisted-Learning (CAL) and/or Computer-Assisted-Instruction (CAI). In distance education systems employing a multi-media approach, CAL and/or CAI are the important media that enhance effectiveness and efficiency.

CAL and CAI

Over the past decade there has been an almost explosive growth of interest in applications of the computer as a learning resource. Consequently, the production of effective courseware has become a major factor influencing the successful uptake of this approach in Computer-Assisted Learning (CAL) and Computer-Assisted Instruction (CAI) [76]. Rushby [77] has put forward the view that CAI is synonymous with CAL, but it can have different
connotations in Europe (where it can imply tutorial CAL) and in North America (where it is used as a general description). Both activities mean teaching with the aid of a computer using a variety of media in an appropriate combination. Hodgson [78] has described CAL as the interactive use of computers for explicit learning purposes, there being various ways in which computers are used for this. Meurrens [79] viewed CAL as a way to fill the gap between the computer and the educational process. He further suggested that the usual approaches to CAL can be viewed as methods of moving from the computer towards the learning process: these approaches use several tools, such as programming languages and tutorial systems, to provide satisfactory answers to computing problems and screen management.

In the past [80], conventional approaches to CAL development have been based primarily on the use of a keyboard and screen. Most past CAL developments have also relied on mainframe systems in directing and assisting sources of information [81]. This means that CAL developments around the 1970s were limited to the mainframe system, a keyboard and screen management. Today, new information technology offers a wide variety of educational programs covering almost all the stages of learning. The advent of networks and microcomputers have made it feasible to replace the basic peripheral combination (of keyboard and screen) by a sophisticated CAL workstation. Peripherals, such as Windows, Icons, Mice and Pointers, have helped to make the teaching/learning environment more effective, as Whiting [82] has
pointed out. The reason for this is the development of interfacing technology for telecommunication ports which has permitted use of a wide range of teaching aids and encouraged sophistication in developing the use of different media. The most important media development in recent years has been the emergence of Hypercard, Hypertext and Hypermedia for the Apple Macintosh which was a milestone in the commercial evolution of multimedia. These advanced technology media have made teaching/learning systems more effective and efficient and have increased the learner's interaction environment within the computing system.

Hypertext has led to a re-evaluation of computer communication. The rationale behind Hypertext was to optimise the process of writing, storing textual information, and accessing that information. Hypertext can be seen as a non-linear text organised as nodes with information connected via links in a web-like structure. Hypermedia which has been available to Macintosh users through Hypercard since 1987, consists of Hypertext combined with still or moving images and sound. Hypercard is one particular form of Hypertext. It was the earliest commercially developed package by Apple Macintosh to combine text, graphics, sound, etc. Thus Hypermedia can be said to be a relatively mature area of multimedia.

These changes in information handling have led to debates concerning how the teaching system might be made more effective
by the use of modern technology. Gardner [87] has suggested that an institution needs to impart IT skills to its students in terms of how the computer can be used to solve specific problems. He further felt that, due to technological developments in the educational system, the emphasis should be given more to the dissemination of information and knowledge and less to technology. This statement was endorsed in a different way by the Committee of Scottish University Principals [88]. They indicated that the status of teaching in higher education must be significantly raised to harness the creative skills of those involved in teaching and learning. This means that dissemination of information and knowledge should be developed via "skill" development. There should be some plan to raise staff/student skills in using computing IT more effectively. These developments will not leave the teaching system untouched. Law [89] has commented:

"There will be a shift from teaching to learning, from instruction to self-paced discovery. It is equally true that this will place enormous burdens on academic services whether library, computer centre or even refectory...We shall be expected to devise ways of actually managing this increased activity. Some institutions have begun to recognise this and are looking to shift resource into infrastructure support."
Numbers of developed countries now have projects relating to teaching/learning via computers. A good example exists in the UK. An initiative called the Teaching and Learning Technology programme (TLTP) [90] was instigated in 1992 to address computer-based teaching/learning activities in universities. This project has established multi-institutional consortia in a variety of disciplines, to provide intensive courseware development. Loughborough University [91], for example, has started developing a teaching/learning programme to support user skills. Four objectives are involved in the programme: (i) to produce courseware which will introduce students to the full range of basic information skills, ensuring that such courseware is acceptable to all students regardless of their particular subject backgrounds; (ii) to establish the centralised teaching of information skills, relying on established study techniques for computer-based teaching, and to provide a library-based network for the dissemination and updating of the necessary courseware; (iii) to develop JANET for communication about, and teaching of, information skills; (iv) to allow students to acquire basic information skills via self-study and self-evaluation. Again, the University of Leeds [92] has started to develop a courseware software package called the "course-processor" that supports teaching in any subject. This model is intended to exploit features of a Hypertext program. The idea is to change the old traditional method of courseware development, the "dialogue" system, to a more convenient "conversation-processor" system, which provides conversation-based teaching/learning activities.
In the era of SuperJANET system development, advanced technology is expected to be used to support a wide range of distance teaching and learning activities, such as inter-site X-windows and some inter-site video communication and video conferencing, etc. An example [93] is that University College London has developed facilities to pilot the use of SuperJANET's high-speed network performance for teaching surgery via interactive video. A series of surgical demonstrations can be set up by the University on SuperJANET, and other connected sites can then watch and share the range of interactive activities for teaching/learning and discussion purposes.

Given all these technological developments, most of the universities in the developed countries, especially UK, have directed themselves towards trying to improve their teaching systems.

3.6 Research

In the research area, too, computer networks have undergone a period of rapid growth since the mid-1980s: advanced IT development has opened up new avenues for scientific, engineering and clinical research [94]. The IUCC [95] reported in 1991 that a high-speed network is now essential in the research area. The report remarks:
"A very substantial network capacity - both on and off campus - will be needed to support applications as well as the heavy traffic loads arising from the exploding use of electronic mail, shared library resources, external database etc."

Coupled with this need for network power is the increased sophistication required of the software and storage facilities [96]. Researchers are now gathering data at rates of over a gigabit a day [97]. They demand connectivity in local and wide area networks and this requires sophisticated workstations and networks.

**Workstations**

Meadows [98] has defined a workstation as an intelligent computer terminal which integrates together a wide range of activities, such as analysis of experimental data, sending messages to colleagues, handling text, acquiring journal articles in electronic form and so on. Thus a workstation today is becoming the pre-eminent tool in the research process [99], supporting all the activities involved in research information handling. Many of its requirements mesh in with optical disk technology [100]: downloading and manipulations software, graphics and structure software, electronic mail, electronic document delivery, networking and improved telecommunications speeds are all appearing in various types of integrated research process. The similarity reflects the convergence of the research functions involved in new IT
developments in computing, telecommunications and information handling.

Developments of various sorts have already appeared. Thus Tsai [101] has developed a MAchine Readable Mapping (MARM) model which applies geometric coordination skills to control monitor screen representations. The graphic resolution permits a system operator to navigate users in searching large-scale databases in local or wide area network environments. Gey [102] has proposed an academic information technology infrastructure that can provide information to individual students, librarians and researchers from a CD-ROM workstation holding up to 30 CD-ROM per service workstations in a distributed network environment. Kahle [103] has listed five interfaces to distributed systems that exist today. These are WAIStation for the Macintosh, XWAIS for X Windows, GWAIS for Gnu-Emacs, SWAIS for dumb terminals, and Rosebud for the Macintosh. All these interfaces communicate with WAIS on the Internet. Innovations offered by these servers include screen viewing, rather than scrolling, context sensitive help functions, relevance feedback function, editors, indexes, automatic query and retrieval searching.

In the light of these discussions and needs a workstation is evidently essential as part of an efficient high-speed network to provide an adequate infrastructure for all the basic information handling needs of researchers [104].
Applications

Application developments, such as an intelligent Hypertext system, are becoming an important tool in the research area, especially when researchers want to finish their work from their own offices on an intelligent workstation. Addison and Nelson [105] explain that intelligent hypertext is an easy-to-use system which adds structure to electronic documents by linking concepts. Recently, a system known as ConQuest Software has been developed as the first smart natural language concept tool [106]. It can intelligently index, search, retrieve, browse, organise, route, summarise and edit full text information. In principle, a hypertext package is suitable for the researcher's needs [107]. For example, text citations, list of references, published documents, etc., enhance the research process.

According to Bawden [108]: "It is necessary for the users of these systems to become familiar with the searching system or retrieval system, that is to say the way in which the information is actually obtained from that computer system." Edwards and Rideout [109] have suggested the development of a software package to help researchers use the research system more effectively. Similarly, there is the possibility of choosing easily modifiable educational software as a curriculum resource. Thus a hypertext program can be developed by institutions or departments to be used as a study guide to provide a structure for all kinds of network research activities (e.g., e-mail, library materials, etc.). A courseware
development project can be established involving short definitions of research resources and step-by-step interactive guides on how to use them. This self-adapted teaching/learning ability will enhance and encourage researchers to manipulate and analyse their data more freely and might satisfy their needs and avoid fear of using the computer system.

Researchers are evidently involved in several types of automated information handling. Hypertext programs have been mentioned as one way to enable the researcher to handle research information in more efficient ways. Edwards and Ridout [110] concluded that "there is every prospect that better and cheaper hypertext packages will continue to become available. The immediate task is to try out the best of the current packages and see what they have to offer to researchers, using this as the basis for suggestions to developers for future improvements."

The latter part of this statement applies more generally to all courseware packages. In the UK, for example, LIS departments have already developed several home-made packages for the integration of library functions. These packages provide good practice in research and teaching/learning to enhance researchers' skill in using computing facilities more effectively. Most such current software development is listed by CTILIS [111]. This list indicates some of the good examples in this area, such as:
(i) Bookshelf - a library management system, designed for use in a real library setting. The bibliographic database created by the cataloguing module is at the heart of the system; its record can be in MARC or non-MARC format, and the enquiry and OPAC services run from this file. All the modules are menu-driven. The system is used in this way at the Department of Information and Library Studies at Loughborough University.

(ii) GripsLearn - a self-contained training package which can be used by anyone who wants to learn how to conduct an online search. It assumes no prior knowledge and takes users through a course of easy lessons on instruction and demonstrations of actual online search.

(iii) URICA - a library-management package, which contains modules for acquisitions, cataloguing, circulation, serials control, enquiries and OPAC. It provides students with valuable experience of using a full-scale library management system; and finally.

(iv) QCIP - a citation indexing and information-retrieval system. This has two datasets, one on educational technology developed for the SED's use under the original contract, and one on librarianship and information studies (LIS) used by SLIS and RGU for teaching purposes.

All these illustrate some of the possibilities opened up by the technology and permit the delivery of electronic documents. These will be extended further with the development of SuperJANET,
which will make the delivery of multimedia documents, images and the full text of articles directly to individual workstations in different institutions much easier and more flexible [112]. The impact of technology on information provision will grow accordingly.

3.7 Information provision

Libraries have moved increasingly to electronic information flow since the early 1980s [113]. In the first part of the 1980s, the most obvious example of this was the development of the online public access catalogue (OPAC). This was developed to help patrons search the holdings within an individual library. In this case, network development was limited to the library campus. The latter part of the 1980s has seen the expansion of this facility to allow users to access library materials from different libraries directly from their offices, laboratories or even home [114]. Thus there is no doubt that today's access to library information has become easier and new possibilities are emerging [115].

So what of the impact of electronic services on the library and its structure today?. Akeroyd [116] suggests that the impact of IT and networking on academic libraries throughout the 1980s was actually not very large and the effect was mainly a form of office automation (e.g. circulation, online) or similar system development. The real impact occurred when libraries began to integrate their systems through the provision of advanced IT and
networking to develop the 'electronic library' or the 'virtual library' during the mid-1980s. Several important changes have occurred in the last five or so [117]. These have included - the emergence of high-capacity, private, campus telecommunication networks; increased use of mainframe computers for local library systems; access to additional information databases through (OPACs); recently, the use of the SuperJANET high-speed national network.

Malinconico [118] suggests that libraries need to remain keenly aware of these changes in order to ensure that their own requirements are adequately taken into account. In view of this, Mitchell [119] concludes that merging library materials via the use of technology needs to be matched by policy changes relating to material and organisational aims. In terms of materials, effective electronic library facilities must be developed properly for library users. Under the direction of British Library, several projects have been started in the UK to develop good physical facilities - online links for CD-ROMs, linking CD-ROMs to local library systems, menu interfaces for multiple CD-ROMs, definition of requirements for a retrieval interface for bibliographic data on CD-ROM and tools for MARC conversion and distribution mechanisms [120]. In terms of organisational policy, these developments indicate the need to control technology and services and manage them via a well-developed organisation to deliver various kinds of information to campus-wide users more effectively [121].
Early information technology provision was typically controlled by the campus computer centre. The development of time-shared computing three decades ago enabled people to share the power of the same computer [122], especially in research. Today, advances in IT facilities and the development of SuperJANET are making possible collaborative work among faculty, students and researchers. Libraries, computing centres and other similar information service facilities are all available on SuperJANET. Computer centre staff will necessarily be involved in the decisions made by libraries regarding data storage, updating and indexing files, data compatibility, networking, communication, etc.

OPACs

An Online Public Access Catalogue was defined by the Council of Library Resources (CLR) as "any computer-based set of bibliographic data that can be accessed by library users working directly at a terminal" [123]. OPAC searching started on the individual campuses, at first only in the library, then later by modem from home or campus office [124]. During the 1980s, much library catalogue and OPAC research was conducted in libraries themselves [125]. The reason was the technical constraints on systems, such as mainframe computers, dumb terminals and limited baud rates, discouraging the development of graphical and direct manipulation interfaces [126]. Thus, for some time, searching continued in its traditional way: the major new
features were simply the addition of circulation data and greater flexibility in the display of information [127].

In today's development of improved communications (LAN-to-WAN connections, etc.) remote access to OPACs is increasingly feasible [128]. Good examples are the development of SuperJANET in the UK and NREN in the USA and the enhanced information access they provide.

CD (Compact Disc)

Nelson [129] has pointed out that 1989-90 was an important period of change for academic libraries. The most important of these changes related to CD-ROM (Compact Disc Read Only Memory) and computer networks for printed library literature. CD-ROM appeared in 1985 and marked the beginning of a new era in switching from magnetic storage to optical technology [130]. The current trend [131] has gone further to include CD-Video (Compact Disc Video) and CD-I (Compact Disc Interactive). The latter is a natural development of the highly successful CD-Audio system which combines sounds, data, text, video, picture and printed word into a single fully digital system. Another notable trend to mention is the recent announcement of Sony CD-WORM and erasable CD-MO (Compact Disc Magneto Optical) developments [132]. The first is an ideal support system for multimedia selective dissemination of information with text, graphics, drawing, and images. The latter is able to read, erase, and
rewrite different audio, text, and video data. Attributes such as these, may make CDs ideal for the distribution of computer software, courseware, maps, databases, reference material, multimedia and more [133].

Today many academic libraries have developed CD access workstations to serve students and faculty. The lower-cost solution of networks, the existence of some standardisation of CD systems and CD's flexibility and mass storage ability have helped academic libraries to build an effective library environment [134]. In Europe, a survey of UK libraries concluded that more than 50 CD products were commonly in use [135]. The UK and Dutch have now established a standard for the publication of national bibliographies on CD-ROM to allow the use of the same search strategy and language to search discs produced by different national libraries [136]. The current trend is strongly towards linking CD-ROM and other products now available to a network to allow broader access [137].

Various network software developments applicable to libraries now exist. For example, VINES (V'l'rtual NE'tworking System), which is based on a UNIX system, has been developed [138] to serve not only a single site LAN, but to join multiple LANs into a wide area network (WAN). Opti-Net CD-ROM LAN (optical networking software) has been developed to allow for up to nine optical servers and thirty products per server [139]. In the USA many projects have been developed based on state-wide network systems.
with the specific aim of promoting resource sharing, by providing a unified set of standard services across a number of different types of library [140]. Long Beach Library at California State University has developed a powerful network system to link all the university campus with the library [141]. The goal was to deliver CD-ROM based bibliographic data to as many students as possible by the development of a universal workstation which would access CD-ROM products, online database, online catalogue, local minicomputers and mainframes, PC-based products, and other sources on the Internet.

The aim behind the development of these powerful network systems was to meet users' demands. The objectives were: (i) to provide networked student workstations that would access CD-ROM products previously available only on stand-alone workstations; (ii) to provide similar access from the instructional classrooms located in the Main Library and from the Reference Desk; (iii) to address the needs of users who are asking for remote access to CD-ROM products (faculty from their offices, students in departmental computer laboratories, and students and faculty from their homes). Another good example is the Texas Medical Centre Library [142]. People in the library realised that library users were becoming increasingly aware of services and data available from various resources outside the library. Therefore, they started to develop library electronic mail connections, by installing MSD Inc.'s Promulgate Electronic Mail Gateway Software, to allow library patrons to send and receive messages across the
Internet. This reflects a new trend entering the library environment in the USA: the development of the NREN should dramatically expand and enhance the capabilities of the existing interconnected computer networks [143].

Hypertext

The library, like teaching, is witnessing the advent of hypertext, linking together graphics, audio, and video laser disks [144]. For example, the South Bank University has produced a prototype hypertext library guide based on Hypertext [145]. The aim was to provide an automated library guide which will answer the majority of routine questions dealt with by the increasingly pressured enquiry desks. As a different example, Nene College has designed and implemented an interactive hypertext guide to the library and its resources [146].

All these developments relate to network capabilities where users can access OPAC, CD-ROM and other materials from various points on the campus. Users are able to read about the library's electronic sources and use them as they wish. Hypertext in the academic library environment is playing an important role due to the nature of hypertext search facilities. As Dimant [147] explains "there are two approaches to providing hypertext. One way is to embed the hypertext links in the source data and the other is to use the search interface to provide hypertext capability".
What do all these IT developments in the educational system imply? It is possible to hypothesise that they all ultimately mean a move towards better satisfying users' demands. This is a changing environment where two factors have a special relationship with IT development in the campus: these are the university organisation and user training.

3.8 Copyright

Over the past eight years [148] there have been some major achievements towards the establishment of a legal environment which affords protection against 'software theft'. The 1985 Act (for computer software) and the 1989 Act (for computer-generated works and a rental right for computer programmes) have been important in the UK. There are, however, still plenty of copyright problems [149]. As IT gives the users more and more facilities, and information can be related between different users, the author's right of control should expand to cover these new uses [150]. A good example of this is the development of SuperJANET in the UK where by 1994 most sites will be sharing large amounts of text and graphics with each other in teaching, research, training, consultation, etc. The development of new technology has proved to be an important force behind the development of new copyright law: 'even though disparities between national legal systems may create obstacles to intra-community trade, the object and scope of copyright protection are in principle matters of national law.' The question for academics is how they can use
materials flexibly in teaching and research in the present confused condition relating to copyright.

It should be noted that several developing countries, such as Saudi Arabia, do not have copyright protection. These countries sooner or later will all join the network systems. This will raise difficult questions about international exchange of information.

3.9 Training

From the previous discussions about the impact of IT and networking on the educational system and the changes that are occurring, due to the rapid development of IT on the campus, it appears that effective training is becoming essential for all kinds of campus-user.

The aim of training [151] is to develop new skills, knowledge and experience in the organisational context to achieve specified objectives. Correspondingly, Pont [152] has defined training as developing people's confidence and competence to help them in their jobs. Buckley and Caple [153] see it as a planned and systematic effort to develop knowledgeable and skilled people who can achieve effective performance in a given task or job, whilst Cowan [154] believes it is as a means by which people can achieve greater ability within their organisation. These definitions all imply that training is a developing process concerned with the acquisition of skills, knowledge and experience, which has the
result of enhancing peoples' ability to improve their performance on jobs.

Training as an organisation

University organisation deals with two main systems - the educational system, including teaching, research and administration, and the information service system, including the library and computing centre. These two systems together provide the knowledge and learning activities in the educational setting. Thus in the light of IT and networking spread over all campus area, use of computing activities must be increased in these two. To meet this requirement, effective training is important.

In reality, as the library becomes involved in providing electronic information services over networks, relevant training programmes must be provided, so that librarians can take advantages of appropriate in-service training. In return, they will be able to train their users to cope with the huge amount of networked information that is available [155]. Computing centres are also involved in sharing assistance, consultation, advice, etc., to make campus-wide network facilities operate efficiently, so effective training is also needed to make computer centre staff aware of the new IT entering the campus.

Associated with this is the corresponding need for users in teaching, research and administration to develop the required...
skills for the effective use of IT [156]. Academic staff need to know about technology, network, e-mail, etc., to help their teaching activities, whilst students need the same thing to increase learning activities. On the other side, researchers need these facilities to communicate with each other in more effective way. In view of this, well-planned and organised training programmes must be developed to deliver the necessary support for the changing technology.

Training as a system

Training within any organisation can thus be viewed as a system with its own specific goals or objectives [157]. This system can be divided into many subsystems, each of which performs a particular function - such as CAL and CAI subsystems to provide an effective learning process in the teaching/learning environment, or OPAC and CD-ROM subsystems to increase information access to material in the library environment. Training as a system therefore involves looking at these various components and then developing a plan to provide effective programmes to meet user needs. However, developing a training system is not an easy task. It involves so many subsystems (such as students, researchers, academic staff, operators, managers, selection, funding, materials, etc.). All these must be considered in any plan to develop effective training programmes. Three models have been selected and developed for this purpose here.
Training models

The first model [158] concentrates on manpower and physical resources. It is intended to determine the main features of the training system, such as what tasks will be used for the training, the type of training materials, where training takes place, etc., as shown in Figure 3.2.
Figure 3.2. Outline of the training system
This model indicates how the training system should be regulated for managerial and trainee attitudes, policy, plan, selection, location, etc. Correspondingly, it measures a range of features of the training from performance level to costs and social acceptance.

The second model [159] involves six major functions associated with the development of training, as shown in Figure 3.3.

![Diagram](image)

**Figure 3.3. Relationships between training and selection decision in the training system**

This model reflects relationships between training and selection decisions in the training system. The concept is that identification of changing needs and objectives is the first step in the development cycle. Patrick [160] has commented that if these
objectives and changing needs are not identified accurately, the subsequent training context will be inappropriate. Information associated with each training function must therefore be gathered systematically and has to be related directly to the subsequent activity in the development cycle. This means that the objectives must be properly determined so that the training system can be effective and efficient: otherwise a failure will occur in the whole system.

The third model [161] concerns learning systems development for training activities and includes three phases: analyses, design and development, and implementation and control. All these phases are broken down into the tasks facing the training designer as shown in Figure 3.4.
The model examines the development of learning systems and identifies the types of learning, structure of material of learning and optimum presentation.

One further model for course provision [162] is worth mentioning. The model consists of the following 15 functions or stages: (1) assessment of needs, goals and priorities, (2) assessment of...
resources, constraints and selection of a delivery system, (3) identification of curriculum and course scope and sequence, (4) determination of the gross structure of courses, (5) determination of the sequence of units and specific objectives, (6) definition of performance objectives, (7) analysis of objectives for sequencing, (8) preparation of assessments of learner performance, (9) designing lessons and materials: instructional events, media, prescriptions (utilising appropriate conditions of learning), (10) development of media, materials, activities, (11) formative evaluation, (12) field tests and revision, (13) instructor training, (14) summative evaluation, and (15) diffusion and operational installation.

These models show that formulating objectives is an important first step in the planning process and that the relation between such objectives and other elements of the training model should be consistent. They also indicate the need for different model development plan processes to meet different people's needs. Finally, they all involve feedback. It seems possible to use a combination of these models to develop effective training programmes.

**Computer-based training (CBT)**

Computer-based training is a way to develop computer courses to deliver instructional material for training purposes [163]. It is supposed that instructional materials can be designed as a series
of interactive learning sequences. Today, many examples exist which reflect the various approaches to design [164]. There are windows, graphics packages, desktop publishing, multimedia and hypertext training activities, all being used to develop different training applications. In windows, for example, improvements in the quality of the screens attached to microcomputers and workstations have enabled users to become largely graphical instead of textual.

**Technology-based training (TBT)**

Due to the advanced information technology that is emerging in education, government and industry, changes are occurring in these sectors and more intensive and expensive training programmes in all aspects of work are becoming essential. For example, in libraries, new technology means a shift from an on-line database system to more integrated technology system. In teaching/learning, it means a shift from traditional classroom and laboratory courses to more open and distance teaching/learning systems. All this places a further emphasis on the need for establishing effective systematic training programmes. One way [165] is to develop a training centre. This may be a powerful multimedia and communication system, which provides access to an information, help and advice service and can serve as a place to meet experts and colleagues. It may rely on courses using cable, satellite technology, videoconferencing, audio graphics, and electronic handling on a regular and on-going basis to enhance all
kinds of training activities by using computing more effectively. Another way is to establish a training programme jointly between industry, academic institutions and government. Courses by means of an effective two-way communication system can be provided between these sectors to develop integrated training services for employees, students, researchers, etc. Thus the 1990s will be looking forward to institutions, industry and government having more joint training and collaboration on a national basis as in Figure 3.5.

![Figure 3.5. Connection of a professional training centre](image)

This model represents the development of a professional training centre [166]. What is needed is good collaboration between the organisations that are depicted in Figure 3.5 to develop effective training programmes by setting appropriate objectives, material selection, location, funding, and so on.
In the UK, for example, the government has set up a national policy to stimulate the provision of education and training to meet the needs of IT users and suppliers for suitably skilled people. This covers curricula issues, administration, training, purchasing policy, maintenance, software, hardware, and the need for a network of support for the new technology [167]. In terms of universities, policies developed by IUCC, CTI, and other related bodies have helped universities set up effective activities (in training, purchasing, networks, communications, etc.) to support IT provision for higher education institutions. Currently, the UK is probably the most advanced country in Europe in terms of the introduction of IT into education and training.
REFERENCES

(Details of publishers are included in the bibliography at the end)


20. Elbert, ref. 9, p. 18.


27. Ibid., p. 341.


41. Romiszowski, ref. 26, p. 301.

43. Ibid., p. 63.


46. Darby, ref. 37, p. 196.

47. The Committee of Scottish, ref. 42, pp. 69-76.

48. Hodgson, B. *Key terms and issues in open and distance learning*, 1993, p. 11.


56. Lewis and Spencer, ref. 50, p. 16.

57. Paine, ref. 52, p. 9.

58. Rowntree, ref. 55, p. 16.


62. Rowntree, ref. 55, p. 29.

64. Srisa-An, ref. 59, p. 127.


66. Ibid., p. 71.


73. Paine, ref. 52, p. 8.

74. Botto, ref. 71, p. 137.


78. Hodgson, ref. 48, p. 216.


80. Barker, Lees and Docherty, ref. 76, p. 123.

81. Winders, ref. 65, p. 71.


83. Barker, Lees and Docherty, ref. 76, p. 123.

84. Botto, ref. 71, p. 11.


86. Botto, ref. 71, p. 13.

87. Gardner, N. Two reports on the computer literacy workshop held at the University of Durham. CTISS File, 1991, (11), 51.


106. Ibid., p. 28.


110. Ibid., p. 100.

112. Joint Funding Councils', ref. 44, p. 63.


121. Woodworth, ref. 17, p. 80.
122. Joint Funding Councils', ref. 44, p. 43.


130. Botto, ref. 71, pp. 18-19.


133. Botto, ref. 71, p. 19.


140. Mitchell, ref. 119, p. 139.

141. Sugrans and Cone, ref. 139, p. 270.


155. Joint Funding Councils', ref. 44, p. 68.


161. Patrick, ref. 151, p. 122.


164. Ibid., pp. 175 & 184.


166. Van den Brande, ref. 67, p. 85.

Methodology

4.1 Introduction

A methodology is defined as "an explicit way of structuring one's own thinking and action. Methodologies contain model(s) and reflect particular perspectives of 'reality' based on different philosophical paradigms. A methodology differs from a conceptual framework in that methodologies always imply a time-dependent sequence of thinking and action stages" [1]. A tool to develop methodology depends on a useful research design technique. It is a plan which deals with resources, scheduling, assignment of personnel and other tasks involved in administering a research study [2]. It attempts to link the beginning to the end of a study, so helping the investigator to get 'from here to there'.

This chapter discusses the research methodology developed for this work. Further, it describes the characteristics of a model approach developed for the study and the general types of research questionnaire and interview which were employed.

4.2 Guidelines for the research

A case study approach was chosen since the nature of this research is essentially exploratory. It was suitable for studying and
understanding how IT is used, how it affects organisations and how organisational factors affect its development. Such methods reflect respondents' reactions to a situation, their characteristic behaviours, or their responses to interaction [3]. A case study makes it possible to examine the technology and the users in the actual environments into which the technology is being introduced. It provides a means of rigorously analysing interactions of the technology, the organisation and the individuals affected by the technology as these interactions occur and changes develop, thus adding a dimension to understanding the role of IT.

Models make it easy to break down elements or variables of IT into an effective framework. Thus, the set of elements used in the present research were: (i) organisational structure (this element was used to determine decision-making factors relative to IT planning, policy), (ii) organisation of computing activities (this was concerned with IT systems and services provided for university users), and (iii) organisation of academic computing activities (this element was used to consider the impact of IT on the communication systems both within departments and between departments).

4.3 The research model

Three models from the literature were developed for this purpose, with some changes. The first model used was developed by
Siegmann [4] to show university information systems (as shown in Figure 4.1). This model shows how information channels between the three systems (teaching, research and administration) can be integrated with the IT activities (which are shown in Figure 4.2). The latter diagram shows the second model used to relate the university information system (IS) with the information technology (IT) activities. This model was developed by D'elia and Funin [5].
Figure 4.1 Basic model of university information system (IS)

Figure 4.2 Basic model of university IT integrated components
The third model developed for this research was based on Galletta's and Hufnagel's [6] model. This is shown in Figure 4.3. The main idea was to relate the university information system (IS) (model 1) with information technology (IT) activities (model 2) to develop an effective information infrastructure on the whole campus and between campuses. From this model, the methods and technique were derived for improving and developing appropriate questions.

IT has an impact on the whole university information system (teaching, research and administrative information systems) and the university organisational structure plays an important role in supporting information system objectives on the campus. The research model in Figure 4.3 has been developed to look at these two activities - information technology and the information system - and at their effect of these activities on the university campus. Figure 4.3 depicts the relationships of interest here: the numbered links correspond to the research question to be explored:
Figure 4.3 Research model
Link 1: How does university organisational structure affect the IT activities in terms of which decision-making, policies and procedures are developed and administered?

Link 2: How does the university organisation (plan, strategy, etc.) affect the university information system (Figure 4.1) with regard to the use of IT on the whole campus?

Link 3: How does the process by which all IT activities (Figure 4.2) are developed and administered affect the university information system (Figure 4.1)?

Link 4: How do IT activities (Figure 4.2) affect university computing infrastructure?

Link 5: How does the university information system (Figure 4.1) affect operation and management of university computing infrastructure?

Link 6: How does the university computing centre provide effective communication between the university IT infrastructure and other activities (as in library, academic and administrative departments)?

These links have been established by looking mainly at three variables. These are the university organisation, the computer centre and departments. University organisation plays an
important role in decision-making with regard to IT plans, policy, procedures and so on. The other important factor that involves the university organisation is the university Information System. Basically, IT is only one of the IS dimensions. Computerised information systems should be conceptualised as a social system, involving technical, behavioural and organisational issues. This broader perspective on information systems offers opportunities for a deeper understanding of IT activities in the university information system development and implementation. Moreover, computerisation within the university information systems has undergone a dramatic change as new IT bring in new concepts, such as "micros on campus", "electronic campus", etc., whose implementation can lead to a more efficient campus, and a more systematic and reliable working environment throughout the university institution [7]. The university organisation is postulated as the key determinant of the process by which Links 1, 2, and 3 are developed and administered. The variables investigated include the degree to which university organisational structures have been formalised, the placement of computer/IT committee activities within the organisational structure, the university information system growth strategy, and the experience the organisation has in dealing with IT and related issues.

One way to develop and disseminate computerised information services on the university campus is through the university computer centre. Much has been said about university computer centre staff, regarding decision-making, decision support and
strategic planning [8]. They must provide help in supporting the choice of IT software tools, understand user applications, manage and operate the university information system, and be competent, experienced and responsive. In this study, two variables relate to university computer centre staff: the management and operation of IT within the university information system (Links 4 and 5), and the number of staff with a computer background, which is related to competency, ability to provide technical assistance to users and so on. Furthermore, an important part of any computer centre's operation is to ensure maximum reliability and availability of the information system to university users (staff, students, faculty, departments, etc.). It is argued that a key factor in running a successful information system service responsive to user needs is to provide effective communications between the central computing side and departments [9]. In this study, the variables that relate to this context are library, administration and academic (Link 6).

Based on these arguments, the sets of variables obtained in each group (university organisation, computer centre and department) are quite broad. The overall model was designed to explore the issues created by the installation of campus-wide microcomputers and a network as perceived by (1) the academic users of such a network, (2) the computer centre personnel responsible for its implementation and (3) the departmental computing representatives for the departmental operation.
4.4 Methods

Questionnaires and interviews were used for this research as they play a dominant part in data collection methodology [10]. Although questionnaires and interviews are two different types of methodology, they are complementary to each other. Questionnaires incorporate assumptions about the nature of what is to be measured [11]. Interviews have been described as a way to explore an expectation of the opinions, ideas, value, etc. of interviewees [12]. Questionnaires and interviews are described as the most general useful devices for gathering information [13], and are widely accepted as the best way of gathering information about past behaviours and expectations, private actions and motives, and values and attitudes [14]. Thus a combination of both questionnaire and interview methods was developed for data collection in this study.

In order to draw conclusions from past experience and to make suggestions for future policies, a deeper understanding was needed of the nature of IT diffusion in SA universities in order (1) to identify trends amongst users concerning the provision of effective communication systems between the university computing centre and its users (academic computing, library and administrative departments), (2) to identify the current and expected future pattern of demand for IT infrastructure development (networks, plans, policies, etc.) on the university campus and (3) to develop a
conceptual framework model that describes a good organisational structure.

A parallel study has been carried out of the use of information technology by scientists at universities in the UK and SA. A questionnaire survey on this topic was originally carried out in the UK during 1985-86. New surveys, based on the same set of questions, have been carried out in the UK and SA during 1991. On the one hand, this provides a five-year baseline of data for the UK, which can be used to discern trends in usage. On the other, it permits a comparison of current Saudi usage with the position in the UK. This makes it possible to compare the current position in SA not only with the current position in the UK, but also with the position in the UK as it existed in the mid-1980s. The comparison between the UK and SA was carried out via questionnaires distributed to academic staff in the two countries (one set of questionnaires in English, the other in Arabic) (see Appendix I).

In the earlier survey, questionnaires were sent to 48 science departments (divided between biology, chemistry and engineering) in various types of university (technological, red-brick, etc.). The repeat survey has had a somewhat different coverage, with physics substituted for engineering, and the method of distribution has also been different. It was decided for the repeat to concentrate on science departments only. (The rationale was that these appeared from the earlier data to be somewhat ahead of other departments in their range and sophistication of usage of computers. Hence,
their responses should reflect the 'leading edge' of current IT activities in universities.) The original questionnaire was modified slightly to allow for changes in IT terminology over the preceding five years.

Since 1986, various CTI (Computers in Teaching Initiative) Centres have been set up in universities to encourage the use of computers in teaching in each subject field. These centres have established contacts in every department in their respective fields. The Centres for Biology, Chemistry and Physics kindly agreed to distribute our questionnaires to their contacts. There is, obviously, an immediate question whether such distribution does not preferentially select those staff who have most interest in computers. However, an examination of the 1986 survey showed that the method of distributing questionnaires used then - batches of questionnaires sent to departments for circulation - led to a similar bias. A recent series of interviews has shown that, even in science departments that are heavy users of IT, some members of staff make little use of computers and would be unlikely to answer questionnaires [15]. Hence, it is reasonable to suppose there is a similar bias in the two surveys.

In the 1986 survey, 480 questionnaires were sent out, with an overall response rate of 55.1%. This response subdivided into 45% from chemists, 35% from biologists and 20% from engineers. In terms of background, 76% of the responses came from academic/research staff and 24% from research students. In the
present survey, 900 questionnaires were distributed and the response rate was 43.7%. This subdivided into 53% from biologists, 26% from chemists and 21% from physicists. However, because of the differing numbers of respondents available in each subject, different numbers of questionnaires were dispatched - 450 in biology, 250 in chemistry and 200 in physics. In terms of the number of questionnaires dispatched to each group, the response rates were 46.2% for biology, 41.2% for chemistry and 41.0% for physics. Hence, there was a reasonably even response across all three subjects. In the second survey, virtually all questionnaires were returned by academic staff, and very few by research students. The previous survey had shown that there were significant differences between staff and research students in only two areas - word processing and use of indexes. For these areas, we shall use only the staff returns from the previous survey in our discussion below. A post hoc analysis also indicated that substituting physics for engineering led to no major shift in the results. The data in both surveys were analysed using SPSS-X.

A comparable exercise in SA universities involved distributing 697 questionnaires. In SA, but not in the UK, questionnaires were distributed to engineering departments, as well as to biology, chemistry and physics departments. The rationale behind this move was to compare responses from science and engineering departments to see whether staff in these two groups are using computers in different ways. (It was already known that use of information technology by academic scientists and engineers in
the UK is generally similar.) A few changes were made to the Arabic version of the questionnaire to allow for the fact that some areas of IT use, now common in the UK, have not yet developed in SA (see Appendix I).

For the 697 questionnaires dispatched in SA, the response rate was 72.7%. This subdivided into 15.4% from biology, 18.7% from chemistry, 10.7% from physics and 55% from engineering. The quantity of questionnaires dispatched to departments differed due to the various numbers of staff working in different departments. The number of questionnaires dispatched was 228 in science (78 in biology, 96 in chemistry and 54 in physics) and 279 in engineering. Comparing the figure for science questionnaires dispatched in SA with that for the UK showed a lower quantity for the former. So engineering in SA was included to make the two surveys reasonably even. In the UK, questionnaires were distributed by mail, whilst in SA they were distributed and collected by hand. The reason for this was due to problems posed by other forms of distribution and the fact that most respondents do not return questionnaires if not collected individually. This entailed a great deal of travelling between universities and departments in order to collect questionnaires through personal contacts.

The emphasis was on three basic questions:
(1) For which information handling activities are computers and networks being used?

(2) What sorts of computer are being used?

(3) From where is advice on usage being obtained?

All questions were phrased in terms of staff activities during the preceding 12 months.

The interviews were set up on the basis of the questionnaires in order to draw picture of the current computing resources and the needs of the universities in the Kingdom of Saudi Arabia. The interview process was developed in 1992 in order to cover the management and operational side. The rationale behind this was to look at the related questions of how use of technology may be shaped by the university's requirements, and how IT can best be utilised to improve information handling activities on the university campus. Two basic questions were asked:

(1) How is the university trying to provide effective communication between the computer centre and other campus activities, such as faculty, administration, etc.?

(2) What policy planning is there in Saudi Arabia which may affect the provision of IT in Higher Education?
The framework for developing the questions was based on the current computing environment in SA universities. The relevant categories identified were:

- organisational structure.
- on-going computer committee policy.
- IT needs, purchasing, equipment, policies, etc.
- Connectivity, communication, networking.
- Education and training.

Interview questions (see Appendix II) were established for the computer centre managerial staff in both countries, and focused on aspects of the general requirements for IT resources. The questions highlighted areas that should be explored for better understanding the requirements for the integration of IT resources on the university campus. The questions covered three aspects: (1) the existence of IT resources in the university and its policy regarding their purchasing and funding; (2) networking and communication systems between the computer centre and other areas, such as library, faculty, etc.; (3) the university's planning with regard to the use of IT in teaching, research, and administrative systems.

Finally, questions were asked (see Appendix III) about computing (terminals, computers, access, networking, etc.) available within departments; computing and users within departments (use of computers, training, job role changes, integration, etc.).

Chapter 4
policies with regard to equipment (hardware, software) and financial resources.

In the SA a third set of questions was needed to cover the country as a whole with regard to national networking plans. Consequently, a further set of interview questions (see Appendix IV) were devised for the senior staff of the King Abdulaziz City for Science and Technology (KACST) in SA to cover the government's responsibility with regard to IT policy planning, networking, and training in Higher Education.

In addition to these questions, information on university organisational structure was obtained from all of the universities visited in both countries to look at the university hierarchical structure regarding computing policy in terms of decision making, consultation, co-ordination, computer committees, user committees, etc.

The interviews carried out in SA, were subdivided into three sections - the computer centre, academic computing and KACST. The interviewees were drawn from the senior staff, heads of departments and departmental computing representatives within the three universities (King Abdulaziz University (KAU), King Saud University (KSU), and King Fahad University (KFU). At the King Abdulaziz City for Science and Technology (KACST), three senior staff were interviewed. The reason for choosing these three universities was the installation of campus-wide microcomputers.
and networking facilities found in all three. The reason for choosing KACST was its central importance for the purpose of supporting technological and scientific databases for all education as well as the government in SA.

Interviews with 13 individuals - 7 academic computing departmental representatives, 3 computer centre personnel, and 3 administrators from KACST - were conducted in this survey. The senior staff involved were the three Directors of the University Computer Centres. The heads of the Departments of Computer and Information Sciences in the three universities were interviewed, as were the departmental computing representatives. The other departmental computing representatives included those of the College of Engineering (computer centre laboratory) and the Department of Library and Information Science (computer laboratory) at KAU; the Faculty of Administrative Science (computer centre laboratory) and the Department of Library and Information Science (computer laboratory) at KSU. These departments were chosen because they had computing laboratories. Finally, at KACST three senior staff were interviewed - the Director of General Information Systems, the Director of National Network, and Director of the Computer Centre. (see Appendix V for names and positions).

In the UK the same interview procedures were followed as in SA. Three universities in the UK have been involved in the interview processes to cover the management and operational side. These
universities were: Loughborough University of Technology (LUT), Leicester University (LU), and Nottingham University (NU). These three British universities were chosen to provide parallel comparison between the UK and SA. Amongst the different types of British universities, these three seemed to represent a reasonable sample. The same set of questions was used for both surveys (see Appendix II and Appendix III).

Interviews with 9 individuals were conducted in the UK. This covered 6 academic departmental computing representatives and 3 computer centre personnel. The senior staff were the three Directors of Computer Centres in the three universities mentioned above. Departmental computing representatives included those from the Department of Information and Library Studies, Department of Computer Studies, Department of Chemical Engineering, Department of Civil Engineering, School of Business, and the Systems Manager in the Department of Computer Studies. (see Appendix V for names and positions).

In all cases 22 interviews were conducted in this study. All information was recorded on a cassette then transcribed manually. Interviews lasted for an average of 45 minutes with each individual. In SA a week's visit to each of the three universities and KACST were enough to meet the people and complete the interviews. Interviews in the UK took more time because of the varied scheduling time of interviewees. In addition, visits to the Computer Centre at Loughborough University were done.
frequently, when needed, to collect more information about the position in the UK. This involvement was very valuable in giving some insight into the types of networks that can be developed using the very recent ATM and other related technologies, and also provided the necessary documentary materials regarding network layout, etc. Figure 4.4 shows the project timetable, including fieldwork.
Figure 4.4 Project duration time and period of fieldwork
REFERENCES

(Details of publishers are included in the bibliography at the end)


Chapter 5

Results of responses to questionnaire

5.1 Introduction

This chapter presents the results of a survey of computer use carried out in SA and UK universities in 1991. The purpose of the survey was to discover the current level and the nature of use of computers in SA. The survey in the UK can then be compared to see whether the results carry any implications for future activities in SA. A similar survey, conducted in UK in 1985 [1], is used here together with the UK survey of 1991 so that comparison can be made between them to see if any changes in IT provision have occurred during that period.

The questions were designed to allow the respondents to answer by simply ticking 'yes' or 'no' entry with open-ended format included in some questions for respondents to enter their comments in their own words. The data were entered on a mainframe computer using SPSS at the Computer Centre at Loughborough University. Respondents were queried on three topics. The first involved use of computers for information-handling activities. The second concerned the types of computer used, and which sort of task was performed on each type. The third asked respondents to describe
the sources of advice they sought as an aid to their computing activities.

This chapter consists of three parts. The first part looks at the SA results, the second part looks at the UK results and the last part compares the two.

Saudi Arabia

5.2 Information-handling via computers

The sample were first asked whether they make use of computers for information-handling activities. Table 5.1 below indicates involvement in each activity. The actual numbers involved are given in brackets after each percentage.
Table 5.1. Percentage of staff who used a computer for each activity

<table>
<thead>
<tr>
<th>Activity</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word processing</td>
<td>63% (319)</td>
</tr>
<tr>
<td>Graphical display of data</td>
<td>40% (203)</td>
</tr>
<tr>
<td>Statistical analysis of data</td>
<td>38% (193)</td>
</tr>
<tr>
<td>Searching an on-line database</td>
<td>32% (162)</td>
</tr>
<tr>
<td>Collection of data from experiment</td>
<td>31% (157)</td>
</tr>
<tr>
<td>Programming languages</td>
<td>29% (147)</td>
</tr>
<tr>
<td>Application development</td>
<td>22% (112)</td>
</tr>
<tr>
<td>Modelling/simulation</td>
<td>19% (96)</td>
</tr>
<tr>
<td>Design</td>
<td>12% (61)</td>
</tr>
<tr>
<td>Sending/receiving e-mail</td>
<td>5% (25)</td>
</tr>
</tbody>
</table>

As a whole, the results show that the staff are most interested in word processing. After that there comes a collection of activities relating to research (e.g. statistical analysis of data). More specific research stills (e.g., use of programming) are less used. On-line databases are clearly well-used, but little attention is paid to electronic mail.

Alongside their use of databases, most respondents (60%) wished to have greater access to a wider range of library facilities from their own departments. The very low usage of electronic mail by
academic staff clearly reflects the networking situation, since 65% of respondents would like to make a significantly greater use of e-mail.

The number of respondents who were using computers for their information-handling activities was then calculated in terms of the range of activities involved, as shown in Figure 5.1. This shows that 29.4% (149) of staff used the computer for three activities in their work. This was clearly the favoured number, with smaller, approximately equal numbers favouring two and four activities. The maximum number of activities used by any one individual was six.

Figure 5.1. Staff versus number of computer activities
In terms of the two to four activities favoured by most staff, word processing is virtually always included. The other dominant activities in these representations are typically collection of data from experiments, graphical display of data and statistical analysis of data.

From this figure and the previous table, it appears that computerisation of certain activities needs to be encouraged in SA because the usage levels are lower than they should be for fully integrated computerisation. For example, there was very considerable support for the development of the e-mail system so that all staff and departments could be accessed. All respondents wished to have e-mail in their offices to provide mail going off campus.

The table below shows the breakdown of usage by subject area. It shows the differing percentage and number of science academic staff who had used a computer for each activity.
Table 5.2. Percentage of the different sciences who used a computer for each activity

<table>
<thead>
<tr>
<th>Activity</th>
<th>Biology</th>
<th>Chemistry</th>
<th>Physics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word processing</td>
<td>56% (43)</td>
<td>57% (43)</td>
<td>65% (49)</td>
</tr>
<tr>
<td>Graphical display of data</td>
<td>38% (29)</td>
<td>42% (32)</td>
<td>47% (36)</td>
</tr>
<tr>
<td>Statistical analysis of data</td>
<td>55% (42)</td>
<td>46% (35)</td>
<td>47% (36)</td>
</tr>
<tr>
<td>Searching an online database</td>
<td>44%* (33)</td>
<td>21% (16)</td>
<td>15% (11)</td>
</tr>
<tr>
<td>Collection of data from experiment</td>
<td>42% (32)</td>
<td>37% (28)</td>
<td>45% (34)</td>
</tr>
<tr>
<td>Programming languages</td>
<td>6% (5)</td>
<td>6% (5)</td>
<td>28%* (21)</td>
</tr>
<tr>
<td>Application development</td>
<td>11% (8)</td>
<td>21% (16)</td>
<td>21% (16)</td>
</tr>
<tr>
<td>Modelling/simulation</td>
<td>12% (9)</td>
<td>15% (11)</td>
<td>19% (14)</td>
</tr>
<tr>
<td>Design</td>
<td>5% (4)</td>
<td>6% (5)</td>
<td>19%* (14)</td>
</tr>
<tr>
<td>Sending/receiving e-mail</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

(Asterisks indicate statistically significant differences)

As can be seen, there is an overall similarity in the use of the computer for graphical display of data, statistical analysis of data and collection of data from experiments between the three subjects. Other activities varied between departments. The chi square test shows statistically significant differences in searching an online database, use of programming languages and design. In the first case, biologists show more interest in searching an online database, whilst in the second and the third cases physicists are more concerned. Chemists do not seem to have particular areas of
concern. It is that e-mail is not used in these departments. This is can be related to the absence of networking from staff offices.

The table below compares the differing percentage and numbers of academics who had used a computer for each activity in science and engineering departments.

Table 5.3. Percentage of the science and engineering staff who used a computer for each activity

<table>
<thead>
<tr>
<th>Activity</th>
<th>Science</th>
<th>Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word processing</td>
<td>59% (150)</td>
<td>69% (175)</td>
</tr>
<tr>
<td>Graphical display of data</td>
<td>42% (106)</td>
<td>42% (106)</td>
</tr>
<tr>
<td>Statistical analysis of data</td>
<td>49%*(124)</td>
<td>26% (66)</td>
</tr>
<tr>
<td>Searching an on-line database</td>
<td>29% (74)</td>
<td>34% (86)</td>
</tr>
<tr>
<td>Collection of data from experiments</td>
<td>42%*(106)</td>
<td>24% (61)</td>
</tr>
<tr>
<td>Programming languages</td>
<td>12% (30)</td>
<td>18% (45)</td>
</tr>
<tr>
<td>Application development</td>
<td>18% (45)</td>
<td>30%*(76)</td>
</tr>
<tr>
<td>Modelling/simulation</td>
<td>10% (25)</td>
<td>11% (28)</td>
</tr>
<tr>
<td>Design</td>
<td>5% (13)</td>
<td>8% (20)</td>
</tr>
<tr>
<td>Sending/receiving e-mail</td>
<td>0</td>
<td>5%*(13)</td>
</tr>
</tbody>
</table>

(Asterisks indicate significant differences)

The chi square test showed that four cases have statistically significant differences. In collection of data from experiments and
in statistical analysis of data, scientists used the computer more than engineers, whereas in application development and in e-mail the engineers used the computer more.

The e-mail figures again reflect the low rate of connection to networks. The data also underline the fact that computers entered academic work as a research tool, rather than as an aid to office automation. It is also true that engineering staff are rather more enthusiastic computer users than the scientists, typically being involved in a greater range of activities. Engineering staff have a greater knowledge of computer applications and more hands-on experience (including e-mail) than scientists. They also tend to make much greater use of department-based facilities and the university computer centre.

5.3 Use of computers

Respondents were then asked about the types of computer they used to carry out these different activities. The choice included microcomputers, minicomputers, mainframes and if they used more than one computer for each activity. Table 5.4 below shows the percentage and number of respondents who used different computers for each activity.
Table 5.4. Percentage of activities carried out on each type of computer

<table>
<thead>
<tr>
<th>Activity</th>
<th>Respondents using different computers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Micro</td>
</tr>
<tr>
<td>Word processing</td>
<td>54% (273)</td>
</tr>
<tr>
<td>Graphical display of data</td>
<td>46% (233)</td>
</tr>
<tr>
<td>Statistical analysis of data</td>
<td>45% (228)</td>
</tr>
<tr>
<td>Searching an online database</td>
<td>43% (218)</td>
</tr>
<tr>
<td>Data from experiment</td>
<td>66% (335)</td>
</tr>
<tr>
<td>Programming languages</td>
<td>65% (330)</td>
</tr>
<tr>
<td>Application development</td>
<td>64% (324)</td>
</tr>
<tr>
<td>Modelling/simulation</td>
<td>62% (315)</td>
</tr>
<tr>
<td>Design</td>
<td>56% (284)</td>
</tr>
<tr>
<td>Sending/receiving e-mail</td>
<td>5% (25)</td>
</tr>
</tbody>
</table>

The table shows that the computer used most extensively for each activity was the microcomputer (51%), followed by the mainframe (23%) and more than one computer (10%) respectively. The minicomputer was not used at all. This means that microcomputer led the use for each activity. The use of the mainframe was moderate for each activity, resulting from some of the activities being done on central computing facilities rather than on a micro (for example, online searching). Use of more than one computer for
each activity envisaged integrated computerisation, but at this time was quite low.

This can be seen from the table, where use of microcomputer for all activities (except sending/receiving e-mail) represent a high percentage. In the case of e-mail the use of the microcomputer shows a very low percentage (5%), which may indicate absence of networking from the campus.

The use of mainframe computers appeared to be greatest in searching online database (39%). This indicates that staff are interested in using this activity more than others. One thing that should be noted is that 'searching an online database' did not mean searching of a database through the GULFNET system. This means that ability to search online can only operate from the Computer Centre and not from the departments or even individually-owned computers. This became clear from the comments written on the questionnaires.

All the above information indicates that use of computers in the academic departments still remains in a form of single-purpose activity and not as multi-purpose activities. This can be seen from the table, where collection of data from experiments (66%), programming languages (65%), application development (64%) and modelling/simulation (62%) represent the highest percentages. These activities are single-purpose ones which staff use individually for their own work.
Accordingly, information activities are used for personal single-purpose work rather than for communication and networking use. Clearly this is an area that needs to be addressed. In general computerisation of certain activities needs to be encouraged because use level of some applications is still too low to permit effective network computerisation. There is a need for GULFNET information services to be expanded widely to include all departments, so that users can search for their needs from any place on the campus instead of just from the Computer Centre.

Table 5.5 below gives the same information broken down by science and engineering departments. It shows the percentage and number of staff who used different computers for each activity.
Table 5.5 Percentage of the science and engineering staff who used different computers for each activity

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Word processing</td>
<td>57% (145)</td>
<td>50% (128)</td>
<td>0</td>
<td>0</td>
<td>19% (48)</td>
<td>12% (30)</td>
<td>10% (25)</td>
<td>7% (18)</td>
</tr>
<tr>
<td>Graphical display of data</td>
<td>40% (101)</td>
<td>52% (132)</td>
<td>0</td>
<td>0</td>
<td>21% (53)</td>
<td>15% (38)</td>
<td>9% (23)</td>
<td>10% (25)</td>
</tr>
<tr>
<td>Statistical analysis of data</td>
<td>48% (123)</td>
<td>41% (105)</td>
<td>0</td>
<td>0</td>
<td>17% (43)</td>
<td>15% (38)</td>
<td>6% (15)</td>
<td>8% (20)</td>
</tr>
<tr>
<td>Searching an online database</td>
<td>40% (101)</td>
<td>46% (117)</td>
<td>0</td>
<td>0</td>
<td>38% (96)</td>
<td>40% (101)</td>
<td>11% (28)</td>
<td>10% (25)</td>
</tr>
<tr>
<td>Data from experiment</td>
<td>70% (177)</td>
<td>62% (158)</td>
<td>0</td>
<td>0</td>
<td>19% (48)</td>
<td>10% (25)</td>
<td>10% (25)</td>
<td>6% (15)</td>
</tr>
<tr>
<td>Programming languages</td>
<td>64% (161)</td>
<td>67% (169)</td>
<td>0</td>
<td>0</td>
<td>24% (61)</td>
<td>22% (56)</td>
<td>12% (30)</td>
<td>9% (23)</td>
</tr>
<tr>
<td>Application development</td>
<td>59% (148)</td>
<td>70% (177)</td>
<td>0</td>
<td>0</td>
<td>35% (89)</td>
<td>29% (74)</td>
<td>11% (28)</td>
<td>15% (38)</td>
</tr>
<tr>
<td>Modelling/simulation</td>
<td>59% (148)</td>
<td>65% (165)</td>
<td>0</td>
<td>0</td>
<td>26% (66)</td>
<td>30% (76)</td>
<td>13% (33)</td>
<td>13% (41)</td>
</tr>
<tr>
<td>Design</td>
<td>55% (138)</td>
<td>58% (146)</td>
<td>0</td>
<td>0</td>
<td>21% (53)</td>
<td>20% (51)</td>
<td>13% (33)</td>
<td>10% (25)</td>
</tr>
<tr>
<td>Sending/receiving e-mail</td>
<td>0</td>
<td>5% (25)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Some general points can be derived from these tables. First, the two groups show a similar use of the different types of computer for each activity: no statistically significant differences were found. Secondly, minicomputers were not used at all by either of the two groups. Thirdly, use of microcomputers were rather more used in engineering than in science, whilst use of mainframe computers was rather greater in science. Due to the absence of networks from several departments on the campus, this result suggests that stand-alone microcomputers/PCs exist more on the engineering side where they are adequate for the work staff do from their offices, whilst scientists use the computer centre more often because they require more powerful computing facilities for their work.

When respondents were asked about the make of computers used in their work, 65% indicated they used IBM and/or IBM compatible systems, whilst 7% used Macintosh systems. Most respondents, who commented specifically on this, saw a need for departments to have access to both Macs and IBM. It was widely accepted that desk-top micros should be available in all departments as a step towards taking full advantage of networking facilities.
5.4 Advice on computers

The final question asked respondents where they obtained advice and information about computerisation. Table 5.6 below shows the percentage and number of different sources of advice used by respondents. (Since they could mention more than one source, the percentage in the table exceeds 100%.)

<table>
<thead>
<tr>
<th>Sources</th>
<th>Respondents using this source</th>
</tr>
</thead>
<tbody>
<tr>
<td>University computer centre</td>
<td>18% (91)</td>
</tr>
<tr>
<td>Program/computer manuals</td>
<td>44% (223)</td>
</tr>
<tr>
<td>Local computer shop</td>
<td>8% (41)</td>
</tr>
<tr>
<td>Books</td>
<td>46% (233)</td>
</tr>
<tr>
<td>Departmental colleagues</td>
<td>46% (233)</td>
</tr>
<tr>
<td>Computer magazine articles</td>
<td>7% (35)</td>
</tr>
<tr>
<td>Departmental superiors</td>
<td>15% (76)</td>
</tr>
<tr>
<td>Academic journal articles</td>
<td>8% (41)</td>
</tr>
</tbody>
</table>

Most staff stated that they had used between one and four sources of advice. In detail, 26% used one source, 32% - two sources, 13% - three sources and 3% - four sources. Three sources - program/computer manuals, books and departmental colleagues - represent more than 40% of the total. The results indicate that
most staff have requested advice using a combination of these three highly used sources.

Books were one of the most popular sources of advice, whereas computer magazine articles and academic journal articles were not so popular. This may be due to the relative absence of these latter types of publications from the university library. Equally, the small percentage of academics who get advice from the local computer shop may simply be a reflection of the fact that there are very few computer shops in SA.

Of those who favoured two methods of giving advice, over 40% used departmental colleagues and manuals. Advice from departmental superiors was not in common use by academics. This may be due to shortage of such expertise even within the science and engineering departments. (It is also possible that junior staff prefer to communicate to a greater extent with each other rather than with senior academics.)

The university computer centre, which seems the obvious place to get accurate information or advice about computerisation, ranked fifth amongst the eight different sources of advice. This suggests that they have either an insufficient number of support staff, or these staff have inadequate expertise.

A breakdown of the sources of advice used in science and engineering shows no statistically significant differences (see the
The table also indicates that both science and engineering staff are using program/computer manuals, books and departmental colleagues as the most frequent sources of advice.

Table 5.7. Percentage of the science and engineering staff who used advice for computer activity

<table>
<thead>
<tr>
<th>Source of advice</th>
<th>Respondents using this source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Science</td>
</tr>
<tr>
<td>University computer centre</td>
<td>23% (58)</td>
</tr>
<tr>
<td>Programme/computer manuals</td>
<td>42% (106)</td>
</tr>
<tr>
<td>Local computer shop</td>
<td>9% (22)</td>
</tr>
<tr>
<td>Books</td>
<td>39% (99)</td>
</tr>
<tr>
<td>Departmental colleagues</td>
<td>48% (121)</td>
</tr>
<tr>
<td>Computer magazine articles</td>
<td>9% (22)</td>
</tr>
<tr>
<td>Departmental superiors</td>
<td>10% (25)</td>
</tr>
<tr>
<td>Academic journal articles</td>
<td>7% (18)</td>
</tr>
</tbody>
</table>

Breaking down the sources of advice between the sciences leads to a similar result, as shown in the table below.
Table 5.8. Percentage of staff who used advice for computer activity by the different sciences

<table>
<thead>
<tr>
<th>Source of advice</th>
<th>Respondents using this source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Biology</td>
</tr>
<tr>
<td>University computer centre</td>
<td>25% (19)</td>
</tr>
<tr>
<td>Programme/computer manual</td>
<td>40% (30)</td>
</tr>
<tr>
<td>Local computer shop</td>
<td>11% (8)</td>
</tr>
<tr>
<td>Books</td>
<td>40% (30)</td>
</tr>
<tr>
<td>Departmental colleagues</td>
<td>56% (43)</td>
</tr>
<tr>
<td>Computer magazines articles</td>
<td>15% (11)</td>
</tr>
<tr>
<td>Departmental superiors</td>
<td>13% (10)</td>
</tr>
<tr>
<td>Academic journal articles</td>
<td>4% (3)</td>
</tr>
</tbody>
</table>

Program/computer manuals, books and departmental colleagues are favoured in of all sciences. Statistically, no significant differences were found. In terms of who used sources of advice this amounted to 43% of all physicists, 31% of all biologists and 32% of all chemists. This means that physicists are somewhat more likely to seek advice about computerisation than biologists or chemists.

5.5 Discussion

The process of expanding microcomputer use on the university academic campus and integrating it with the mainframe, network and communication facilities in SA has taken time. At the time of
the survey, 53.4% of all science and engineering staff in SA universities were not using computers at all. Furthermore, most academics use a computer for specific tasks so that their ability in dealing with different types of computer is limited. The facilities must now move towards supporting multi-purpose user activities, more especially via networked microcomputers/PCs [2]. Such equipment provides a more user-friendly interface which results in more exploratory behaviour [3] and experimentation [4]. It also gives the user greater control, resulting in higher user satisfaction [5,6]. In terms of the activities mentioned in the previous sections, the use of microcomputers rather than the mainframe, has tended to restrict specific activities which rely on networking, such as e-mail and online searching.

With regard to the sources of advice and information about computerisation, staff used computer/manual, books and departmental colleagues more than other sources. Riley [7] argues that knowledge relevant to the understanding of a topic tend to integrate a user's skill. This suggests that wider reading, especially in computer magazines, is desirable. The library or the computer centre, for example, could hold monthly or quarterly magazines, newsletters and similar materials. Since users have different backgrounds and experience, new systems should also be adequately flexible to provide acceptable performance in accessing and using software applications and peripherals for a range of skill. The user should be able to make a choice of software applications from a rich and diverse software library.
The need for an increase in user training is particularly important. This means that appropriate objectives, strategies, etc. must be developed to meet user needs (see Chapter 3). A reconsideration of education/training programmes and types of publications that may enhance the ability of users in computing activities should therefore be undertaken. The developments should be such that both experienced and inexperienced users can benefit from them.

Putting all these points together, there are some recurring themes in the questionnaire responses. The major ones are as follows. (1) There is a need for strong support for a more centralised authoritative and proactive IT policy. For example, it should be insisted that all staff must be prepared to use e-mail. Again, standards should be laid down and supported campus-wide. Departments should be allowed maximum flexibility in areas that concern their own teaching and research (e.g. in the selection of software to support these activities). (2) There should be much more insistence on appropriate IT training for all staff. This requires high-level support from the university (in making sure staff have time made available, and in providing extensive advisory, as well as training back-up, and so on). (3) Adequate hardware and software should be available campus-wide for staff. The university should move as rapidly as possible to one desktop 'workstation' per member of staff. (4) The provision of intensive networking within and between departments should be given top priority. This should lead to
an array of services of all kinds (library-based, computer centre, etc.) which can be accessed via high-quality networks.

**United Kingdom**

5.6 Information-handling via computers

The first set of questions investigated what areas of information-handling activity had been carried out by respondents over the previous year. The results are compared with a similar study carried out in 1986 (see reference 1). In both surveys, the questions concerned not amount of use, but whether the activity had been implemented at all during the preceding year. Table 5.9 gives the results, with the percentages from the 1986 survey in brackets. All the differences between the two sets of data are significant at the 1% level (apart from collection of data). The number of respondents involved in each survey was 264 in 1986 and it was 396 in 1991.
Table 5.9. Percentage of staff who used a computer for each activity

<table>
<thead>
<tr>
<th>Activity</th>
<th>Respondents using a computer for this activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collection of data</td>
<td>54% (40%)</td>
</tr>
<tr>
<td>Analysis of data</td>
<td>72% (55%)</td>
</tr>
<tr>
<td>Graphical display of data</td>
<td>87% (59%)</td>
</tr>
<tr>
<td>Word processing</td>
<td>96% (62%)</td>
</tr>
<tr>
<td>Electronic mail</td>
<td>70% (16%)</td>
</tr>
<tr>
<td>Electronic data exchange</td>
<td>38% (8%)</td>
</tr>
<tr>
<td>Academic bulletin board</td>
<td>23% (1%)</td>
</tr>
<tr>
<td>Searching an online database</td>
<td>58% (28%)</td>
</tr>
<tr>
<td>Electronic diary/scheduler</td>
<td>16% (1%)</td>
</tr>
<tr>
<td>Personal bibliographical index</td>
<td>39% (20%)</td>
</tr>
<tr>
<td>Non-bibliographical index/database</td>
<td>39% (22%)</td>
</tr>
</tbody>
</table>

These results can be divided into three groups. The first consists of those activities that were already common five years ago, and have become commoner since. Collection, analysis and graphical display of data and word processing come under this heading. Collection of data shows the slowest growth under any heading, presumably because those areas of science where computer collection of data is of value were involved in this activity early on. The second group contains those activities which have shown moderate growth over the past five years - personal indexes and
accessing online databases. The figure for the latter activity may seem surprisingly high. Interviews with academic staff suggest, however, that frequency of usage per year is generally low [8]. The final group consists of those electronic activities which have grown considerably over the past five years. Leaving aside the use of a diary/scheduler, these are all communication activities - electronic mail, electronic data exchange and bulletin boards. Since, with the exception of collection of data, all the increases shown in Table 5.8 are statistically significant, the results reflect a considerable growth in the utilisation of IT facilities by computer-oriented scientists over the past five years.

Table 5.10 shows the breakdown of activities by scientific field. As can be seen, there is an overall similarity, but with one or two variations. These may be related to the field. For example, the nature of the information in chemistry and physics is particularly suited to the electronic exchange of data. Equally, a personal non-bibliographical database may be found more helpful in biology than in the other two sciences. Respondents who indicated that they held such a database were asked to list its contents. Of those who replied, 46% - kept address lists, 38% - personal or departmental records, 37% - annotations on information available in the literature and 22% - information relating to experiments.
Table 5.10. Percentage of staff who used a computer for each activity

<table>
<thead>
<tr>
<th>Activity</th>
<th>Respondents using a computer for each activity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Biology</td>
</tr>
<tr>
<td>Collection of data</td>
<td>51%</td>
</tr>
<tr>
<td>Analysis of data</td>
<td>73%</td>
</tr>
<tr>
<td>Graphical display of data</td>
<td>84%</td>
</tr>
<tr>
<td>Word processing</td>
<td>98%</td>
</tr>
<tr>
<td>Electronic mail</td>
<td>67%</td>
</tr>
<tr>
<td>Electronic data exchange</td>
<td>31%</td>
</tr>
<tr>
<td>Academic bulletin board</td>
<td>26%</td>
</tr>
<tr>
<td>Searching an online database</td>
<td>59%</td>
</tr>
<tr>
<td>Electronic diary/scheduler</td>
<td>20%</td>
</tr>
<tr>
<td>Personal bibliographical index</td>
<td>44%</td>
</tr>
<tr>
<td>Non-bibliographical index/database</td>
<td>44%</td>
</tr>
</tbody>
</table>

The various activities can be looked at from a different viewpoint, asking how many of the different activities listed in Tables 5.9 and 5.10 are actually carried out by the average scientist. As Figure 5.2 below shows, the mode is currently seven. This compares with a modal value of three in the 1986 survey. There has clearly been a diversification of computer-based activities in the past few years.
5.7 Use of computers

Respondents were then asked which computers they used in carrying out these various activities. The choice was between microcomputers, minicomputers and mainframes. They were also asked to indicate whether they used more than one computer for each activity. The responses are given in Table 5.11. The results from the 1986 survey are again included in brackets.
Table 5.11. Percentage of staff who used different computers for each activity

<table>
<thead>
<tr>
<th>Activity</th>
<th>Micro</th>
<th>Mini</th>
<th>Main-frame</th>
<th>More than 1 computer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collection of data</td>
<td>47% (66%)</td>
<td>3% (11%)</td>
<td>3% (14%)</td>
<td>48% (9%)</td>
</tr>
<tr>
<td>Analysis of data</td>
<td>42% (34%)</td>
<td>3% (8%)</td>
<td>2% (39%)</td>
<td>53% (19%)</td>
</tr>
<tr>
<td>Graphical display of data</td>
<td>44% (54%)</td>
<td>2% (8%)</td>
<td>2% (23%)</td>
<td>52% (15%)</td>
</tr>
<tr>
<td>Word processing</td>
<td>47% (76%)</td>
<td>2% (4%)</td>
<td>3% (12%)</td>
<td>48% (8%)</td>
</tr>
<tr>
<td>Electronic mail</td>
<td>37% (11%)</td>
<td>3% (6%)</td>
<td>4% (66%)</td>
<td>56% (17%)</td>
</tr>
<tr>
<td>Electronic data exchange</td>
<td>33% (11%)</td>
<td>5% (11%)</td>
<td>4% (47%)</td>
<td>58% (31%)</td>
</tr>
<tr>
<td>Academic bulletin board</td>
<td>38% (20%)</td>
<td>6% (0%)</td>
<td>2% (60%)</td>
<td>54% (20%)</td>
</tr>
<tr>
<td>Searching an online database</td>
<td>39% (30%)</td>
<td>2% (14%)</td>
<td>4% (47%)</td>
<td>55% (9%)</td>
</tr>
<tr>
<td>Electronic diary/scheduler</td>
<td>41% (50%)</td>
<td>5% (0%)</td>
<td>2% (0%)</td>
<td>53% (50%)</td>
</tr>
<tr>
<td>Personal bibliographical index</td>
<td>45% (72%)</td>
<td>4% (7%)</td>
<td>1% (18%)</td>
<td>49% (3%)</td>
</tr>
<tr>
<td>Non-bibliographical index</td>
<td>44% (60%)</td>
<td>3% (5%)</td>
<td>3% (23%)</td>
<td>50% (12%)</td>
</tr>
</tbody>
</table>

Some general trends are evident from these tables. The first is that minicomputers have never established themselves for the types of activity discussed here. The second is that the use of mainframe computers as the sole medium for an activity has declined considerably (though it must be remembered that some categories of activity, e.g. academic bulletin boards, involved very few respondents in the earlier survey). Above all, the percentage of people who use more than one computer for their information...
handling has risen very appreciably. There has been much talk in recent years concerning the need for a researcher's workstation, from which all information handling could be done at once. It is clear from Table 5.11 that such a concept has still a little way to go before it makes a major impact on the university scene.

The data can be looked at from another viewpoint. We can ask what percentage of the activities are carried out on each type of computer. In this case, we distinguish use of more than one microcomputer for a specific activity from use of a single micro for that activity. (No respondents used more than one mini or mainframe computer.) The results from this form of analysis are given in Table 5.12. The data indicate that micros and mainframe computers (singly, or in combination) are the most popular machines for the electronic handling of information.
Table 5.12. Percentage of activities carried out on each type of computer

<table>
<thead>
<tr>
<th>Activity</th>
<th>Single micro</th>
<th>More than 1 micro</th>
<th>Mini</th>
<th>Main-frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collection of data</td>
<td>33%</td>
<td>31%</td>
<td>11%</td>
<td>25%</td>
</tr>
<tr>
<td>Analysis of data</td>
<td>45%</td>
<td>13%</td>
<td>8%</td>
<td>34%</td>
</tr>
<tr>
<td>Graphical display of data</td>
<td>51%</td>
<td>13%</td>
<td>10%</td>
<td>26%</td>
</tr>
<tr>
<td>Word processing</td>
<td>53%</td>
<td>25%</td>
<td>7%</td>
<td>15%</td>
</tr>
<tr>
<td>Electronic mail</td>
<td>37%</td>
<td>7%</td>
<td>10%</td>
<td>46%</td>
</tr>
<tr>
<td>Electronic data exchange</td>
<td>47%</td>
<td>0</td>
<td>11%</td>
<td>42%</td>
</tr>
<tr>
<td>Academic bulletin board</td>
<td>49%</td>
<td>6%</td>
<td>14%</td>
<td>31%</td>
</tr>
<tr>
<td>Searching an online database</td>
<td>41%</td>
<td>13%</td>
<td>7%</td>
<td>38%</td>
</tr>
<tr>
<td>Electronic diary/scheduler</td>
<td>60%</td>
<td>0</td>
<td>13%</td>
<td>27%</td>
</tr>
<tr>
<td>Personal bibliographical index</td>
<td>47%</td>
<td>20%</td>
<td>9%</td>
<td>25%</td>
</tr>
<tr>
<td>Non-bibliographical index</td>
<td>51%</td>
<td>13%</td>
<td>13%</td>
<td>23%</td>
</tr>
</tbody>
</table>

Table 5.13 records the use of computers in the different sciences. (It should be compared with Table 5.11) The overall picture is similar, but chemists are significantly less likely than biologists or physicists to use only a micro for their work.
Table 5.13. Use of computers in the different sciences

<table>
<thead>
<tr>
<th>Field</th>
<th>People using different computers</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Micro</td>
<td>Mini</td>
<td>Main-frame</td>
<td>More than 1 computer</td>
</tr>
<tr>
<td>Biology</td>
<td>52%</td>
<td>1%</td>
<td>2%</td>
<td>45%</td>
</tr>
<tr>
<td>Chemistry</td>
<td>37%</td>
<td>0%</td>
<td>2%</td>
<td>61%</td>
</tr>
<tr>
<td>Physics</td>
<td>50%</td>
<td>7%</td>
<td>5%</td>
<td>38%</td>
</tr>
</tbody>
</table>

5.8 Advice on computers

The final question concerned from where scientists obtained information and advice about computers. The responses are listed in Table 5.14 with the results from the 1986 survey again in brackets. (The percentages do not add to a hundred because several respondents used more than one source of advice.) There does not appear to have been a great deal of change, although university computer centres seem to be less relied on than hitherto, and somewhat more use is made of computer magazines. Advice from colleagues remains the single most popular source of information.
Table 5.14. Percentage of people who used advice for computer activity

<table>
<thead>
<tr>
<th>Source of advice</th>
<th>Respondents using this source</th>
</tr>
</thead>
<tbody>
<tr>
<td>University computer centre</td>
<td>36% (56%)</td>
</tr>
<tr>
<td>Local computer shop</td>
<td>8% (7%)</td>
</tr>
<tr>
<td>Departmental colleagues</td>
<td>65% (67%)</td>
</tr>
<tr>
<td>Departmental superiors</td>
<td>5% (14%)</td>
</tr>
<tr>
<td>Programs/computer manuals</td>
<td>51% (50%)</td>
</tr>
<tr>
<td>Books</td>
<td>34% (29%)</td>
</tr>
<tr>
<td>Computer magazines</td>
<td>40% (24%)</td>
</tr>
<tr>
<td>Academic journals</td>
<td>9% (17%)</td>
</tr>
</tbody>
</table>

Table 5.15 gives the same information broken down by field. There is an overall similarity between the responses, except that biologists are much more likely than chemists or physicists to turn to their computer centre for advice. A few respondents indicated that they obtained information from other sources. The most frequently mentioned of these was advice from colleagues in other institutions, especially where they were involved in collaborative research.
Table 5.15. Percentage of people who used advice for computer activity by different sciences

<table>
<thead>
<tr>
<th>Source of advice</th>
<th>Respondents using this source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Biology</td>
</tr>
<tr>
<td>University computer centre</td>
<td>55%</td>
</tr>
<tr>
<td>Local computer shop</td>
<td>9%</td>
</tr>
<tr>
<td>Departmental colleagues</td>
<td>63%</td>
</tr>
<tr>
<td>Departmental superiors</td>
<td>7%</td>
</tr>
<tr>
<td>Programs/computer manuals</td>
<td>47%</td>
</tr>
<tr>
<td>Books</td>
<td>33%</td>
</tr>
<tr>
<td>Computer magazines</td>
<td>39%</td>
</tr>
<tr>
<td>Academic journals</td>
<td>7%</td>
</tr>
</tbody>
</table>

5.9 Discussion

The results presented here reflect the fact that computers were first introduced into the sciences as research tools. By the mid-1980s, their use for this purpose was well-advanced. As computer capabilities have become more sophisticated over the past five years, especially in the area of computer graphics, so more opportunities for their research application have appeared. But the growth rate has been relatively moderate because the 1986 baseline was already high. The same can be said of word processing, which was already a well-developed activity five years ago.
The situation with regard to electronic communication is different. The requirements here are access to a good network and the immediate presence of a terminal, preferably on the user's own desk. Both of these factors have improved considerably in recent years. There has consequently been a rapid growth in electronic communication activities. Since all staff are involved in communication (whereas not all are necessarily involved in research that requires a computer), it can be expected that use of electronic mail, in particular, will expand towards saturation in the 1990s.

Finally, there is the question of the use of databases, whether external or personal. As with electronic mail, some use of information storage is required of all academic/research staff. Hence, although there has been appreciable growth in use over the past five years, we can expect database access and construction by end-users to continue to expand during the 1990s. As use of information technology by staff continues to grow during the 1990s, it can be expected that adequate advice on usage problems will increasingly be available within the department, or from readily available information sources (whether electronic or printed). Hence, the only likely change to the trends reflected in Table 5.15 will be as a response to online sources increasing rapidly in this decade.

Despite recent developments in the provision of workstations, the results of this survey do not indicate a major trend towards
integrating all computer activities onto a single terminal. One reason may be that the range of activities involved has expanded too rapidly over the past five years to have allowed this. However, the data do reflect a general move towards distributed computing in universities, so computer activities of staff will, in any case, reach a higher level of integration in the 1990s.

As noted in the introduction, the data presented here reflect the concerns of computer-oriented scientists. The pressure currently, certainly in the sciences, is for all staff to be involved in computer activities, even if only at the communication level. It can therefore be expected that a significant increase in IT usage in the 1990s will come from those members of staff who have hitherto lagged behind, as well as by further diversification by computer-oriented staff.

Comparative results

5.10 Information-handling via computers

Table 5.16 compares the SA responses (scientists only) with the responses of the UK scientists for 1986 and 1991. It suggests a close similarity between the level of activity in the UK in the mid-1980s and the current level in the SA. This similarity is also reflected in the data concerning the number of different IT activities in which the respondents are involved. As Figure 5.3 shows, this currently has a mode (and median) value of three for the SA respondents,
whereas for the UK respondents it is currently six. However, the corresponding value for the UK in the mid-1980s was also three.

Table 5.16. Percentage of staff in three surveys who use IT for the indicated activity

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Collection of data experiments</td>
<td>42%</td>
<td>40%</td>
<td>54%</td>
</tr>
<tr>
<td>Statistical analysis of data</td>
<td>49%</td>
<td>55%</td>
<td>72%</td>
</tr>
<tr>
<td>Graphical display of data</td>
<td>42%</td>
<td>59%</td>
<td>87%</td>
</tr>
<tr>
<td>Word processing</td>
<td>59%</td>
<td>62%</td>
<td>96%</td>
</tr>
<tr>
<td>Sending/receiving e-mail</td>
<td>0</td>
<td>16%</td>
<td>70%</td>
</tr>
<tr>
<td>Searching an on-line database</td>
<td>29%</td>
<td>28%</td>
<td>58%</td>
</tr>
</tbody>
</table>
Figure 5.3. Total computer activities used by respondents in the UK and SA

One exception to this is e-mail. It has already used in the UK fin the 1980s whilst it is likely used in the SA situation today. Noteworthing was already becoming widely available in the UK in the 1980s. This more rapid development as compared with SA continues with the development of SuperJANET to provide a high-speed network and good communications practices to meet diverse user need.
5.11 Use of computers

Table 5.17 shows the use of different types of computer for each activity in SA and the UK. The similarity between SA in 1991 and the UK in 1986 in the use of computer also appears in some of these figures. In SA, for example, the use of microcomputers for all activities was 43%, whilst in the UK it was 45%. Similarly, the use of more than one computer in SA was 6% and, in the UK 13%. It will be noted that the use of minicomputers does not seem to have been popular in SA.

Overall, it can be concluded that the use of computers in Saudi Arabia is much less diversified than in the UK, for Saudi Arabian scientists typically employ one type of computer only. In fact, 70% use stand-alone micros almost exclusively. The great emphasis on stand-alone micros can obviously be related to the low level of usage of IT for communication in SA.
<table>
<thead>
<tr>
<th>Activity</th>
<th>Microcomputers</th>
<th>Minicomputers</th>
<th>Mainframes</th>
<th>&gt; 1 Computer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collection of data</td>
<td>70% 66% 47%</td>
<td>0 11% 3%</td>
<td>19% 14% 3%</td>
<td>10% 9% 46%</td>
</tr>
<tr>
<td>Analysis of data</td>
<td>48% 34% 42%</td>
<td>0 8% 3%</td>
<td>17% 39% 2%</td>
<td>6% 19% 53%</td>
</tr>
<tr>
<td>Graphical display of data</td>
<td>40% 54% 44%</td>
<td>0 8% 2%</td>
<td>21% 23% 2%</td>
<td>9% 15% 52%</td>
</tr>
<tr>
<td>Word processing</td>
<td>57% 76% 47%</td>
<td>0 4% 2%</td>
<td>19% 12% 3%</td>
<td>10% 8% 48%</td>
</tr>
<tr>
<td>Electronic mail</td>
<td>0 11% 37%</td>
<td>0 6% 3%</td>
<td>0 66% 4%</td>
<td>0 17% 56%</td>
</tr>
<tr>
<td>Searching an online database</td>
<td>40% 30% 59%</td>
<td>0 14% 2%</td>
<td>38% 47% 4%</td>
<td>11% 9% 55%</td>
</tr>
</tbody>
</table>

Table 5.17. Percentage of staff who used different computers for each activity
On the UK side, the increased use of e-mail can be seen as a significant development for communication both on and off campus. It is clear that the actual volume of networked communications has risen dramatically in the UK over the past few years. The increase in the use of more than one computer for all activities (52%) - in comparison with (13%) in 1986 - also indicates a significant development of scientists' interest in using different computers more effectively. The decrease in the use of mainframes and minicomputers in 1991, as compared with 1986, and the increase in the use of more than one computer can be related to the significant development of LANs and WANs.

From these results and previous discussions of the relative situations in the UK and SA, it may be expected that SA universities are going to see big changes in the use of IT and networking within the next few years. Therefore, SA must now start to plan a national network strategy to develop a good IT and communication infrastructure. This, in return, must provide users with the capability of using, storing, retrieving and communicating information more effectively.

5.12 Advice on computers

Table 5.18 indicates the sources of advice relied on by the SA respondents and compares them with the UK reliance on sources in 1986 and 1991. The overall pattern is quite similar. However,
the SA respondents obtained advice from the computer centre and from departmental colleagues less than the UK respondents. As against this they made greater use of books. This picture is consistent with a recognised problem in Saudi Arabia: skilled personnel are at a premium and greater reliance therefore has to be placed on formal sources of information. (It should be noted that there are few computer shops in Saudi Arabia and computer magazines are less ubiquitous than in the UK.)

Table 5.18. Sources of advice about computerisation in three surveys

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>University computer centre</td>
<td>18%</td>
<td>56%</td>
<td>36%</td>
</tr>
<tr>
<td>Programs/computer manuals</td>
<td>44%</td>
<td>50%</td>
<td>51%</td>
</tr>
<tr>
<td>Local computer shop</td>
<td>8%</td>
<td>7%</td>
<td>8%</td>
</tr>
<tr>
<td>Books</td>
<td>46%</td>
<td>29%</td>
<td>34%</td>
</tr>
<tr>
<td>Departmental colleagues</td>
<td>46%</td>
<td>67%</td>
<td>65%</td>
</tr>
<tr>
<td>Computer magazines</td>
<td>7%</td>
<td>24%</td>
<td>40%</td>
</tr>
<tr>
<td>Departmental superiors</td>
<td>15%</td>
<td>14%</td>
<td>5%</td>
</tr>
<tr>
<td>Academic journal articles</td>
<td>8%</td>
<td>17%</td>
<td>9%</td>
</tr>
</tbody>
</table>

(It should be noted that respondents were allowed to specify more than one source of advice each.)
In the UK, the use of the computer centre as a source of advice amongst scientists has decreased as compared with 1986. It seems that the spread of microcomputers across the campus encourages advice to be obtained from different sources. This can be seen from Table 5.18, where sources of advice amongst departmental colleagues, magazines and books show high percentages.

5.13 Discussion

The results of this survey indicate that the current position with regard to use of information technology by scientists and engineers at Saudi Arabian universities bears a considerable resemblance to the position typical of UK universities in the mid-1980s. Saudi Arabian academic staff are already making extensive use of micros. What remains to be done is for these micros to be linked via the networks that have recently been installed. Some expansion in the provision of sources of advice (especially via the computer centres) also seems desirable.

Given this, it seems reasonable to predict that the development of IT use in the SA will follow the same path as at universities in the UK. This means, in particular, that most of the electronic communication activities examined here will become commonplace amongst the Saudi staff by the end of this century. As Evans, Meek and Walker [9] point out, users are experiencing a complete change of computing environment. SA must now start to
develop high-speed networking, similar to SuperJANET, to be ready to meet the next generation of campus-wide user needs.
REFERENCES

(Details of publishers are included in the bibliography at the end)


Chapter 5 -208-

Questionnaire
Chapter 6

Results of interviews

6.1 Introduction

There has been much academic concern in recent years about the structural implications of the adoption of computer technology in university campuses [1]. The focus of such concern was on the managerial implications of computer information technology and on the more strategic aspects of the choice of organisational structure design. A recent survey [2] indicates that information technology support strongly relates to organisational strategy. It has been said that linking the IT with organisational structure tends to reflect the organisational decision-making structure. This means that organisational structure, whether it is centralised or decentralised, will affect the degree of IT system development. Hence, university organisation plays an important role in decision-making with regard to the IT development plan, training, funding, purchasing, policy, etc., around the entire campus. A key challenge is this respect as Brindley [3] indicates is the initial creation of widespread access and interconnection through local and wide area networking. The notion of a 'working desk' requires access to on-line libraries and academic departments as well as to all campus services. So the operation and management of these
network information technologies are another factor of importance to university organisation.

The purpose of this chapter is to determine the extent to which computerised information systems (use of technology) are currently being managed, operated and utilised in SA universities. In order to accomplish this, it was decided to interview senior personnel to see whether their present activities and perception of future needs differed significantly from those of academic staff. The study revealed that a multitude of complex issues were perceived to have arisen at SA universities due to the implementation of a campus-wide network system. A comparison is made with the position in the UK as revealed by further interviews.

6.2 Results

The following results are based on the interviews conducted: the questions have been grouped into three categories - network, organisational and user issues. The SA responses and the UK responses are represented under each of the sub-headings for the purpose of comparison. The results have been put in sequence: first from the perspective of the university computing staff and then from the perspective of academic departmental computing representatives. A discussion of the two perspectives is presented after each category.
6.3 IT and networking issues: KACST Perspective

6.3.1 Network system

Saudi Arabia

It was found that the network connections throughout all of the universities and the lack of specialised staff in computer and network environments were regarded as major factors in affecting the provision of IT in Higher Education. The interviewees indicated that universities in SA required enough specialised people in computing, networking and communication systems to obtain benefit from KACST's network services. At present, most university and research institution users (scientists, researchers, etc.,) lack awareness of and familiarity with the IT environment. For instance, mainframe computers, PCs, networks, and communications all need some understanding in order to obtain proper access to the information needed from the system. Correspondingly, different types of people need to know how to use the system. It was remarked that there should be support in terms of equipment, information, training, knowledge, etc., for each type of person. However, although KACST provides its services to all kinds of user, it does not have time to train all of the users in SA. So each organisation in SA, whether it be government or educational, has to have a plan to train its users if it is to make effective use of the KACST network system.
Plans for training at KACST were limited to KACST staff. Most of the training programmes are carried out locally. It was mentioned that an attempt had been made to contact big companies within SA, such as IBM and CER (which provided a lot of services to the SA private sectors, but not on the government side), to obtain from them their training programmes. One observer commented that this would save money in training, and at the same time, gain technological insight from the companies' experience in SA. KACST staff could have training in these companies or they might send technical staff either to the central training establishment or other sites of these companies outside SA.

6.3.2 Computer centre

Saudi Arabia

As far as the computer centre at KACST was concerned, the interviewees indicated that existing IT resources (hardware, etc.,) provided by KACST do not match the users needs because of rapid obsolescence. However, KACST buys the equipment according to users' needs with the available funds. The interviewee pointed out that users coming from different universities and organisations in SA to KACST in order to carry out online searches needed more knowledge and more training on computers. Many users come to the centre from outside with little or no experience of computers. Although there are a lot of on-line terminals and several CD-ROM facilities in the KACST centre, many of visitors do not know how to
use these systems. As one respondent remarked, if the user is not computer-literate, he cannot get the information he wants anyway.

With regard to IT equipment purchasing policy, the decision on what new equipment to purchase is always made by a committee which decides on policy. Sometimes they co-operate with people from outside KACST who have already had some previous of working with them in terms of computerisation. When there is a need to buy something, an analytical study is carried out to see what there is on the market and to determine the purpose behind each purchase. Effectively, there is a study team which consists of people from administration, from the centre, and from outside KACST (whether it be the government side or university side). Sometimes people from the private sector are involved, but this happens very rarely.

With regard to the future plan for the use of IT in Higher Education, the Fifth Development Plan (1990-1995) is guided by the following policies: (1) supporting services for science and information technology - this programme aims to consolidate the infrastructure for science and information technology by upgrading computerised information services and providing the necessary patent services and legal framework for the introduction of new technologies in higher education, and (2) the science and technology awareness programme - this programme will mobilise numerous means and opportunities, such as technology-related
news, publications, programmes, seminars and exhibitions, as well as education at all levels, to deepen the public's awareness and understanding of science and technology (see Appendix VI for more details of the Development Plan in SA).

One interviewee indicated that at present human resources to fulfil these policies (such as technicians, engineers and scientists) are insufficient in quality or quantity to ensure future substantial development in technology. In addition, the lack of co-ordination between institutions is considered to be one of the major problems facing the higher education system during the five-year plan period. Hence, it may take more time to fulfil these policies.

6.4 IT and networking issues: University perspective

6.4.1 Computer centre

Saudi Arabia

All of the computer centres visited for the purpose of this survey agreed that the direction in which information technology was going, particularly with regard to microcomputers, is towards Local Area Networks (LANs) because of the widespread introduction of PCs on all the university campuses. Therefore, they described their campus networking as being in a transitional phase of development. In order to see how the universities in SA have established and implemented the network systems on their
campuses, it was necessary to consider the present structure of the university network.

In the universities visited in SA, network systems appeared to be more advanced at the KSU campus than at the KAU and KFU campuses, because the former is much bigger. KSU can therefore be used as an example of best practice in SA universities. Although KAU has a larger number of student bodies as well as more staff, the networking facilities on the campus were found from this study to need a lot of improvements. KFU is a small scientific university with just a few thousand students and a small campus as compared with the KSU.

In the mid-1980s, network plans and structures were needed on the campus at KSU to meet the university’s growing needs. During a visit to the university computer centre, the development of an effective communication network system was discussed. The objective was to develop a communication system network for the MIS composed of many local area networks (LANs), based on personal computers and with possible links to the mainframe computer and other minicomputers to achieve the best utilisation of the developed information system. KSU had developed a network topology for the MIS integrated communication system network:

- System Network Architecture (SNA) with LU6.2,
- API and APPC,
. Departmental LAN with different topologies, Ethernet or Token ring,
. Internetwork Bridges and Gateways,
. NETBIOS and TCP/IP protocols,
. SDLC, synchronous, and X.25 packet switching links,
. Alternative media including Fibre Optic, Coax, and Twisted Pair Cable,
. Intelligent Workstations for network Access,
. Standard User Interface/Open Look Interface.

The Director of the Computer Centre indicated that two kinds of network system have been designed to fulfil the above objectives. The first one is based on a direct link with the mainframe and the second on the remote communication telephone system. He added that, with the introduction of a Fibre Distributed Data Interface (FDDI) to increase the speed of data transmission, a conceptual design has been established to provide university computer communication with prototype standards to which additions and modifications can be made. This design is based on:

. A 100 Mb/s FDDI dual fibre optic token ring with as many FDDI stations as needed.
. Many departmental 10 Mb/s Ethernet LANs that communicate among each other using the FDDI backbone.
. Alternative LAN topologies, such as Ethernet or Token ring, with inter-LAN communication possibilities.
Alternative LAN media links such as fibre optic for point to point hosts, thick cable for inter-departmental LANs, and thin cable for the overall LAN.

- FDDI direct or LAN link to Ethernet supported computer host and communications with Ethernet LANs.
- FDDI link to IBM/SNA computer host and communications support with Ethernet LANs.
- Direct IBM/SNA computer host link and Ethernet LANs.

The conceptual design is also based on remote communications through the university and public telephone systems, using leased or dial-up lines as well as synchronous or asynchronous modems, to provide:

- Direct on-line links between hosts and/or terminals.
- X.25 packet switching capabilities.

Figure 6.1 shows KSU's proposed FDDI prototype scheme. The direct communications between the PC LAN and the IBM/compatible mainframe were:

- Direct Coax links.
- Ethernet - IBM370 Access.
Figure 6.1. KSU networks layout
The Direct Coax links were used to link the LANs to the IBM mainframe through direct standard SDLC dedicated lines and the LAN gateway. Most LAN gateways use NetBOIS as the application transport protocol and must be compatible with IBM. This option allows the user to connect a PC with the mainframe - a LAN with the IBM/Amdahl mainframe available at the university computer centre. It is capable of providing complete Arabic/English support, using a menu-driven interface to select both Arabic and Latin script, and allows the user to transfer files to and from the mainframe using IBM's INDSFILE under Xbasic. This is an integral part of the proposed university integrated MIS network, which provides the option to connect directly between PC's and the IBM/Amdahl mainframes available at the university computer centre. The Ethernet-IBM370 Access was another alternative to the above. It was established through the IBM Block Multiplexer channel and a LAN gateway, and combines the use of TCP/IP LAN network communication protocols with compatible access to a MVS or VM mainframe through System Network Architecture (SNA). This provides comprehensive access: it links the LAN users to the system network, allows users to log in to other hosts on TCP/IP network, moves files from one host to another regardless of the operating system used and of the type of file, and support the exchange of electronic mail amongst the LAN users. The linkage between the mainframe and the LAN is shown in Figure 6.2.
Figure 6.2. FDDI, IBM, and LAN interfaces
The telephone communications facilities included:

- Remote links between LANs.
- Remote Links to Mainframe.
- X.25 packet switching.

As can be seen, this approach has taken advantage of the existing telephone voice and digital communication capabilities of the KSU telephone system.

Four LAN groups have been implemented to cover all buildings, departments, faculties, and colleges. The first LAN group covers the Administration departments in building 19, the Colleges of Pharmacy and Dentistry in building 23, the College of Medicine and the Central Library. The second LAN group covers the College of Agriculture in building 2 and the College of Engineering, Architecture and Planning, and Computers and Information Sciences in building 3. The third LAN group covers the College of Science in buildings 4 and 5 and the College of Computers and Information Sciences in building 4. Finally the fourth LAN group covers the Audio-Visual Centre in building 8, the College of Art in building 26, the College of Education in building 15, and the College of Administrative Science in building 14. This means that networking has been developed and implemented by groups. Amongst these four groups, group one - the university administration - was given the highest priority in the networking environment. Groups two and three - science and engineering -
were given higher priorities for information-handling activities through the network than other academic departments (such as Arts and Education).

Some of the groups mentioned above had a WAN access capability. Groups 2 and group 3 - the scientific colleges and engineering departments - had access to each other. Furthermore, branches in Olaishah and Malaz for female participants and in Abha and Al-Kasim for males were remotely connected with the computer centre at Riyadh. These WANs were networked by optical fibre.

**United Kingdom**

The universities visited are currently discussing plans to replace their existing network facilities by fibre optics to provide higher speed and better connections to the buildings. JANET itself has been upgraded to a higher bandwidth, and, at present, in all these universities more than 50% of departments are connected to the network. All plan to wire up the whole campus completely so that all departments, offices, and buildings will be networked fully to each other and to the computer centre. In fact, this process is already well developed. The universities also plan to increase bandwidth because of the load on the network. This might be done within the next two years, depending on the money available. Some interviewees indicated that they have already invested funds and the process of implementation is already going on.
Electronic mail and bulletin boards were found to be used widely in all of the universities visited. This supports the results from the questionnaire to scientific academic staff, discussed previously, which showed that the use of communication facilities - electronic data exchange, bulletin boards and e-mail - has increased within the last five years.

The factors that put the UK ahead of SA appear to be the availability of technology, manpower and the form of educational system which exists at universities in developed countries, whilst at universities in developing countries the absence of these factors is slowing down the utilisation of IT facilities as well as their introduction. Consequently, network communication systems in the UK universities are ahead of those in the SA universities. These differences are presenting serious technological and human problems for most universities in the SA.

6.4.2 Library system

Saudi Arabia

During a visit to the three universities in SA, it was found that each has one central library which covers most campus needs. The network system at the KSU library appeared to be more important than in the other two universities, at KAU and the KFU, because KSU had more branches and the biggest campus. So at this university the strategy for connecting the central library to the
whole campus was a particular matter of importance. The decision had been made to have all library branches outside the campus networked with the same system as in the central library, so as to be compatible. Conversely, the network at the KAU and the KFU libraries were limited to the central library and local network systems.

The IT development plan at these latter two universities has undergone rapid change in administrative and academic systems. For example, the strategy for developing library automation at the KAU started late in 1987 and the work started in 1989 after a contract was signed with IBM to support and implement the DOBIS/LIBIS systems in the library. At KSU, a similar strategy started in 1981, and at KFU it started in 1980. The first introduction of the DOBIS/LIBIS system into SA universities started in 1980 at KFU, when a contract was signed between IBM and KFU to have the system installed at the KFU library. In 1986/87 the library was fully automated and, in 1988, the library started to build up a bibliographic Arabic database to meet the needs of the library and its users. Consequently, in 1988 IBM and KFU signed another contract indicating that KFU would be the central support for the DOBIS/LIBIS system in the Gulf Countries. (DOBIS was developed by the University of Dortmund in West Germany and LIBIS was developed by the University of Leuven in Belgium. These two systems form an integrated on-line library management system.)
All three universities' central libraries are connected to the mainframes, but the KAU library is not linked with other departments in the university. Therefore, the users (staff, faculty member, students, etc.,) at this university must go to the library or to the computer centre to access the library resources. The situation at KFU and KSU is different. Several departments which already have terminals linked to the computer centre can connect to the library. Other computers (such as departmental computers, computers in the staff offices, and PCs in the laboratory) had no access to the library databases.

Nationally, all of the libraries visited were networked to the GULFNET facility via their computer centre and use this route to consult the KACST database held at Riyadh. Internationally, they were networked to BITNET in the USA and to EARN in the Europe through the KACST network system.

One interviewee indicated that the slow progress in implementing an integrated library network system was due to two problems. The first one was lack of money. There were no separate funds for the libraries. All libraries get their money from the University Budget System under what is called 'Equipment, Material, and Book Supplies'. This depends entirely on the budget provided by the Ministry of Higher Education. Taking this into account, together with the increasing size of the academic programmes, the available budget is not sufficient to acquire all the IT equipment necessary to meet libraries' and users' needs.
The second problem related to integration with the Management Information System (MIS). The management information systems in all libraries are not fully utilised, especially in network services, due to the lack of qualified skilled personnel. In the opinion of the computer centres, a great deal remains to be done in educating the management staff in the use of network services generally. At present, there is insufficient awareness of the potential of network applications, computer literacy and keyboard skills. This has slowed down the development plan of the library network system in all three universities. At present, the KSU network facilities need improvements to fully integrate the library within and outside the campus. The plan is to connect all library branches with the central mainframe, to train the staff of the library to manage this network system, and to connect the central library with other departments and faculties in the campus. At KAU, work is presently at the development stage and a lot of effort needs to be made by the university to expand networking facilities across the campus. The future plan at this university is to train the staff of the library on the DOBIS/LIBIS system, to develop bibliographic Arabic database records according to needs, and to implement the DOBIS/LIBIS system for all library functions, such as circulation, serials, etc.

United Kingdom

In the UK, all the university libraries visited have been fully networked to each other through the Joint Academic Network
(JANET). The Computer Board for the University and Research Council (CBURC) has agreed to fund a new upgrade initiative for JANET. This initiative (which has been given the name SuperJANET) should provide more powerful access to networks across the UK universities. One important result may be that teaching materials can be exchanged between universities. Thus it would be possible to televise lectures at one university and show them in another university.

6.4.3 Academic and administrative systems

Saudi Arabia

According to the findings from the interviewees in the SA universities, the use of IT in academic and administrative systems emphasises the latter, since the plan is to have administrative systems fully automated. The administrative system at KSU is already fully automated. The director said that KSU is also far advanced towards networking other facilities. In fact, 80% of the network development in the whole campus has been completed. It may take two or three years to make it 100%. At KFU, development is in progress to have office automation with a centralised database for the information needs of the whole university, but the initial focus will be on the administration system. The director added that, at present, there are deficiencies in the PC laboratories throughout the campus, and there is a plan to add five more PC laboratories in the near future. There is an additional need for
more powerful PC laboratories, including workstations, for researchers at the graduate level. The case at KSU is different, as less than 50% of the network facilities have been completed across the university campus. Most of the existing facilities are concerned with administrative systems, such as student registration, payroll, employee numbers, etc. The computer centre reported that there is a lack of systems in the academic areas.

With regard to administrative system networking, all the administrative offices in all three universities visited were networked within the campus. Some applications such as financial, payroll, budget and student registration were networked to the mainframe. Others were locally networked and had their own databases. All these applications were commercially developed and tailored according to the university's needs. However, attempts have been made by these universities to develop in-house by their staff further facilities, such as hospital administration, etc. The director said that some applications, such as house-keeping and inventory, had already been developed in-house at KSU. At KFU, the director indicated that the whole campus is moving towards office automation to reduce paperwork to the minimum. He hoped this would be completed within the next two years. He added that the change will include having a centralised database for the provision of information to the whole university community.
It appears that the academic side lags behind in SA universities. It was clear that there is a need in the research area for the provision of more powerful computing facilities by an increase in the number of terminals, provision of more software programs and the encouragement of the teaching staff and researchers to use the on-line and CD-ROM systems in the library. In the teaching system, the normal teaching courses in computing studies were the only ones found to be using computers for education. No departments have shown any interest in Computer-Assisted Learning (CAL), courseware development, or in any related subjects for their teaching within the universities. A noteworthy finding, however, is that, at KFU, the IT policy in the academic teaching system is to introduce computer courses where possible around the campus. The policy of the university is for students to use computers while doing their studies, and all the students must participate in a computer course before their graduation. Courses such as introduction to computer science (ICO01) and (IC101) which is a computer programming course (e.g. Basic), are mandatory and must be taken by every student entering the university. Students take these courses during their first (preparation) year (first semester). Because the university is a science and engineering institution and the teaching systems are in English, the objective of this preparation year is to improve the student's ability in the English language as well as in computer systems. Thus one of the objectives of the IT policy is that no single graduate leaves without university computer competence.
With regard to the UK universities, all the administrative and academic systems have undergone rapid changes. In terms of administration, all the universities visited were involved in the Management and Administrative Computing Initiative (MAC). This is a database system to provide better management tools for the use of universities in areas such as accounting, timetabling, and so on.

On the teaching side, universities have put a lot of effort into new ventures such as the Computers in Teaching Initiative (CTI) which blossomed into a significant experiment in UK higher education in 1985. Two stages have been involved. The first stage was the development of computer courseware (software for teaching) and the second stage was for disseminating knowledge of courseware among all users. The work has acquired ancillary aims, such as to evaluate more fully the educational potential of the new technology, and to enhance awareness and experience of IT among teachers and students in all disciplines. During the interviews in the UK universities, it was noted in each case that universities are looking towards a major expansion of the use of computer teaching/learning systems. There should be a considerable expansion as courseware becomes available and deliverable over the campus networks which are currently being upgraded. From the point of view of other universities, a number of shared facilities have been set up. These facilities are connected to a central file
server system so that anybody within the region or country can have the same access to software.

The research has seen less change in terms of number crunching. However, graphics handling is developing rapidly. Obviously beyond the basic level of access to equipment, very specialist equipment such as a powerful workstation or parallel processing is required. However, in terms of research communication, electronic mail and electronic bulletin boards for professional and research communication have become increasingly popular.

IT development plans in the UK universities appeared to be more integrated and more wide-ranging, as well as more extensive than current SA plans.

6.5 IT and networking issues: Academic perspective

6.5.1 Departmental network

Saudi Arabia

All universities agreed that computers were not being fully exploited. One of the problems highlighted by some interviewees was the fact that none of the departments had fully up-to-date equipment everywhere. The other problem was the lack of a networking facility in most departments. One interviewer said, "In order to utilise the full potential of the computer, it was felt that if
a set of computers could be networked fully into the department, then more work would be transferred to be done on the computer and more activities would be done on computer. The changeover will be complete when everybody is connected to the network." This statement was endorsed by another interviewee when he observed that an attempt to push students into computerisation for more work assignments was required in order to improve current levels of computer literacy.

**United Kingdom**

In the UK all interviewees also commented that computers were not being fully exploited. It was remarked that the usage of applications varied. It was felt that at least half of the staff used their machines primarily for WP. Computers were not used as often as they should be, mainly because the staff have not had time to get round to using them. According to one interviewee, the problem was that computers often fulfilled multiple roles and staffs did not know how to exploit these properly, again due to lack of time. The other problem highlighted was the lack in some departments of network improvements which allowed the work done on computers to increase. In most of the departments visited, the computer/student ratio was found to range from 1:6 to 1:8, which limited teaching opportunities.
6.5.2 PCs laboratory sharing

**Saudi Arabia**

All departments indicated that they were using different types of computers in their laboratories. More than one type of computer was found in each department, but almost 80% were IBM or IBM-compatible. Some of these laboratories were locally networked through ethernet, while others were working as stand-alone systems. None of the existing laboratories in departments was networked with the university computer centre except for few terminals, such as the Arabic/English terminals in the computer centre laboratory in the College of Administrative Sciences at KSU, and the software research laboratory at the KFU, which had the capability of accessing the university mainframe computers. The rest were locally networked by Novell and VAX systems. The computer centre therefore acts as the networking focus. If students want to work on the mainframe for any reason they have to go to the computer centre. Perhaps surprisingly, the Department of Computer Science at KAU has no network facility, though networking arrangements are being set up at the present time. Furthermore, there was a lack of computers and ancillary equipment, so students of this department mostly go to some other department where there are more facilities - for instance, the university computer centre or the engineering computer centre laboratory. They have to move from one place to another in the university campus to finish their work.
United Kingdom

Most of the departments visited are already networked to the mainframe computer. It was also found that most staff offices and postgraduate students' rooms were furnished with various types of computer. Again, 80% of all departments visited were using IBM or IBM-compatible systems.

6.5.3 Job role change

Saudi Arabia

It was difficult to define the changes which the computing network had brought into the academic environment in SA. All agreed that the job roles and the organisational structure of departments had not changed because of computerisation. The main reason is that most staff are not using computers. The other reason is that the use of computers has not developed in such a way as to make major changes in job roles in the department. The only change that appeared within the department was in the secretary's job, where, in some academic departments, secretaries had begun to use computers. Although the secretaries' computers were multifunction machines, the majority of their tasks involved managing text and they used only the word processing capability of the computer.
United Kingdom

The situation in the UK universities was somewhat different. All the academic departments visited agreed that communications especially have changed because of e-mail. Thus major change was in the job role of the departmental computing representatives: they now tend to be programmers, system managers or technicians, whereas before a member of staff acted as the representative. All agreed that the overall perception was that computers had increased efficiency. For example, teaching had improved because of the use of computer. Also word processing was felt to have increased efficiency by obviating the need for retyping both for staff and students.

6.6 Discussion of these perspectives

A comparison of the responses of the two countries yielded some similarities and some differences. The most striking differences appeared to be in the academic system. In the UK, committee structures such as the Inter-University Committee on Computing (IUCC) and its sub-committees (software, hardware, networks, teaching and so on) were founded to assist and review major policy issues and problems. In addition to this, the existence such experiments as the Computers in Teaching Initiative (CTI) has affected staff and student outlook on computers in teaching. Gardner [1] asserted that the most significant contribution of CTI has been to highlight the organisational and institutional
character of the inhibitors to success in educational computing in universities. Many projects in CTI have demonstrated that the technology has a place across the full breadth of the curriculum, with successful projects in areas as diverse as history, engineering, physics, education, clinical studies and economics [2]. Accordingly, these projects have shown the potential for improvement in computer-based teaching as IT is creating new study media - interactive video, cable TV, computer-assisted learning packages and hypertext instructions - which are helping students to learn on their own and which bring new opportunities for innovation in distance learning.

In SA the absence of this kind of committee infrastructure has inhibited the utilisation of computer technology in the academic system. Similarly, the absence of teaching initiatives has slowed down the acceptance of courseware development to help the teaching/learning system. Hence, both national and local universities appear to be lacking in SA.

Because computers were originally introduced into universities for research, there has been less fundamental change in this area. One obvious difference is in the use of network facilities, such as electronic mail, electronic data exchange and bulletin boards. These electronic communication activities appeared to be used much more widely among the staff in the UK universities than the staff in the SA universities. One reason for this is the greater experience of the UK staff in access to, and use of network services.
The other reason is the existence in UK staff offices of networked hardware/software facilities and the use of the computer as a multi-purpose workstation. Meadows [3] suggested that efficient workstations connected by efficient networks provide an adequate infrastructure for all basic information handling needs of researchers. The questionnaire results of 1991 showed that many UK academic staff have been using computers for more than six activities, whereas SA staff are only using them for three.

Within departments, less was said about job changes among those interviewed, except that one department remarked that there was certainly more teaching of undergraduate computing now than before and e-mail were slightly changing communication roles. However, there was a belief in most departments that, when every staff member is equipped with a terminal connected to others in the department and other departments and colleges via the network, then the working style will change to greater extent as communication activities change. Respondents in SA agreed that integration of individual computing activities (e.g. the use of a multi-purpose workstation) is increasing, but this is not true of integration in their departments.

A frequently mentioned problem was the lack of adequate hardware and software applications. At present, few of the existing machines meet the needs of the staff or the PC laboratories. It was felt that networking, power and user friendliness were not yet available in one machine. Similarly, with regard to software
applications, there was not enough on one computer to cover all the areas of the staff's work. One interviewee related this to the absence of network facilities from most of the academic staff offices. He said, "How do you expect a member of staff to use the computer as an integrated part of computerisation, such as online, e-mail, WP and so on, if his office is not fully equipped with network facilities?" Consequently, he added, integrated computerisation has not concerned many academic staff. Another observer stated that, although networking systems had appeared around the university academic campus, especially on the science and engineering sides, more than 60% of all departments were not involved in integrating their activities.

Another problem was the lack of staff awareness of such aspects of integrated computerisation as the network facility, command language, etc. One interviewee remarked that if the academic computing areas such as laboratories and staff offices could be fully networked within the campus, and the proper steps take place to train people how to use the system, then more work would certainly be done on the computer, including more on-line searching, e-mail and other communication activities.

The administrative systems show much greater resemblance between the two countries. Both sides are trying to develop in-house administrative databases for the payroll, employee numbers and so on. Maybe on the SA side several of these data sets are commercially tailored to the university's needs, whilst...
side these databases have often been developed in-house. In the opinion of all the interviewees in the SA universities, staff education in MIS and in the use of network services generally is a necessary step to making effective use of any library system. They hoped that the introduction of services, such as OPACs and CD-ROM, and encouraging faculty staff to use these services during their visit to the library would serve to stimulate interest among the less computer-literate members of the university.

There is generally thought to be a lack of a consistent computerisation policy in SA, on the part either of the department or the computer centre, in letting the users know what is going on in the system. The inadequacies of the current working environment point to the need to design an integrated system which can identify significant features to the users. Such an approach seems the primary route to processing network problems such as the provision of adequate hardware/software functionality, user-friendly machines and the involvement of users in the design of integrated computerisation. It would also help point up insufficient awareness by potential users of network applications, computer literacy and keyboard skills.
6.7 Funding and purchasing issues: University perspective

6.7.1 Funding system

Saudi Arabia

Respondent were asked if there was any connection between the funding for central computing and the funding for departments. It was found that there was no separate allocated IT funding system in the SA universities, whether to the computer centre or to the departments. There is what is called the University Budget System which covers all campus expenditure. What happens is that, before the university requests its annual budget from the Ministry of Finance and Economic Development, it asks all the faculties, colleges, and centres to prepare and provide their estimate of the funds needed to cover their future programmes. Their estimates are looked at by the main university committee. The university then puts its whole budget forward to be looked at by a Government Committee and the resultant allocation must be approved by the government (Cabinet Minister).

Table 6.1 shows the universities' budget systems during the period 1986-1989. In 1986-1988 each university received its budget system separately. In 1987 the budget was not announced and in 1989, for some political reasons, the government announced the budget to include all universities and colleges in the SA.
Table 6.1. Universities' budget systems
(Government support)

The table indicates that KSU receives the most money. The budgets of the universities depend, in fact, on their size, the number and type of faculties, teaching staff and administrative personnel and the projects for construction of campus buildings and other physical facilities. KSU is the leading university in this respect, as it has the largest number of faculties, teaching and administrative staff and a huge campus construction project which has recently been completed. KAU and KFU came second and third, respectively, as shown in Table 6.1. Priorities within the campus are thus entirely predetermined, and tend to be determined by the ranking of the university.
United Kingdom

In the UK system, funding now comes from the government either directly or indirectly, as well as from other sources (e.g. research). It is possible, therefore, for a university to try and attract extra funds in more than one way. In SA universities no indirect money comes from the government, nor are there other external sources. Furthermore, students do not pay university fees. There is thus a difference between the two funding systems in the UK and SA. In the British system, there is more flexibility which allows a university to make more decisions about which way it wants to go, whilst in the SA system there is much more restriction.

6.7.2 Purchasing policy

Saudi Arabia

The computer centre basically supports the whole university campus with the necessary IT equipment. When interviewees were asked about purchasing policies to support campus needs, answers varied from one computer centre to another. The respondents at KFU said, "There is a committee for our centre. This committee consists of people from the centre and people from the departments who are nominated as departmental representatives by the centre. These people meet together as needed to discuss matters concerning needs, policies, and so on". This type of committee does not exist in either KSU or KAU.
With regard to purchasing processes, all universities indicated that they had a five year plan policy for the purchase of IT equipment of all kinds. Respondents commented: "What happens is that we, after looking at the campus needs, send our purchase requests to the local vendors. They then come here to the university for consultation and advice. They present information about their systems, reputation, experience and so on. Then the computer centre (usually the director) chooses what he sees as the best". One respondent remarked that this approach can be risky. He added, "I do not blame the director for his choice and decision, because of shortages in qualified personnel and technical assistance to share in the decision making: I blame the vendors themselves. For instance, some vendors who have already had a contract with one of the universities may announce that they are not going to supply particular hardware of software any more. If this occurs the university has to switch to a new system and the purchasing policy cannot be implemented successfully in this stop/start situation. Another problem is the availability of spare parts. They may take months to arrive. Maintenance contracts can also be a problem. Thus it is better to think of these technical issues before one contracts with any vendors, because their information is not always perfect."

One interviewee suggested that, because of all these constraints, the computer centre should rethink its second development plan. This should be done one or two years before the expire date of the first development plan. The idea behind this was to evaluate and
discuss the needs of the university computer centre and the needs of all of the departments in advance so as to arrive at a satisfactory solution. He added that development planning, implementation, management and monitoring require human resources, knowledge, facilities, and equipment and finance. Therefore, an IT plan supporting such a development effort must provide information about these aspects as resources. The interviews suggest that the following points should be considered:

- What are the IT resource options?
- What are the alternative sources of resources?
- Under what conditions are the resources available?
- What are the experiences of using these resources in similar departments elsewhere on the campus?
- What further development is required?
- What hardware and software are needed?
- What networking facilities exist on the campus?
- What other improvements are needed?
- What are the characteristics of the vendors in terms of delivery time, reputation, maintenance, etc.
- Other related problems which may transpire.

In addition to the main requirements of the five year plan, there is also a need for an improved purchasing policy within the universities. At the moment, the match between user needs and the actual purchases is far from perfect. Apart from this mismatch, it was agreed that the budget provided for the on-going operation
and acquisition of IT services should be sufficient, if it is maintained consistently from year to year.

United Kingdom

In terms of the UK universities, each had a committee system to deal with purchasing policy. In one university there was 'the Computer User Advisory Panel Committee' which is a committee of departmental users. Every department in the university nominates a departmental representative. These people meet six times a year to discuss and plan for the needs and aspirations in the academic departments. These plans go through the computer centre committee which includes a senior academic from each of the faculties. The computer centre then puts in a bid to the university equipment for whatever has been decided. This has then to be compared with the computer equipment bids from academic departments.

In another university the purchasing policy depends on a university committee called the 'IT Co-ordination Committee'. This committee has a representative from each university faculty and from the computer centre, library, administration and audio-visual unit. The committee attempts to co-ordinate policy around the university. The third university indicated that there are what are called 'User Committees' around the university. These committees look at IT policies in terms of hardware, software,
network, services, etc., in their area and make their recommendations. These are forwarded to a central committee.

Regardless of the name of the computer committee in the three universities visited in the UK, the findings suggested that there are usually two levels of committee relating to computers. The first is called the 'Computer Committee' that looks after the guidance of the computer centre. The second is called the 'Computer User Committee', which involves people who use the computer centre. They feed back problems that are found with the centre. Consequently, the first committee is concerned with policy and the second committee with the practical operations of the centre.

As far as funding for purchasing IT equipment is concerned, there is some agreement on the infrastructure in each university. The computer centre is responsible for the general infrastructure (e.g. cabling) up to the departments, but within the department the departments themselves are responsible.

6.8 Funding and purchasing issues: Academic perspective

6.8.1 Purchasing policy

Saudi Arabia

There is no formal written purchasing policy concerning the acquisition of equipment due to the following factors. It is, after
all, the university rule that the university computer centre will provide all IT equipment to all the departments in the university. None of the departments can buy their equipment separately. Most departmental computing laboratories operate under a teaching staff member assigned by the department. These members of staff do not have enough time to stay in the laboratory to keep a watch on all systems. Furthermore, most of the staff are not technically qualified to control the laboratories and are unable to compose policy reports about the department's needs. Consequently most discussion is limited to one particular aspect - the need for equipment, the lack of more computers and terminals, the problem of compatibility and lack of specific hardware/software.

United Kingdom

In the UK universities, by way of contrast, departments are concerned with making policy decisions. For example, a department in one university has an Infrastructure Sub-Committee. This committee has to think about long-term developments, and actually does have to formulate policies. There are other committees, such as the Academic Affairs Committee and the Management Committee, which also have an influence in this respect. In another department an Advisory Group Committee was found. This consisted of selected professors and senior lecturers to advise and make decisions on purchasing policy. Indeed, all the departments visited had formal written policies and committees
to help and formulate departmental purchasing policy. One interviewee remarked that the main policy thrust, however, is really to keep the computers as up-to-date as much as possible within the restraints of cost. Another interviewee added that most departmental laboratories are routinely upgraded. Each laboratory is looked in turn to upgrade as necessary, and the rest of the facilities are dealt with on a need basis.

6.8.2 Decision and consultation prior to purchase

Saudi Arabia

Respondents were asked whether or not they were involved in decision-making and consultation prior to the purchase of new equipment. In all cases, they said that the departmental computing representative and the head of department were the people involved in decisions and consultation on purchasing new equipment. The situation at present, because all of the academic departments are supported by the computer centre, is that the computer centre makes the final decision after consultations about the purchase of IT equipment. Consequently, computing policy often seems irrelevant to departments because they are so constrained by the decisions of the computer centre. Their only policy is to try to get as much computing power as they can.
United Kingdom

The situation is different in the UK departments. Decision and consultation about purchasing varies between departments. In one department the responsibility lies with the Management Committee's, but they are advised by an Infrastructure Sub-committee for IT. Within this Sub-committee there are three system managers who provide technical advice. The Academic Staff Committee was also expected to provide input. These committees meet together once or twice a term as needed to discuss IT purchasing. In another department, the approach was very much simpler. The departmental computing representative actually makes the decisions, and has the power to make purchases.

6.8.3 Future purchases determined by past purchases

Saudi Arabia

Since all the equipment in the departments was supported by the university computer centre, there was no indication that any future acquisition policy would be determined by past purchase. The only thing that the departments can do is to make recommendations when they request new machines. These recommendations depend on the success of old machines. If the machines have proved to be successful, and the staff are quite satisfied with them, then similar types of machine will be preferred
again. However, the final decision lies with the computer centre committee to decide whether to provide the same or different models.

It was also found during the survey that adequate facilities do not exist in most departments to meet user needs. It is not only that the computer centre may not provide all of the necessary resources to the departments but also that the existing facilities in the departments lack the personnel to control the equipment effectively. There is also a lack of infrastructure necessary to manage IT resources. It was agreed this would be helped if departments were allowed to prepare a strategic IT plan using co-ordinated teams which might consist of the head of department, departmental computing representative, an external technical staff member (if an internal one is not available) and staff from the computer centre.

**United Kingdom**

No big differences appeared between the academic departments in the UK and the SA universities in terms of future purchases of computer systems in the light of past purchases. UK respondents agreed that previous experience, the success of old machines and reliability and satisfaction were important factors related to future purchasing acquisition policy. It can be difficult to change direction, not only in terms of the money invested, but also the fact that people have acquired knowledge about the system. There
may also be advantages especially if the computers bought are going to be used in teaching classes. The use of different computers within the same class would need much more time and effort. So all interviewees agreed to a great extent that there are some constraints related to what one has previously purchased.

6.8.4 Acquisition policy

Saudi Arabia

In many departments surveyed in SA, the acquisition policy regarding IT purchase was not clear. In some departments the policy was put forward by advisory groups (small groups of staff members, usually one to two persons). The group seldom had any executive function, but served as a forum for the exchange of ideas and recommendations. In some other departments the policy was formulated by a departmental group (heads and departmental computing representatives). This group appeared to have a more effective approach to policy formulation than others but the concepts behind the policy were not always clear or applicable. The introduction of new information technology within a department was therefore often a one-off initiative on the part of an advisory group or small group of professors and lecturers or even individuals.

SA departments do not provide computers for staff. The heads of departments indicated that most of the staff buy computers from
their own pockets and install them in their offices to do the work. It was also mentioned that some staff bring their own computers from home to their offices to do the work. Thus, the department cannot insist that staff buy a certain type of computer. However, in some departments staff are recommended to get compatible machines to suit the departmental machines. Consequently, more than one type of computer was found in most departments and this led to incompatible systems. This incompatibility may cause the system to be unable to transfer or share data with other systems and inevitably hampers efforts to increase computerisation.

**United Kingdom**

The overall acquisition policy is approved by heads of departments. Most departmental acquisition policies envisage purchasing microcomputers that are compatible with present ones. The university mainframe provides many of the computing facilities academic staff require, so departmental purchasing only arises because some needs are not satisfied by the mainframe. Consequently, departmental purchases are concerned with achieving greater local control over computing (e.g. to access online databases) to access services more flexibly than is possible with the mainframe.
The staff were to some extent restricted to compatible machines. However, there were exceptions: some staff bought computers out of their own project funds.

6.9 Discussion of these perspectives

With regard to purchasing policy, some interesting differences between the UK and SA were observed during the interviews. In the UK system, although money was the main problem for integrating IT equipment on the campus due to shortages in funding and the inflation rate, all the universities had developed policies for the expansion and support of integrated computerisation. In SA policy was less well developed and implemented. In particular, there were the following constraints: lack of skilled and experienced technical people in management information, a lack of organisation to share ideas, responsibility and decision making with regard to the purchasing, problems with vendors and an absence of a purchasing policy. One result is that a lot of money, time and effort are wasted. A recent paper by Sabah and Abd-Elwahed [4] suggests that one of the mistakes many organisations in the SA are making is that they start buying hardware/software without having made a complete study of the applications required and without paying adequate attention to future expansion needs. Another problem is that the lack of adequate overview means that the system, subsystem, application and the relationship between them are not integrated properly which results in problems when implementing the system.
Wiseman [5] has described an approach to analysing the value of an information system in terms of an IS strategy. Such a strategy decides on the infrastructure to deliver the information system. In part, the approach offers a decision making process and, in part, it involves managers and technology managers in getting together to discuss how proposed investments can take place. This kind of approach leads to a number of significant economic advantages:

- comprehensiveness - all relevant economic and technical issues are addressed.
- consistency - in the decision-making process.
- clarity - of objectives, values and attitudes.
- communication - vastly improved across and between functions.
- confidence - that projects have been thoroughly analysed and justified.
- consensus - between managers from different units and functions.

Sutton [6] has suggested that if IT were addressed from an integrated strategic viewpoint, lower costs in some areas should support expansion in others. Therefore real management strength is needed at the infrastructure level. This would provide a framework so that IT-related initiatives could be seen to support and facilitate the funding strategy, rather than allowing a series of sub-optimal decisions to be taken. It has been mentioned previously that IT plans cannot be implemented successfully due to the vendor problems. Thus one suggestion is that universities should have a good relationship with all local vendors to ensure
that communication lines between the computer centre and the
vendors remain open and that planning starts at contract time.
Another consideration is the question of separate funding for the
computer centre. In this respect, Brindley [7] has remarked that
there is a need to recognise that with the increasing devolution of
cost centre management, computing will be taken outside the
central service ambit, and this needs to be recognised in overall IT
investment patterns. There is a cogent argument for including
these costs in the base budget and plan of the institution.

In SA, particularly, an understanding of funding and investment
issues is required. Universities must begin to recognise the
importance of investing money in the computer system as a key
institutional resource. The funding system, including early plans,
strategy, policy, vendor relations and other related factors
demands considerable attention in investing money as well as
reducing time and effort. The explosion of computing on campus
has pointed up the need for overall planning campus computing
and, especially, for financial planning.

With regard to acquisition policy on the SA side, there was a feeling
that a form of defined departmental policy on purchasing needs
to be available to all those departments involved in computing IT.
A formal statement of policy is necessary to provide a framework
within which the action required can be taken. This policy may
well focus on meeting the needs of departmental computing IT as
well as user needs.
The earlier discussion of the UK and SA suggested that SA staff are given an opportunity to use computers in the same way as UK staff, but they do not have the opportunity for such extensive use. The obvious reason for this difference is the ability of UK staff to access the whole university campus network from their offices. This comparison suggests that similar developments are necessary in SA universities. Hence, there is a need to establish formal departmental policy regarding the provision of every staff office with a computer and access to the network to increase the integration of computerisation, and to establish policies necessary to ensure effective and efficient access to the data and applications required in support of staff computing.

6.10 Organisational issues: University perspective

6.10.1 Organisational structure

Saudi Arabia

Basically, the university committee structure was found to be similar in each of the three universities visited in SA. The main body of the structure was the Court Committee (which is not involved in the organisational structure). It consisted of people from inside and outside the university, and included the Minister of Higher Education as the chairman, the Chancellor of each university (in the seven universities in SA), and five people from outside the universities. The Minister of Higher Education acts as
the Chairman of the Court Committee for every university in the SA. Basically, this structure forms all the universities' supreme governing bodies in SA. Sometimes more than five people from outside the universities may be involved in the committee: for example, there may be seven or eight people from different ministries, such as the Ministry of Finance and Economic Development, Ministry of Education, and Ministry of Planning. They meet together once or twice a year to discuss all the university activities, such as the budget, academic and financial affairs, future plans for new university development, manpower, etc. They may also meet specially for other purposes. These meetings will be called by the university and they depend on requirements. This body, however, cannot appoint the Chancellor, the Vice-chancellor or the General Secretary. These appointments are by the Cabinet which is presided over by the King. Often the Court makes recommendations only, and the Cabinet makes the final decision. Usually these appointed people (Vice-Chancellor and General Secretary) serve for a period of three years and are eligible for re-election once on the basis of a recommendation made by the Minister of Higher Education. The Chancellor, on the other hand, remains in his position until he resigns, or the Cabinet assigns another person.

The other important body is the Senate Committee which works under the Court Committee. This committee involves people from inside the university. It includes the Chancellor, the two Vice-chancellors, General Secretary, Deans of Faculties and Colleges and
Institutions, and one staff member from each college. This committee meets together once a month. It has authority over all academic, financial and administration affairs. Under these headings come all the different departments, the individuals within them, the computer centre, the library, and the various facilities. These are shown in the organisational structure of each university as depicted in Figures 6.3, 6.4 and 6.5.
Figure 6.3. KAU organisational committee structure
Figure 6.4. KSU organisational committee structure
Figure 6.5. KFU organisational committee structure
As can be seen, the exact forms of the university organisations were different. The Board of Faculties at KSU and KAU were directly under the Chancellor's Board, whilst at KFU it was under the Vice-chancellor for Academic Affairs. Furthermore, at KFU and KAU the responsibilities for financial and administrative affairs such as housing, financial matters, employees, maintenance, etc., came under the General Secretary, whilst at KSU some of these areas came under the Vice-chancellor for Financial, Administrative and Technical Affairs (planning, budgeting, housing, etc.,) and other areas under the General Manager for Administration and Future Plans (communication, transportation, maintenance, etc.,).

The position of the computer centre within the university structure differed in all three universities. At KFU, the computer centre (which is called Data Processing Centre (DPC)) came under the Vice-chancellor for Graduate and Research Studies. At KAU, the centre came under the control of the Vice-chancellor for Administrative Affairs, whilst at KSU it was under the Department of General Administration for Computer and Information Systems. In this department, it formed a separate entity within the university structure. Similar variations occurred for other service functions. Thus the central library at KSU was directly under the Chancellor, whilst at KAU and KFU these libraries came under the Vice-chancellor and the Vice-chancellor for Graduate Studies and Research, respectively. It follows that the discussion of IT interaction between the library and the computer centre at KSU ultimately takes place in the Chancellor's committee (Senate).
the case of KAU and KFU, they are directly under the Vice-chancellor's committee, though again the discussion goes to the Chancellor's committee (Senate) for final decision.

Whatever the organisational system, there was no such structure as a university committee for IT planning in any of the universities visited. Indeed, there was no proposal for a committee devoted to IT nor any kind of technical committee on computerisation within the university structure. Consequently, any IT plan was produced by the computer centre in each of the universities visited. This reflects the fact that universities in SA are more centralised in their decision structures than British universities.

**United Kingdom**

In looking at the university committee structure in SA and the UK, UK universities were found to be different from SA universities, as shown in Figures 6.6, 6.7 and 6.8. For example, in all three universities visited in the UK, the structure was the same in that the internal government of universities consisted of three main bodies, the Court, the Council, and the Senate. The Court is usually the supreme governing body in the university, but in practice its authority, especially over academic matters, is limited to formalities. It meets once or twice a year to review the financial accounts and other reports on the work of the university; it may also meet specially for other purposes. In most cases it is
Figure 6.6. NU organisational committee structure
Figure 6.7. LU organisational committee structure
Figure 6.8. LUT organisational committee structure
the body which elects the Chancellor and, in a few cases, appoints the Vice-chancellor. It consists of representatives of the academic staff and graduates of the university, heads of local schools and nominees of other universities, local authorities and educational organisations, religious denominations, learned societies and professional bodies. There are considerably more outside members than representatives of the university.

As the body which administers the finances of the institution, the Council is responsible for all policy decisions. In most universities it appoints the Vice-chancellor, in consultation with Senate. In most cases, there are more lay than academic representatives on the Council. Subject to the powers of the Council, the Senate (sometimes called the Academic Board) is the chief academic body. It approves and co-ordinates the work of the faculties and is responsible for the teaching and discipline of students. It also be responsible for discussing the computer centre and the library and all those involved in IT. As noted previously, part of the IT discussion (on building, strategy, space, etc.,) goes to the Senate, whilst the part which relates to money goes to the Council. So in order to develop computer services it is necessary to have agreement between the Senate and the Council. In the case of SA universities the authority belongs to the Senate Committee. The Vice-chancellor is the chairman of this body, which consists exclusively of members of the university.
The other important point concerning computer centres is the existence of the IUCC (Inter-University Committee on Computing) linking the universities. The IUCC has produced many Sub-committees, such as the Inter-University Software Committee (IUSC), the Inter-University Networking Committee (IUNC), the teaching committee, the research committee, and so on. The IUCC was supported by the University Grants Committee (UGC). During the interviews, it was mentioned that the idea of having a committee structure between the UK universities was to assist the former Computer Board in its policies. The Board discussed with universities strategic proposals which took account of the rapid pace of technological change. More recently, matters relating to computing have been taken up by the Higher Education Funding Councils.

Consequently, computers are no longer treated separately in university planning, and this reflects their widespread use across faculties and functions in the modern British university.

This kind of organisational structure was not found in the SA universities. Each computer centre has its own board within its university, and does not coordinate plans with other universities. Hence, there is no cooperative structure to develop IT plans as in UK universities.
6.11 Discussion of these perspectives

A difference in perspective on organisational issues between UK and SA universities is clearly evident. One difference concerns the decision making processes within the structure. In the SA, decision are more centralised. One of the interviewees related the issue of the centralised decision structure to the shortages of skilled technical people in the operation, maintenance and management of the computer system. He stated that this led to more active involvement of top managers in decision processes. Thus, the system led to greater centralisation and quite strong control over lower levels. Another factor was the lack of co-ordination of and communication between computer committees in different universities which hindered the search for better decisions and better solutions. One interviewee from the academic departmental side viewed the situation differently. He suggested that the absence of communication between the computer centre side and the academic computing side, may be because the academic users feel uncomfortable due to the presence of many non-faculty members on the university committee concerned. He added that decision making authority for information technology matters typically ranks relatively low in the university organisation.

These points indicate that the present organisational structure at SA universities does not enables all parts of the university community to participate in shaping IT programmes. They also indicate that the existing structure lacks the communication and
co-ordination of a senior management body both within and outside the university. The introduction of IT clearly affects the patterns of communication and the interaction of people involved in the decision making process.

In the UK, decision making appeared to be more decentralised, in that many administrative and faculty members from different university organisations share the responsibilities for IT strategy. One university indicated that it had set up a very senior committee called the 'Information System Committee' which was headed by a pro-vice-chancellor and had the registrar, the librarian, and the director of the computer centre as members, together with a number of elected academics. The committee oversees the activities of the computer centre, the library, and administrative computing for academic departments. The computer centre committee, the library committee, and the administrative computing committee now all report to that information system committee. So the university tries to co-ordinate its various IT activities in terms of information systems.

In another university, it was found that a new committee structure had recently been set up. It was based on an advisory committee made up of faculty members from each department in the university. This group advises the computer centre on such matters as software, hardware, priorities, strategy and so on.

This basic similarity of organisation between the UK universities may well help different universities to communicate more
effectively with each other. It also helps in decision making. A committee containing a range of experts is more likely to produce better solutions. This in return will affect the whole IT decision making process in the university, in providing more alternative solutions (e.g. on planning, strategy, and purchasing), and affecting the choice of technology.

The centralised SA system does not reap these benefits. This does not necessarily mean that decentralised decisions are always better than centralised decisions, but decentralisation allows decision-making at lower and middle levels producing better decision making overall [8]. Against this must be set the fact that centralised decision making allows information to become more rapidly available to higher levels [9]. As a compromises decentralisation may simply entail the delegation of more routine decisions whose outcomes are more closely controlled [10].

Universities in SA must clearly rethink their computer board structure. It is necessary to recognise that IT on a campus is no longer concerned with individual services, such as libraries, computing centre, or educational technology units, but with the institution as a whole. Many institutions of higher education believe communication and co-ordination can best be achieved through a carefully organised committee structure [11]. On the basis of research [12] it can be said "that (i) highly centralised communication like the 'wheel' is superior for routine tasks, where errors are acceptable; while (ii) a decentralised communication
like the 'circle' is better suited for less routine tasks, where adaptation and innovative thinking are required. When only centralised communication (as in the 'wheel') was allowed, the task was seldom completed successfully; performance improved when decentralised communication (the 'circle') was allowed.

6.12 User issues: University perspective

6.12.1 Staff training

**Saudi Arabia**

The directors of the computer centres in the SA universities were asked how the computer centre staff keep up-to-date with the computer technology. One director said that staff training is very important currently because of the need to help with networking facilities used around the whole campus. Another director observed that staff training is very important in keeping the staff up-to-date due to the lack of qualified skilled technical staff in the centre. Another director looked at the situation from different angle. He said that there is a need for staff training to discover the knowledge deficiencies personnel have in managing the information system. All agreed that the need to send staff abroad to the UK and to the USA for training and/or for attending some seminars, conferences and courses had been closely considered. However, because of the restrictions of financial constraint, the centres now send very few people outside SA to be trained in IT.
Therefore much staff training is now local, though staff attend the national computer conference that is hosted every year by SA (see Figure 6.9).
<table>
<thead>
<tr>
<th>Number of Conferences</th>
<th>Locations</th>
<th>Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>College of Petroleum and Minerals (Dhahran)</td>
<td>5-7 November, 1974</td>
</tr>
<tr>
<td>2nd</td>
<td>Public Administration Institution (Riyadh)</td>
<td>18-20 November, 1975</td>
</tr>
<tr>
<td>3rd</td>
<td>King Abdulaziz University (Jeddah)</td>
<td>22-24 November, 1977</td>
</tr>
<tr>
<td>4th</td>
<td>King Saud University (Riyadh)</td>
<td>4-6 March, 1978</td>
</tr>
<tr>
<td>5th</td>
<td>King Fahd University (Dhahran)</td>
<td>20-22 March, 1979</td>
</tr>
<tr>
<td>6th</td>
<td>King Saud University (Riyadh)</td>
<td>4-6 November, 1980</td>
</tr>
<tr>
<td>7th</td>
<td>Public Administration Institution (Riyadh)</td>
<td>21-25 January, 1984</td>
</tr>
<tr>
<td>8th</td>
<td>Arabian American Co., (ARAMCO) (Dhahran)</td>
<td>1-7 October, 1985</td>
</tr>
<tr>
<td>9th</td>
<td>Ministry of Interior (Riyadh)</td>
<td>6-13 October, 1986</td>
</tr>
<tr>
<td>10th</td>
<td>King Abdulaziz University (Jeddah)</td>
<td>28-2 March, 1988</td>
</tr>
<tr>
<td>11th</td>
<td>King Fahd University (Dhahran)</td>
<td>4-7 March, 1989</td>
</tr>
<tr>
<td>12th</td>
<td>King Saud University (Riyadh)</td>
<td>21-24 October, 1990</td>
</tr>
</tbody>
</table>

Figure 6.9 National computer conferences hosted in SA since 1974
The reason behind SA hosting this kind of conference was to bring people from abroad to attend the conference and the exhibition to discuss the present IT environment in SA and how to overcome problems. For example, The 10th National Computer Conference and Exhibition hosted at KAU in Jeddah, SA, in 1988, was one of the best supported of these events. The programme also involved many people from abroad such as Dr. Yuko Misouno, the senior Vice-president of Nippon Electric Corporation (NEC), Japan, and Dr. Tage Frisk Vice-president (Europe) of International Business Machines (IBM), USA, who presented keynote speeches. In addition, many papers were presented in the areas of modelling and simulation, distributed systems and networks, artificial intelligence, industrial automation, Arabisation, medical systems, education and social aspects.

One director said that the attendance of computer centre staff members at this kind of conference is expected to help them gain some knowledge of computer technology. They will also see what is going on in the SA market with regard to computer and information technology during the exhibition days. In addition, computer centre staff from one university visit the computer centres of other universities. Some computer centres bring courses to the campus by getting experts from local companies, such as IBM, NEC and Apple Macintosh, to conduct courses in-house. The staff sometimes attend training courses within the Institute of Public Administration (IPA) which is located in Riyadh, SA.
Overall, these procedures are not sufficient to keep the computer centre staff up-to-date with IT services, according to one interviewee. He continued: "There is the problem of staff turnover. Most of the technical staff are foreigners. They work for a few years and then leave their jobs. The problem is who will do their work? What happens if the system goes down? And so on. It is not simply a matter of taking the staff to attend local training, seminars or conferences it is also the matter of who is giving the training. Is this training appropriate to the staff? We are living in the information technology age. Everything is changing fast and everything is developing fast. We need professionals in this field."

This statement was endorsed by another interviewee who remarked that the computer centre needs to develop a consistent plan to keep staff up-to-date. They should invest money and they should look to the future, noting that technology prices are going down. He hypothesised that, "If the money goes to the right place this could be a good investment. In return, the centre can improve its whole organisational level and look to long-range objectives."

It was agreed that most of the staff need to acquire skills for the effective use of network technology and for the computer centre to understand the requirements for and to support appropriate network solutions. One interviewee mentioned the problem of staff resistance to their own IT education. The shortages of computer publications, such as books, magazines and articles, are also affecting computer staff enthusiasm to up-date their knowledge parallel to the new IT existing services which are coming into
higher education. The staff clearly still need more IT education, as by advanced training, and attending seminars inside and outside the university, as well as inside and outside the country.

6.12.2 Information services

Saudi Arabia

Because of factors such as lack of training, MIS problems and so on, the information services within the computer centres can be ineffective in certain aspects. This fact was not true for all of the computer centres visited in SA. At KFU, the interviewee indicated there are many services that the centre provides for the whole campus. In terms of face-to-face service, desk help and consultation staff were available to help with users' problems. But the most effective information service appeared to be via the network. Departments such as Administrative Data Processing (ADP) handled the information flow of all university administrative sections (personnel, accounting, inventory, etc.). The other department mentioned was the Academic Computer Services (ACS). This department has the responsibility to provide computing services to faculty, students, researchers and so on. It handles all matters related to software or hardware, according to the interviewee. He added that all the academic PC laboratories are looked after by this section.
As far as the relationship between the academic computing departments and the computer centre are concerned, it was observed that the centre had a hot-line telephone desk for communication purposes between them. All the academic computing departments have been assigned a representative or co-ordinator by the computer centre, according to the director. He observed that good communication in this respect affects the performance of the network system on the whole campus. He went on to say, "In every semester we have a seminar in the centre and all the staff in the centre and all of the representatives in the academic computing departments attend. We try to introduce all kinds of services old and new to let all the staff know what is available for them. This kind of meeting in each semester helps the staff meet each other and know what responsibility each one has, and effectively increases communication between all computing staff on the campus."

The view at KSU and KAU was different. The directors at these universities indicated that each academic department is responsible for its own services. There is no direct contact between the academic side and the computer centre side. The only contact happens when the mainframe computer on the academic side goes down. In this case, because academic computers are connected to the mainframe, it is the centre's responsibility to provide services. They also indicated that they had assistants, advisers and consultants to help with academic computing problems if they were needed.
All agreed that the existing IT resources and services do not match the present needs of all of the university users (faculty, staff and students). The reason for this was that new things are constantly appearing in the IT environment and most users are looking towards these new things being installed on the university campus, for instance faster machines, e-mail and so on. Some interviewees agreed that there is a gap between the two sides, but this will change very soon. There was agreement that MIS and technical levels need to be continuously raised across all departments to develop the required skills for the effective use of IT. Equally, the computer centre needs to understand requirements and support the appropriate information services and network solutions.

**United Kingdom**

User information services are widely used both in terms of fact-to-face contact and network facilities. In terms of face-to-face communication, a number of advisory services were found in all of the universities visited in the UK. In one, there was a general advisory service for programming problems, and a specialist numerical and statistics advisory service because of a big medical school (the social sciences use it heavily as well). There were central operations staff who manage central printers, day-to-day matters and inquiries. There was also a telephone hot-line for administrative users who have problems using PCs. On-line help facilities were also provided in the network. Also many bulletin boards and e-mail capabilities were found to be accessed over the
network. One interviewee said that there would be further expansion over the next three to four years to provide a campus-wide information service, but there are problems with the money and time needed.

Computer centre staff had an increased awareness of the need for training in general management. With the breadth and depth of applications now available, all users need support and help, and one of the greatest resources if properly managed is the concentration of expertise in the computer centre. There is a staff training unit in the university where staff can go on appropriate training courses. The UFC which is the national body to which the computer centre relates also has quite a large number of workshops on different aspects of computer services to which staff go when it is appropriate. One interviewee mentioned that it is not just the training, it is also the experience the staff gain with new techniques to keep up-to-date with their learning, literature, discussion and communication across the university and between universities.
6.13 User issues: Academic perspective

6.13.1 Staff training

Saudi Arabia

No special arrangement for the training of staff was found in any of the departments in SA universities. In the Department of Computer and Information Science, staff are expected to be already trained because they are computer science professionals. In all other departments, the staff train themselves. In all cases, some training is available in the university computer centre where most users (staff, students, and administrators) receive some formal training courses, such as an introduction to the use of the mainframe operating system, DOS, WP and programming languages. The availability of courses depends on the availability of the staff to teach the training subject and the number of users who want to attend the course.

One of the interviewees complained that the training courses were not always at the right time nor for the right people. Some staff are computer-literate and some are not. The training programmes should fit all users' needs. Most of the existing training courses related to the operating system and programming languages. Training courses in the network communication area such as e-mail, on-line searching and related subjects are needed, said one of the interviewee. The need for academic staff training was an issue...
identified by more than 90% of the academic computing representatives interviewed. But the question of who will plan, organise and implement the training program considered debatable. Some would like the computer centre to give the training, whilst others would prefer the academic computing department. It was suggested that the existence of networking facilities on the whole campus increases the need for training programmes.

At the student level, no formal training was given to students, except at the KFU, where the first-year students (in the preparation year) must take some training course. These courses are mandatory for every student entering the university. All other departments indicated they did not have any formal training.

**United Kingdom**

Training programmes in UK universities varied between departments, according to the differing needs of their staff. Whenever a new package is produced on the machine a tutorial is given by the computer laboratory representative and it is optional for the staff to attend. However, limitations on the training time means that the training programme is not always adequate or efficient. Some departments commented that most staff are self-taught and self-trained, but informal individual help is still given by colleagues or friends within the department.
6.13.2 Information services

Saudi Arabia

One faculty member remarked on the absence of a policy regarding information services in his university. None of the centres had a formal policy regarding the use of IT facilities (computers, printer, manuals, etc.), nor did they have a user support policy, hardware/software policy, information and advisory policy, network policy, etc. Some face-to-face services were available, such as a help desk responsible for computing services for students, faculty and researchers. But sometimes these people manning the desk could not be found and they were not always able to help solve problems. Another faculty member was concerned about the network services, in particular about the inability of MIS staff in the centre to communicate with academic users of the network. This may be due to the lack of computer centre staff with a knowledge of the network facility, or it may be that the services are not enough to meet the user's needs, or that the newness of the network has caused problems. He added that they may be other problems, but anyway there is a lack of communication between the two sides, the computer centre staff and the academic user.

Communication in terms of assistance and advice between the computer centre and the departments in the SA universities varied from one department to another. At KFU, the most effective communication occurred between the computer centre and the
department of computer and information sciences, with a joint
programme for short courses, a training programme, consultations,
seminar invitations, the evaluation of software and other related
activities. At KSU and KAU, the departments of computer and
information science were also involved in some communication
with the computer centre. The other departments all indicated
that they had been in touch with the computer centre to varying
extents for help, advice and assistance when they had problems. It
appeared that they received support and help regarding their
mainframe terminals, but nothing regarding PCs. If any problems
appear with the mainframe terminals, the computer department
technicians come and fix them. If any problems occur with the
PCs, the vendors come and fix them. Because there are few
mainframe terminals in most departments and because, the
maintenance contract for the PCs is negotiated between the
computer centre and the supplier, most of the time the
departments are heavily dependent on the vendors who installed
their computer laboratory.

**United Kingdom**

All interviewees indicated that advice and assistance was always
available from the computer centre. Some departments indicated
that staff in the computer centre are very overworked, both
running their systems and advising departments. So they are
limited in the time they have for giving information. Though
departments could get all information they needed from the
computer centre, it was not always convenient therefore to do so. Other external sources are available, such as suppliers of software packages, mostly commercial. Opinions vary: one department complained that commercial suppliers tend not to be very helpful, whereas another department indicated that they were very helpful. Overall, it appears that one has to be careful about information from commercial sources.

6.13.3 Use of computers

Saudi Arabia

The use of computers and network systems in the academic departments in SA universities also varied from one department to another. One interviewee noted that, because of the mixture people in the departments, the use of computers and network facilities depends very much on people's interest. Some people use them a great deal, whereas others hardly touch them. Some staff are directly associated with computers because they teach the subject, but others are not.

In a few departments (especially the computer and information science department at KFU) use of the computer is extensive. The head said that the KFU department was encouraging the whole staff to get into e-mail. They intended to direct all messages within the department through the e-mail so that they did not need to send memos. This was going to be done very shortly, within
months of the interview. This indicates that the use of the computer is now an integral part of staff work in this department.

At KAU the situation is different. The computer has been little used among the staff due to the absence of facilities such as a network, computers and terminals, lack of staff offices with a computer system and, especially, lack of training programmes. These factors have limited the use of the computer: in most cases, it has been used for teaching purposes only. There were complaints that because of these limitations, students are only required to do only small amounts of work on computers. Therefore, students may have only very basic skills in computing and not really be computer-literate. Even in the Department of Library and Information Sciences the use of the computer among the staff was rare.

At KSU, the weekly rate of computer use was 20% of staff, while at KAU it was less than 10%. Interviewees said that some staff are not interested in using a computer at all and that others need more awareness, knowledge and training on computers to increase their skills.

United Kingdom

In UK universities, there was a feeling that most of the postgraduates and research assistants are computer-literate, although mostly self-taught. On the staff side, some are really keen
and others are not. The situation is the same with technicians. Thus use of computers by staff, researchers and students can vary considerably. Overall use, however, is higher than in SA.

6.13.4 User awareness of IT facilities

Saudi Arabia

Just as the use of computers within departments in the UK and the SA universities was seen to be uneven, so user awareness of the applications of computers was felt to be dependent on their particular field of interest. If they had to teach a particular course, or to supervise students, then they needed to know at least as much as the students. In general, staff can have a good knowledge of computing in specific areas where the computer is used frequently; outside that area they may be aware of certain IT applications, but their overall knowledge was generally poor.

United Kingdom

One interviewee noted that there is a difference between knowing what you want and exploring new avenues and new ways of doing things. Sometimes users want just enough to do what they immediately need and sometimes they want to explore the system. There is a growing feeling that it is not good enough for users simply to understand that computers can be used for WP or e-mail; they need to know what is available in their subject area,
how it can be of use to them, and exactly how they can go about accessing it. Formal or informal seminars within the departments may help to fulfil this role.

6.14 Discussion of these perspectives

The provision of training programmes was seen as an important issue by almost all of the interviewees in SA universities. A common complaint was that computer centre training was rarely provided on user needs. Most of the training programmes hosted by the computer centre in the past, said one interviewee, concerned programming languages, such as BASIC and FORTRAN. None of the training programmes were about on-line searching or the use of e-mail. From the computer centre point of view, lack of skilled personnel, financial constraints and shortage of technical assistance appeared to be the problem for training. In addition to this, the absence of communication between the computer centre and the academic departments regarding computing was an important factor in ensuring poor training programmes.

Traditionally, the computer centre or information system centre is responsible for supporting training and education, information services (e.g. consultation) and information dissemination (e.g. newsletter, documentation) on the campus. However, since the computing centre resources are shared on the campus with departments, cooperation in training is essential. The training models mentioned in Chapter 3 can be used to develop effective
training programmes for the entire campus. Thus the university computer centre must rethink and solve these problems to develop an effective training programme for its staff and for university users so as to make effective use of IT in the campus. Major delays in resolving problems can occur if close communication is not maintained [13].

Training programmes are not easy to organise nowadays. The computer network embraces the whole campus, the microcomputer is invading all the departments, and the user needs to be aware of the skill required for the effective use of computers in his/her research, teaching and administration. Anstey [14] has pointed out that, for a computer centre to offer good training, it is important to consider the rapid development of IT in all parts of an institution. It is not simply a matter of offering training courses in FORTRAN or SPSS as a way of helping users learn those topics. The extent of the computer network and communication facilities on the whole campus must be taken into account in the delivery of training.

To increase user awareness of IT, it is important to have a good information service department. Sutton [15] has emphasised that the computing service has a significant contribution to make to the achievement of the aims of a university's academic plan. It can act as a focal point to ensure the development of a relevant university strategy for IT services on the campus. The approach to the design of information services must relate to the system of
telecommunications between departments and within departments. Berry [16] has noted that one of the greatest needs is to assist in increasing co-ordination between departments. He describes the situation as this: "Often one department is attempting to perform a computing task that has already been accomplished by another. Several user groups are sponsored to provide an avenue so that people across the campus can share their ideas and experiences. It also publishes the monthly Academic Computing Newsletter, which is instrumental in informing the user community of new computing developments on campus."

Despite the present problems of funding departments, universities must ensure that the care is taken with much matters as maintenance and warranties, and that departmental budgeting for IT takes account of support and replacement issues.

6.15 Resource issues: University perspective

6.15.1 Resource to support computer centre IT

**Saudi Arabia**

The directors were asked whether the existing IT resources (hardware, software, network, etc.,) match the present needs of the university users (staff, faculty, administrators and students). The immediate answer was no. One director referred to the rate of
change of the IT environment, making it difficult to maintain everything at the same time. Another director also commented on this situation: "The machines should be changed within four to five years and our machines at present are more than six years old. Consequently, we are looking for better equipment to facilitate the user's activities."

The major problem of supporting IT resources from the computer centre was the lack of money, according to all the directors. In the previous section it was noted that there is no direct or separate funding to the computer centre. Basically, the fund is allocated to the whole university campus by the university budget system. The directors expressed their concern about this allocation process. One of the directors said that most of the money in the past had been directed to the central administration because of the university's needs. This allocation process has affected the adequacy of support for the academic computing services. Another director commented on the present money allocation thus: "We have done a lot of networking to the administrative departments during the good times (a time when money was spread out around the kingdom). There was a lot of money at that time and we were affected by that fact. Now when the computer centre wants to expand its services to the whole academic area because of the invasion of microcomputers and network facilities, we are shrunk to a minimum funding system." During the interview, it was suggested that the shortages will hinder the future effort of the
computer centre to keep pace with the technological innovation affecting the whole university information system.

United Kingdom

In some ways, the answers from the computer centre directors were similar to those in SA. One director remarked that the user's needs could never be matched entirely, since there are new systems, new software, new hardware and new technologies coming on-stream all the time and pressurising the centre to try and keep up. Another director mentioned the lack of appropriate hardware and other equipment. Yet another director indicated the lack of people to cover the needs of academic colleagues. He said: "There is a major development of network facilities around the whole campus and there is a need for more people to cover all these administrative and academic areas. I don't regard this as a problem: I regard it as more as a fact of life." All of the directors agreed that money was the major problem in supporting IT resources for the computer centre, as well as for the whole university campus.
6.16 Resource issues: Academic perspective

6.16.1 Resource to support academic IT

Saudi Arabia

Just as the computer centre staff in the SA situation expressed their concern about the lack of funding and its allocation in the university, so too did the academic computing departments. Lack of financial support appeared to be the major problem in supporting IT. All departments are totally dependent on financial support from the university budget system. One interviewee compared the situation with that in the UK and the USA, for instance, where many universities departments are supported by the private sector from which they can derive funds. (He cited a research project as an example). The other problem associated with money was the lack of skilled technicians in the computing departments which leads to operational and maintenance problems. These were regarded as of major importance in most departments. One interviewee noted the lack of Arabic programs. He added that translation of software into Arabic is very limited, and is affected by the absence of any copyright law to protect them from the chance of software piracy.
United Kingdom

Lack of money, as we have seen, was also a major complaint here. But, in comparison with the SA situation, the UK position appeared to be a lot better, in that academic departments already have quite a good IT infrastructure. Several gather money not only from their departmental income, but also from research projects, awards, and so on. The other major problem was a lack of adequate space in which to keep and use equipment. In general, lack of physical and personnel resources were not regarded as a major problem. But replacement of old machines with new and better ones, and lack of well-trained support personnel were regarded as problems in several departments.

The main factor retarding computerisation in the UK academic departments was felt to be the lack of money. Another factor was space. There was a lack of sufficient empty rooms to use as terminal rooms for postgraduate and research use. Some discussion took place during the interviews about lack of staff with computer knowledge, but the answers varied between departments. Some departments believed that very few staff do not want to use computers. Other departments stated that some members of staff do not look on computing as a high priority. In some other departments, there was a feeling that some members of staff, who do not want to change old habits, will carry on lecturing the way they have done for many years. So departmental computing
representatives were not sure if lack of knowledge or age was the more important factor in retarding staff use of computers.

6.17 Discussion of these perspectives

The resource issues appear to be much the same for SA and the UK. Both sides perceived there was a lack of adequate funds to support academic computing, and that the situation was being made worse by the need to support networks. One difference is that, in SA, lack of human and physical resources is a more urgent problem than in the UK. On the UK side, lack of adequate space for using equipment was cited as a problem. In general, lack of personnel was not regarded as a great problem in the UK.

An information system is also a social system. IT is one of its components and people are the other. Kiesler and Sproull [17] identified three factors that are required when introducing technology. These are resources (changing the technology and creating its necessary infrastructure, allocation of money, service, people, space, etc.), behaviour (learning to use new technology) and attitudes (which means coming to believe that new technology is important for one's work and life). The computer centre and the university as a whole must begin to contemplate how staff can use technology as a part of the changing social structure of their institution brought about through the adoption of IT. The acceptance of IT related changes in organisations will have to include a value-added component if absorption is to be
successful [18]. The computer centre may well need to rethink its organisational approach to change if it wants to have an effective computerised information system that can serve the whole campus effectively and efficiently. More work is required to improve current levels of computer literacy among academic and computer centre staff. At the present time, those not fully acquainted with networking skills often become frustrated with the medium due to their lack of expertise. So failure to set aside adequate resources for computer and network assistance will lead to wasted time and effort.
REFERENCES

(Details of publishers are included in the bibliography at the end)


12. Rogers, E. and R. Agarwala-Rogers. *Communication in organizations*, 1976, p. 120.


15. Sutton, ref. 6, p. 50.
16. Berry, ref. 13, p. 55.


Chapter 7

Devising and implementing a plan for academic networking in Saudi Arabia

7.1 Introduction

Since academic users' demands are increasing for fast and efficient communication, and since IT networks offer a variety of frameworks for satisfying academic needs, user demand and IT network supply must be appropriately matched in the academic setting to provide better information services. At the same time, the network connections and communication activities on campus as well as between campuses must be expected to be constantly changing.

This chapter describes a way of planning the design of an academic campus network based on recent ATM network development technology. Experience and network developments in the USA and UK are considered, and lead to a proposed design system in SA. The design aspects are based on a five year development plan to fit with normal policy planning in SA.
7.2 On-campus networking development

7.2.1 Merging of library, academic and administrative computing

In recent years, discussions regarding the merging of library, academic and administrative computing have been debated in many universities in developed countries, such as UK universities. This debate has gathered momentum in recent years and the general term "convergence" has been employed to characterise what is going on [1]. What is being suggested, is that the potential of networking allows campuses to combine the advantages of centralised and distributed computing to an even greater extent. With the advent of microcomputing and the associated increase of interest in computing, there has been a movement to reunite all computing under one organisational structure. Several universities in the UK, e.g. Salford University, have merged their libraries and computing services [2]. Some others have merged academic and administrative computing functions, for example Queen's University Belfast [3]. More recently, a general merging to use IT across all activities has been developed at Aston University [4].

McDonough [5] reported that the strongest argument advanced for merging academic and administrative computing is that it can lead to significant savings; it will also lead to a better administrative service and a change in the management system from batch to on-line operation. Harris [6] considered two factors
important in merging library and computing services, where the nature of the latter is changing to become more widely distributed. He emphasised firstly that the "service will be increasingly less concerned with providing a computing service and increasingly more concerned with providing advice and guidance on hardware, software purchasing, training, maintenance and other related matters". The second factor is that "computing is increasingly less synonymous with computation. Increasingly people use computers for handling text, handling communications, word processing, database management, etc., bring computing centres much closer to the recent traditional concerns of libraries - information handling in general".

In recognition of these changes, there have emerged several different network concepts for the university campus, known variously as "micro-on campus", "wired-campus", "network-campus" and "information campus" [7]. With this new trend, universities will increasingly acquire products of modern electronic technologies and will employ a variety of electronic information services to satisfy the needs of their users (staff, students, faculty and administrators). These new trends can be referred to overall as the "electronic campus".

7.2.2 Development of the "electronic campus"

The development of the "electronic campus" started in UK universities in the early 1980s. Questions have arisen as a result
concerning what implications and opportunities the electronic campus might have for universities in the UK over the next decade. Is the electronic campus an achievable goal? Is it even desirable? If so, how might it be financed and what obstacles might be encountered? These and other questions have been raised by universities wishing to create an "electronic campus", such as Aston University, Cambridge University and the Open University. Gardner [8] has identified three quite distinct phases in the evolution of the concept of the electronic campus in the UK higher educational environment. During the first part of 1980s, the term was used by many institutions to demonstrate the pervasive provision of microcomputers and the necessary available equipment, without emphasising campus networking, administration impact, curriculum development or academic restructuring. He refers to this phase as "electronic campus = micros on campus". The middle part of the 1980s saw the second phase. The electronic campus during this could be described as "electronic campus = the wired campus", with the emphasis placed on intensive campus networking. By the late 1980s the phrase had come to signify a particular style of campus information management. This last phase has been defined as the "electronic campus = information campus", where opportunities are offered for an integrated campus computing and communication infrastructure. A new strand has correspondingly emerged to enhance teaching and research and offer opportunities for other academic service organisations, such as libraries, to serve
the whole campus electronically. Accordingly, the "convergence" of computer centre and libraries has appeared in reality [9].

Brindley [10] explained the meaning of the electronic campus as a three-fold concept: the interaction of technology, education and organisation. In terms of technology, the key was "a high bandwidth network with gateways onto the world and connectivity for all". As an educational concept, it embraced "a transformation of teaching and learning, giving the ability to access and chart new routes through a wealth of knowledge". In the organisational aspect, it supports "institutional IT strategy to manage a distributed information system (not simply designed for computer procurement but as a genuine platform for action and resource allocation)". It is thus an all-embracing description of services that include electronic information network services to cover the whole of a university campus, where the aims and objectives of library and computing services merge to serve a common objective. Both LAN's and WAN's may, and often are used in order to help achieve such an objective.

Electronic information

What information can be delivered or obtained electronically, or more accurately what categories, what types of information are available in this form? Bawden [11] has summarised three kinds of information available: factual information, reference information and informal information. The factual information is
represented in a direct question-answer form, the particular piece of information that one requires. Examples are statistical data, scientific and technical information, financial data and news information. Reference information does not directly give answers but points to where people may find the answer. Examples of this kind of information are bibliographic databases listing publications, books, lists of experts or organisational consultants and information on research projects under way. Finally, informal information is concerned with individuals and organisations contacting each other directly through the use of computers and networks and exchanging information. Examples of this form are bulletin boards, e-mail and so on. This last is a very important type of information service in promoting two-way information flow and communication.

Electronic information can be obtained in two ways. The first is from an on-line service where the individual user obtains the information by contact through a telecommunications network, a so-called host system (that is to say, a computer centre at which a large number of information sources are maintained). The second is from services where information is provided directly for use on one's own computer system locally (in the form of magnetic media, such as computer diskettes, or optical media, such as CD-ROMs) [12]. The incorporation of information network technology into the operation of the academic community can significantly enhanced academic functions. For example, in the teaching area, instructional computing such as Computer Aided Instruction...
(CAI), and accessing institutional bibliographic data bases, electronic mail instruction, word processing, spreadsheets, etc., over a local area network (LAN) are improving the academic function. A faculty member can, in principle, work with the LAN administrator to deliver lectures, homework, messages and information to students in an efficient, time-saving manner. Researchers can use data retrieval (e.g., library catalogues), e-mail, etc., to send and receive text and messages from one computer to another over the network. Accordingly, computer networks are becoming a primary communication channel for the academic community.

It is important to remember that it is the information content and not the technology which is important. It is clear that technological change alone will not make an electronic campus [13]. It should be borne in mind that technology brings us alternative ways of delivering information. There are usually different choices for getting what we want and therefore we must think about what is best for our particular needs. The choice needs to be made by considering first the information content, the quality of the information, and not the technology itself [14]. Gardner specifically emphasised that universities should focus on information requirements and services, not on the technology itself [15]. He related this emphasis to the demands new administrative and organisational structures.
7.3 Situation of the UK Universities

For all the three universities visited in the UK (see Chapter 6), it was found that they had a similar IT organisational structure. A typical example is shown in Figure 7.1.

![Organisational IT structure](image)

**Figure 7.1. Organisational IT structure**

All these universities are experiencing some impact on their teaching, research and on their administration and internal and external communication, from converging information technologies. The present position within the UK is that about 20% of universities have a merged provision, and this percentage is growing. The first point in favour of a merger is that savings can be achieved in such areas as operations and systems support, networking and communications support, but the most important reason for supporting a merger has been strategic. Administrative computing is no longer an island which can be regarded as justifying separate management. Administrative and academic computing use the same network; the same workstations are used
to access both systems. Hence, there needs to be a unified strategy for both.

7.3.1 Aston University

Aston University can be taken as a prototype example. It pioneered moves towards the "electronic campus". In the 1980s the university started to focus its strategy on the position of library and information services to use information technology across all its activities. In 1981 there was a major drop in its recurrent grant from the University Funding Committee (UFC) [16]. This resulted in a radical restructuring of both library and academic departments. For example, in 1982, the library automated all of its library processes and in 1984 the Centre for Extension Education based on the use of video instruction was established. In 1985, PCs were provided for over 85% of all staff. In early 1989, project Accent [17] was set up to install a broadband, Open System Interconnection (OSI) local area network, to connect every room on campus, providing both data and video to over 2500 service points. Thus the university's overall strategy was to build up a powerful IT infrastructure - including library and information services - to support the entire range of its teaching, research and administrative programmes.

A fundamental review of the operation of the University Library and Information Services was undertaken. This was due to the fast pace of technological change and the widespread use of
information and IT in all academic disciplines. Accordingly, the appointment of a new Director of Library and Information Services (DLIS) was made to develop strategy for IT services into the 1990s [18]. This brought with it an organisational change in which a new Information Service Division of six staff was created which worked closely with staff from computing services until the two units began to converge. On a wider front, the DLIS became the first University Pro-Vice-Chancellor for Information Technology, in addition to her LIS responsibilities, forming an IT organisation committee structure. This post had University-wide responsibility for the development of IT strategy for academic and administrative matters [19].

7.3.2 External experience

The Inter-University Committee on Computing (IUCC) started a long time ago to service universities in the UK. Today, a result of the impact of IT across all disciplines, the IUCC's objective has become particularly to concentrate on the administrative computing environment. IUCC's standing committee has been extended via many sub-committees, such as the Inter-University Software Committee (IUSC), Inter-University Network Committee (IUNC), Inter-University Hardware Committee (IUHC), Inter-University Training Committee (IUTC), Inter-University Purchase Committee (IUPC) and Inter-University Information Committee (IUIC). The purpose behind the development of these sub-committees is to tackle all university computing and IT problems.
Thus the existence of the IUCC organisational committee structure in the UK universities has alleviated several problems. For example, the development of training programmes and purchasing policies by IUTC and IUPC, respectively, has alleviated financial problems in terms of purchasing software as well as training. Such sharing between universities can help reduce financial problems.

In a similar way, the Computer in Teaching Initiative (CTI) and the existence of the Management and Administrative Computing Initiative (MAC) are examples of seeking joint solutions to the problems of British universities [20]. Kelly and Hole [21] here commented that: "university computing centres are fortunate in having those organisations such as IUCC, CTI and MAC which have facilitated a high level of successful IT collaboration and co-operation between sites over many years".

7.4 Situation of SA universities (1991)

Just as in the UK, many universities in the SA started using microcomputer technology in the early 1980s. Campus-wide network systems were also provided in the universities in the mid-1980s but implementation has since slowed down. At KAU, this was due to delays in the university construction plan. This is still affecting the performance of campus networking there. At present the KAU library needs more connections to the academic departments. Academic computing laboratories need more connections between themselves and with the mainframe.
Furthermore, academic staff need their offices to be linked and networked inside and outside the campus. Accordingly, the network situation at KAU resembles the first stage of Gardner's "electronic campus" phases, with the "electronic campus = micros on campus".

The situation at the other two universities (KSU and KFU) seems to be significantly better than that at KAU. KSU has recently developed integrated computer communications networks to manage the university computing information system and to enable university users (staff, faculty and students) to communicate with each other using a campus-wide microcomputer network topology. KFU is in the process of developing an intensive e-mail system, to connect all administrative, library and academic staff offices. In the future, e-mail system users are expected to be able to convey information with integrated text, sound and graphics, according to the Director of the Computer Centre. At present the campus-wide network systems at these two universities, according to Gardner's "electronic campus" phases, could be said to be between the second phase "electronic campus = wired campus" and the third phase "electronic campus = information campus". Cabling exists in all campus buildings and offices, but an electronic information network is not yet available around the whole campus.

From the results of the interviews in the previous chapter, it was found that none of the university organisations have an IT
committee structure. Computing staff often report to different people in the organisation; they often do not talk to each other, and may lack comprehension of what others are trying to do. For example, there are librarians who do not understand the new technology and there are computing staff - computer centre staff or academic laboratory staff - who think only in terms of hardware. This is causing a communication problem. Thus SA universities need an IT structure policy to enhance the use of the technology on the whole campus successfully.

7.5 Factors affecting on-campus network

A strategy for IT infrastructure on the university campus should deal with three basic factors - the physical, organisational and user approaches. The massive rise in the use of networking demands a reassessment of the role of networks and the way they are designed [22]. From the physical perspective, the campus network system has to centre on the IT end product. It must provide acceptable performance in accessing software, datafiles and peripherals (e.g., printers) and attempts to analyse various modes of IT distribution resources. From the organisational perspective, the university needs to implement a solution that encourages and enhances the use of computing whilst investing economically in existing hardware, software and so on. It must attempt to relate IT resources to organisational traits. The main purpose of the physical approach is to depict various network alternatives and to discuss how each alternative should be evaluated and monitored.
It provides a systematic tool for network analysis and design. This approach emphasises the relationship between organisational structure and IT policy. These two factors are not contradictory, but rather complementary. From the user perspective, user aspects should be considered in the context of the organisational framework within which such activities as training, education, etc., take place. Users have to be able to function productively in accessing and using the network system.

It follows that the relationships between these three factors are equally important in developing a campus-wide network strategy. However, for the purpose of the present study, the fundamental questions concern the organisational factor. The user (human) and physical (technical) factors are considered as sub-organisational factors. Thus the key factor for developing an electronic campus is the organisational structure of the IT system, supported by skilled IT staff [23]. The IT organisational structure aims to improve the effectiveness of the whole university computing organisation. According to Weedman [24], the need is to establish a group communication system inside and outside the organisation.

7.5.1 Physical factors

Inter-institutional connections

The discussion in the last two chapters of the SA situation indicates that there is a need for more connectivities within the
academic community. More PC laboratory workstations are needed for teaching purposes. Most of the academic staff offices lack PC workstations for on-line search, e-mail and other related communication activities. Thus a network plan should make these connections as quickly as possible. Not only this, but network developers and implementers must remember that the network will expand automatically as additional PC workstations are provided for the academic community. Most academic staff offices and teaching labs will be provided with PC systems, as is already the case at the KSU, and more PC laboratories will be created, as at KFU (see Chapter 6). Thus for full academic integration, a powerful (multimegabit per second) network system is required to enable academic staff to have freedom to move information effectively within departments and between departments. Therefore, the network planners and implementers should consider techniques for supporting network communications among servers and workstations.

Servers

Servers are usually microcomputers to which special equipment and/or software has been added so they can perform a special function for the benefit of the network. There are many types of servers such as client/server, file server, etc. While most of the computing environments of the 1990s in the SA academic community will be situated on workstations and most of the information will be stored in the network, the file server should be
considered in the design of LAN because it has the ability to store large files for network users and share files among them.

The two dominant types of LAN which are in common use for interconnecting localised computer-based equipment are known as the ring and the bus. Currently, there are many varieties of both types. They require some type of central device to manage network communication. This typically supports a star ring topology (a variation on the ring topology). In this configuration, a number of star hubs are made into nodes on the ring. Each star hub, in return, connects to a star sub-network. The advantages of this topology include shorter cable length compared to that of a bus. This, in turn, increases network reliability. Since each network node connects directly to the central hub independently of the other nodes on the network, a single broken cable will affect only one system, and will be easy to isolate.

Cabling

The installation of network cabling within and between buildings on the campus is the first factor that needs to be planned when designing a LAN network. Network cabling comes in many different forms, including coaxial, shielded twisted-pair, unshielded twisted-pair, or fibre optics. Coaxial cabling is typically used at a transmission rate greater than 60 K bit per second and fibre optics is best suited to those applications which demand either high levels of immunity to electromagnetic interference or very high
data rates. Also it is not easy to make a number of physical taps to a single fibre optics cable. It is best suited, therefore, for point-to-point communications as used with a ring network. More importantly, it is very expensive. Twisted-pair cabling, on the other hand, has advantages over coaxial cable and fibre optics as explained later.

Within the SA academic community, the following points need to be considered in the design of LAN cabling. Distances can be large; so it is necessary to determine, for example, how far terminals can be from the main cable. Network cabling configurations within the facilities of existing buildings must be considered. Elbert [25] reminds us that "any installation should be well documented to facilitate later repair and ensure that existing cable is not damaged by other activities".

Today, the common installation techniques are of four different types [26]. These are underfloor cabling, over ceiling cabling, surface mounted raceway cabling or existing wall ducts. The first technique uses duct installation before the building is erected. This kind of installation does provide a certain amount of physical security. The second one is used when a removable ceiling or wall exists, to make the system easier to expand. The third has cable running around the perimeter of a room. Finally, existing wall ducts are used when they are physically large enough to allow the cable to be installed comfortably. This last technique is, however, less used, because the cable is susceptible to damage. Different
techniques are needed because SA universities have used a variety of building techniques.

Thus network planners and implementers should select the appropriate technique for each building in the design of LAN cabling. Poorly installed cables can lead to many difficulties during the operation of a network [27]. In general, however, it can be deduced that the best cabling technique for SA academic campus networking is highly to be underfloor cabling using twisted-pair wiring. The reason for using underfloor cabling is the dust and high temperature (heat) environment that is common in SA. Thus the underfloor technique can protect cabling from damage. The reason for using twisted-pair unshielded is its advantages over other network cabling. Twisted-pair uses same type of wiring as telephone system wiring. It can be best used for transmission of information over a relatively short distance as in the case of the academic departmental building. Since a telephone system exists in most academic buildings the use of unshielded twisted-pair cabling can be installed without significant expense.

Multi-media capability

A large university, such as KSU and KAU, must think of future information network plans for its campus. Very shortly a network system that is capable of transmitting stationery and moving pictures and voices will be required in the academic environment. For example, at KSU, which consists of a large campus with
branches inside and outside the city, a large proportion of university administration work is being done outside its main campus. For example, student registration, employee payroll and many other administration data are being exchanged between the main campus and branches electronically (see Chapter 6). In the near future, there will be teachers and researchers who need to be connected. In this case, upgrading performance to provide a site interconnection network at speeds in excess of 100 Mb/s will be required to establish a high speed network environment.

The general point is that, although LANs provide a high speed network environment, their capacity to transmit bits of information depends on the microcomputing environment and its ability to transfer high speed information. As a result, network planners must develop a network system that is capable of effectively presenting, storing, retrieving and transporting information of all kinds within LANs.

Geographical coverage

Universities which are going to upgrade their LAN technologies for remote distance teaching/learning must consider the best method for transmission just as transmission techniques locally are different, so there exist different transmission techniques for remote distances, such as ISDN, ATM and MSDS.
Over longer distances, the telephone network communication service is to be avoided due to the problems of telephone line availability, dust and high temperature occurring in the city suburbs where some branches of the KSU are located. A radio network communication service would not necessarily work well over the distances and conditions involved. Thus the most practical technique for remote distance networks in SA is likely to be a satellite network. This could employ a very small aperture terminal (VSAT) network which makes connections between two points directly through a satellite [28].

The advantages of a VSAT is that it is inexpensive. An earth station provides interactive data-communication services compatible with many existing IT network applications, and its transmission system is capable of replacing a complex WAN of leased telephone lines [29]. VSAT can be used as a collection point for data traffic. These data then can be transferred through the VSAT to the host computer unit at each branch site. The hub has a direct connection to a fibre backbone to allow several hosts to connect to it for later access to remote VSATs. This remote distance access technique of VSAT can link all SA campus facilities and provide effective network communication between all users. Since SA is a member of ARABSAT, INTELSAT and INMARSAT [30], it is feasible to plan for a network satellite to provide broadband networks to all academic users and other organisations not only in SA but also in the AGC (Arab Gulf Countries).
Information network access, storage and transport

University network developers know that the fundamental rule of the university life is that information should be broadly accessible everywhere within the campus. As seen earlier, provision of workstations for staff in SA universities should soon become universal. Furthermore, more PC labs will be provided to increase users’ (students’) abilities to access their information more easily and effectively. Correspondingly, a network design should have in it a time-sharing system to broaden network capability and accessibility. For example, multi-user network software applications should be considered, otherwise users cannot communicate with each other simultaneously. If properly designed, users can access, store and transport information from any place where they are using the system. In other words, a network should provide a computer-supported cooperative work group.

Computer-Supported Cooperative Work (CSCW)

This is a growing interest in the UK and USA and aims to support the activities of the institution, for example, to allow students to communicate with their teachers and teachers with students, etc. It is intended to be a way of making computers support the organisation as an institution. Wilson [31] has noted that CSCW has two main components: the support of human groups and the technology which can be used for that purpose. The aim is to
provide interested support to groups of people to communicate face-to-face within institution or electronically between institutions. Categories of technology that can be used to support group work include: communication mechanisms enabling people at different locations to see, hear and send messages to each other through e-mail, shared work space facilities enabling people to view and work on the same electronic space at the same time through remote screen sharing, shared information facilities enabling people to view and work on a shared set of information - for example, multi-user databases, and group activity support facilities to augment specific group work processes - for example, the co-authoring of documents, and idea generation. Thus if the university wants to increase co-operation and collaboration between teachers and researchers, communication among students, informal exchanges between faculty and students, etc., inside and outside the institution, the network designer and implementers should consider establishing a CSCW group organisation.

An example of a component in this design is the Electronic Meeting Support (EMS) system. It is an IT-based environment designed to support group meetings. In designing this, Valacich and others [32] made the following recommendations: "each group member should have their own workstation. Separate workstations allow all meeting participants equal opportunity to make contributions, regardless of their status of group size. These workstations must be networked and fast. Workstations should also be equipped with their own mass storage device (i.e. a hard disk) to allow the EMS
system software to be replicated on each workstation (not the server). The benefit of this approach is to lessen the network traffic, so that only shared data is passes and not applications. This will increase the speed at which geographically dispersed members can participate in electronic meetings. A final recommendation for the developer is to design tools so that they may easily evolve and grow”.

Network services

Many software applications are still not friendly to academic users. In some academic departments, although a LAN is being used, most applications are found to be single-user instead of multi-user. It is clear that a network plan should consider improving network software applications and their ability to deal with computer compatibility. They have to be analysed, tested and evaluated before purchasing them from the commercial vendors.

From the results of interview analysis, more than 80% of PCs in the academic departments in SA are IBM and IBM-compatible systems, whereas less than 20% percent are Macintoshes. It is likely that the delay in introducing Macintoshes into the academic community were due to their late advertisement in the SA market. The Macintosh provides a cost-effective approach with a WYSIWYG (what you see is what you get) system environment. To install the same environment in a PC involves additional investment. Macs
can handle code-based processing at a greater speed than IBM PCs and compatibles. By fitting a MS-DOS card to the Mac SE or II, it can run all the PC applications, so giving the best of both environments. The Mac is good for text processing because: i) it uses a relatively advanced microprocessor, which gives a very good visual interface, and ii) the Apple Laser Writer, together with use of the PostScript page description language, provides a very flexible text-handling system. The Macintosh system is a very easy-of-use system. Its screen looks like a desk system. It has menu bar commands for applications and files, a trash can for throwing away rubbish files and desk spaces which contain all software applications and files programs. Thus all applications and files use the same bar menu commands to finish the work. In the IBM PC and compatible systems each has its own program commands. The Macintosh is an excellent system for desk publishing purposes and for teaching. IBM systems often need more computer-literate people to handle information between files effectively. Moreover, all Macintoshes contain a hardware interface network called LocalTalk, similar to ethernet, which is available for MS-DOS machines with the original PC bus or the PS/2 bus [33]. This makes connection between different types of computing systems workable within LANs without changing or replacing all existing PCs to bring Macintoshes into the environment. Furthermore, Macintosh networking does not require a server nor the loading of any special software to implement LAN because they are built-in systems. These capabilities make them especially appealing. Within this framework, network devices can be connected, installed, removed
or updated with little or no affect on the operation of other network devices [34].

All these advantages suggest that Macintosh systems may be more useful for the average academic member of staff or student than an IBM, and therefore Macintosh systems should be used in academic departments. The network developers should take this into account, since recently Macintoshes have started to become familiar within the academic campus in SA universities. In addition, the local Macintosh vendor in SA is developing many bilingual (Arabic/English) software capabilities which are not available on the IBM systems. Thus the academic network should consider transferring to be based on the Macintosh family of microcomputers.

Standards

Since different types of PC workstations are being and will be used on the campus, such as IBM, IBM compatible and Macintosh, flexible network architecture interface must be used between LANs, especially when a new LAN is introduced and developed. Furthermore, national and international interface standards need to be considered. A model such as OSI, created by the International Standards Organisation (ISO), can be considered to promote the interconnectivity of the network through the standardisation of network functions. Its functionality provides a reference for comparing one network with other and conceptualising how
network connections operate. A network plan must certainly consider the best way to link academic departments into KACST databases.

Compatibility, expandability and adaptability

Since the different vendors' products, such as IBM, IBM-compatible, Macintosh, etc., are being used and interrelated by individual users on a single campus, compatibility should be considered in the design of each campus network. Rotemberg and Saloner [36] have suggested that compatibility problems fall into three main categories: interconnectivity, human skills and complementary products. In the first case, standard interface protocols are needed to permit interlinking of systems so that they can operate in concert. For example, Digital Equipment Corporation's DECNET system provides the capability for networking computers from various LANs together. The second point concerns human skills and the efficient use of human resources. Rotemberg and Saloner commented: "as equipment is configured in ways that either do or do not allow it to work interchangeably with other equipment, the training of individuals may enable them to work a particular set of equipment but not another, if the equipment is incompatible in this way". The last category, complementary products, deals with the need for added peripherals to be compatible with existing equipment. They must be able to connect to a network.
The current belief regarding a computing system is that computers/workstations should be changed every 3 to 5 years. This change may correspond to changes in compatibility in the IT area, the network, interface and other related adaptable materials over time. Thus universities should be able to adapt the existing technology to the networked environment of the future.

Distributed system

Many universities in the UK have established integrated distributed systems as the basis of their computing resources. Many of them have shifted from one big machine to a cluster by building up a small mainframe cluster or minicomputer cluster. For example, one small mainframe is used for e-mail, another for the administrative database, the third for the library database and so on. Such a cluster is more economic: it costs less than one big computer. In terms of maintenance, the cluster is also better in that when the system is down some of the cluster can still work whilst in one big machine everything will be off. Cabling also can be more economic, especially when a minicomputer cluster serves a group of departments so that all academic departments in the same building can be connected, saving distance cabling costs.
7.5.2 Organisational factors

Universities

We have seen at the beginning of this chapter how universities in the UK have established and created new organisational IT structures within their campuses to meet growing university needs as well as user needs. In addition to this, most of the UK IT academic committees exist to develop computing initiatives in the academic environment, such as disseminating information and knowledge, providing a computer plan, developing courseware and so on. The main objective for developing this committee is to look at overall academic planning and developments. In SA, steps need to be taken in the same direction. One example is the need to merge academic, library and computer centre information services. The development of an academic IT committee structure is required to handle academic computing initiatives. An administrative IT committee structure is needed to support administrative computing initiatives and a library IT committee structure is needed to provide 'virtual library automation'. All these initiatives need to work together under a single IT director to provide overall campus strategies and planning.

Departments

On the academic computing departmental side, too, some sort of departmental IT structure must be brought into existence in SA to
discuss academic users' computing needs. Going back to the UK university situation, if a major problem appears, an academic computing representative in each academic computing department calls the computer centre for advice and assistance. If a minor problem appears he fixes it because he is technically qualified. If he needs some help from other academic departments, he sends e-mail and gets a reply. All these factors lead to an efficient system.

On the SA university campus, this kind of organisational structure still needs to be developed on the academic side. To create this kind of structure, the following points should be considered:

1. An academic person well-educated in computing technology should be appointed as the academic computing laboratory/departmental computing representative to operate and manage departmental computing needs.

2. An e-mail system must exist to provide electronic communication facilities where messages, reports, text, etc., can be exchanged easily.

3. Technical staff should be provided to organise rooms or to provide equipment for classes, etc.

4. Training must be organised to increase staff skill and knowledge.
7.5.3 User factors

Training

Computer centre staff, academic computing representatives and librarians in SA all need more advanced training programmes to keep up to date with the continuing developments in IT on the campus in the areas of networking and telecommunication activities. In addition, there is a need for campus users in teaching, research and administration to develop the required skills for the effective use of IT facilities. This can be done by using one of the model(s) mentioned earlier (see Chapter 3) to develop effective training systems.

One of the important initiatives in training programmes is likely to be a good network training programme to move computing staff from solitary skills to communication-based group skills. Computing centres should offer better training on particular topics, such as FORTRAN and SPSS, as traditional help to users in these topics is not enough to cover their needs. The new emphasis must be on training to cover wider topics in networking and telecommunication activities. With the use of IT for remote teaching, users must learn to use the system effectively. One initiative that might be pursued in SA is to develop a "Computing Training Centre" on each campus. Educational courses should be provided and carefully planned to enhance trainees knowledge in dealing with IT facilities. Higher Diploma qualifications can be
awarded at the end of the training programme. Other initiative is to develop training programme with a company. The aim of training between the university and the company must be to provide the opportunity for all students to acquire the skills necessary to use the computer appropriately and effectively in their academic work, so that when students graduate they have basic skills for their new work in the field. In the UK, for example, the government provides the money for research students in universities to work partly in the university and partly in a company. This kind of training programme would be suitable for use in the SA university, where more theory within the university and more practice within the company is, in any case, desirable.

Information services

To summarise the university campus in SA must offer a range of information technology services to increase the efficiency of computer use. First, the university must increase the quantity of PC workstations to reach every academic staff office. Secondly, the university must have a written information service policy, advisory policy, network policy, hardware/software policy and so on (see Appendix VII). These policies must be available to all university users (academic staff, students, etc.,) to increase the awareness of users with regard to the use of IT facilities (use of computers, network facility, printers and so on) around the campus.
The organisation of the computer centre and of academic computing must establish a good information service infrastructure, for example, by issuing regular reports from both sides showing changes and developments. The same kind of activity could be undertaken by the library. In this case, reports might cover training times, new facilities brought in, names of assistants in charge during working hours, e-mail facilities, news and so on. Finally, consultancy and advisory staff should be provided in the computing centre during the afternoon hours to help students and staff who need advice.

7.6 On-campus network design

7.6.1 Physical design

In the foregoing sections the background factors in designing an academic network have been discussed. We now turn to the actual design. In order to provide an electronic campus with properly integrated services, it will be necessary to carry telephony, video, graphics and other data services to all campus buildings through a high-speed network performance.

The analysis of questionnaires and interviews (see Chapter 5 & 6) indicates that the networks on SA campuses must be improved. First, more connections are needed on the campus within the same building, between different buildings and between buildings and the university mainframe computer. Secondly, the existing
network systems within the campus must be upgraded. Although KSU and FKU have developed their network processes, using FDDI fibre optics on their campuses, there is still a need to upgrade the networks. One reason is that FDDI is not available for speech or video. Another is its speed capability. The FDDI network is a high-speed (100 Mb/s) LAN primarily for use with fibre optic cable. In the SA university situation, where video, voice, graphics, etc., are required on the campus as well as between campuses, new technology must be developed to provide a more than 100 Mb/s high-speed network performance to meet user requests. Thus the network transmission rate in the campus needs to be high enough to meet all campus users needs. A prototype design for a campus is shown in Figure 7.2.
The figure takes four academic buildings as a typical example, and assumes an initial 140 Mb/s connection in each building. In the network development, however, several transmission speeds are needed for different applications. For instance, ethernet LANs need 10 Mb/s, video needs 2 Mb/s, X.25 needs 10 Mb/s, workstations need greater than 100 Mb/s and so on. Thus 140 Mb/s or greater
allows information flow of different kinds (video, data, etc,) to be processed smoothly between different kinds of network user. To be effective, the proper technology to be used in integrating this kind of network and service is ISDN. This should greatly improve the quality, reliability and processing speeds of the campus infrastructure without major problems for future considerations of communication with other countries.

The ISDN involved should be based on the Broadband (B-ISDN) ATM technology. ATM has been chosen by CCITT as the basis for B-ISDN services. It runs over and makes use of the new interfaces and speeds associated with the Synchronous Digital Hierarchy (SDH) of digital transmission technologies at speeds of 155 Mb/s (STM-1) and 622 Mb/s (STM-4). So one of the advantages of using ATM design technology in upgrading the existing networks is its ability to present voice, data, graphics, and video. Another advantage is the fast transfer of packets over a 155 Mb/s backbone between ISDN-compatible switches. However, this does not mean that a system with Broadband data rates can be regarded as a B-ISDN. The whole concept of ISDN is that the services are integrated. Therefore, a B-ISDN must be able to support narrowband (up to 64 Kb/s) and wideband (64 Kb/s to 100 Mb/s) as well as broadband. In this case, the advantage is to use these as a backbone network to interconnect a number of slower networks (such as T1 or ethernet) within the campus. The lower port speed can then supply the packets for a carrier-operated frame-relay switch to produce the high speed backbone.
The hub to site network connections run megastream bits of information per second (140 Mb/s), as part of the backbone network, to support all information activities. In the four postulated buildings a total of more than 580 Mb/s would be required. Three switches should be used in three of the buildings as the physical layout connection. This is a more economical way than having four switches, one in each building, since the output result is the same. Users can then connect and communicate within any building or between buildings in the same way. A proper switch controller must be designed to interconnect buildings. For ethernet and X.25 connections, DV2MP must be considered. For video connection, H.261 (video codec) can provide emulation of synchronous data circuits at rates of 2.048 Mb/s on each part simultaneously. For workstation connections, a DV2CL controller must be used to provide greater than 100 Mb/s transmission rates.

The development of ISDN on the campus will affect the PC modifications, where the ISDN service is used primarily for a dial-up connection at the 64 Kb/s standard speed. To be effective, BRI (64 Kb/s standard) should be designed to be used as a LAN infrastructure. This requires PBX and transmission facilities that adhere to the ISDN BRI interface standard to be provided around the campus. In practice, packet switching may be designed to handle sequentially the incoming flow of data highways each handling 32 channels (multiplexed) with each channel delivering data at 64 Kb/s. The flow rate in the switch is thus 32 x 64 Kb/s,
which is about 140 Mb/s, corresponding to about 2000 telephone or other data channels. As many switches of this type can be installed as may be needed to handle the traffic scheduled for the exchange.

Configurations of PCs and Macs in teaching laboratories must be standardised with 4 Mb of RAM and 40 Mb of hard disk and at least one 3.5 inch disk drive. The PC workstations must have a megabits set-up for communication purposes. Printers should be shared between PCs. A ration of 1 : 5 would be efficient in the teaching laboratories. On the academic office side, each staff member must have his own PC workstation and printer, IBM or Mac depending on his interests. These systems must be provided with the various applications and network capability for communication purposes, with high speed performance.

All PCs must have a mixture of programme activities. This is to support teaching languages, common WP, databases, spreadsheets, Microsoft windows, Norton Utility, compatibility and virus checking, SPSS, and Microsoft Excell. The Macs system should be provided with Word 5, Pagemaker, Cricket graph, MacWrite II, Hypercard, Excell, MacDraw, Superpaint, SPSS, Disinfectant, virus and compatibility checking. The department should be responsible for housing the facilities and the computer centre advise on wiring, cabling and installation.
The implementation of this design could conveniently be done in phases. Phase one involves the completion of wiring and connections to all buildings on the campus. Phase two involves the installation of 140 Mb/s in each site building with the equipment necessary to connect LANs to the backbone along with mainframe computer and GULFNET (and, in the future, SuperGULFNET). The third phase should provide any wiring necessary to fully network the campus and to test the ATM systems.

7.6.2 Organisational design

Based on UK trends examined previously, Figure 7.3 shows the design of an organisational IT committee structure within a university campus. It has three management levels. The first involves the top management executives who make decisions on the IT computing technologies on the campus. The second level - the middle management - represents the Academic Computing Committee. This is involved in plans, strategy, development, recommendation and so on. The third management level involves the operation and management of academic and administrative computing activities. The Director of University Computing reports to the Pro-Vice-Chancellor for IT and provides direction and long-range planning for central and distributed computing activities on the campus. He manages the central facilities, operation staff, consultation and campus network, and is responsible for all the major computing systems based on computer centre. The Director of Library Affairs is connected with the necessary...
1: University committee (top management).
   People who make decision and execution - the executive people

2: Campus committee (middle management).
   People who make plan, strategy - merging of academic, library and computer centre

3: Academic representative committee/user committee (bottom management)
   People who operate and manage the academic and administrative computing activities

Figure 7.3. University organisational IT committee structure
integrating library facilities so as to provide better information searching on the campus.

An IT committee structure of this sort could take care of overall computing needs on the campus. It consists of the Director of Library automation (who takes care of all library computing needs) the Academic Computing Committee (who take care of all academic computing needs) and the Director of the Computer Centre (who takes care of all administrative computing needs). These three groups represent the organisational IT committee structure under the control of the Pro-Vice-Chancellor for IT, which is a newly created position and directly links up to the University Chancellor as shown in Figure 7.3. These IT structural groups can communicate with each other to develop a campus-wide IT strategy for the university campus. Furthermore, as shown in Figure 7.3, four new groups must be created within the computing centre: hardware, software, training and network departmental committees. These groups again will work and communicate with each other to provide all administrative computing needs for the campus-wide network system.

On the local academic side, academic computing representatives in each department can work together in a 'users support group committee'. This committee takes care of all academic computing needs and services, such as hardware and software compatibility, local training programmes needed, purchasing policy, user assistance and consultation and so on within the department. In
other words, problems can be discussed, assessed and evaluated within departments and a bid made for what is required in terms of the whole academic environment. The results of the discussion and recommendations then go to a higher committee, which represents the academic computing side, running in parallel with the computer centre for the administrative side and the library for library automation.

The user support committee structure has various advantages. First, problems that occur in each academic department can be noted by other departments and discussed together. Secondly, a close working relationship within a department will increase communication, and can help establish agreed IT policy, as on training, purchasing policy and so on.

7.6.3 User design

Training

The design of training programmes for all kinds of user in the SA universities must involve three initiatives. The first is the training of operational and management computing personnel in the computer centre, academic representatives and computing librarians in the use of the ATM network system. The second initiative should involve the establishment of a 'Training Computing Centre' within the university's main computing centre. This centre should be provided with facilities to train
students, academic staff and anybody on the campus who is interested in getting more computing experience and knowledge. The third initiative involves the development of 'Company Training Programmes'. The kind of skill this requires is now demanded by many local SA companies who employ freshly graduated students. Thus central agreements must exist between the universities and companies to develop training initiative programmes.

The objective behind designing these training initiatives is to increase user abilities in all computing environments. For example, in the second initiative, the design objective is to stimulate provision for the training and development of all categories of university staff and students in order to improve their performance. In the third initiative, the design objective is to consider possible endorsement of, or provide some form of accreditation for, courses run by other organisations (e.g., a company). All these initiatives mean that a good training model must be developed. (see training models in chapter 3 for more details).

7.7 Implementation

As an example of how these design might be implemented, Gantt charts and PERT diagrams have been used to describe the physical, organisational and user IT activity changes in developing a campus network as shown in Figure 7.4.
Figure 7.4 Gantt charts compared with PERT diagrams for start-up and running-up situations of IT planning activities that can be accomplished on university campus.
The Gantt chart is concerned almost entirely with planning future action. It represents a dissection of both the amount of time and amount of work to be done in the available time [37]. Thus Figure 7.4 shows a two-dimensional Gantt chart where time is indicated on the horizontal axis and a description of IT activity changes on the vertical axis. Lines drawn horizontally show the relation of the amount of work actually needed to the amount scheduled. The black shaded bars indicate the reason for having minimum and maximum time is to allow for fluctuations in such factors as money, people, hardware and so on.

A PERT stands for 'Program Evaluation and Review Technique'. It is a method of evaluating progress in order to better control a major research and development programme [38], and is used to define what must be done in order to accomplish programme objectives on time. It employs a network programme to reflect planned resource applications and performance specifications. Thus, in Figure 7.4, implementing a programme is represented by a network of nodes which determine priorities for IT activity. This planning has been estimated to fit in with the SA five year development plan. Furthermore, the experience of UK universities in developing network plans and the time they have taken have formed the basis for these calculations.

The Gantt chart shows the minimum and the maximum times for changes to take place in all IT activities. PERT diagrams, on the other hand, display the changing paths. They show the beginning,
middle and end of events. In order to find the length of the changes, each path from beginning to end is identified, and the length of each is calculated. In this diagram, for example, the path for IT activity changing the organisational structure (10-30-50-60) needs 21 months, whilst path (10-40-50-60) for IT activity relating to user change has 24 months as minimum and 36 months as maximum duration. The diagram requires that all sets of IT activities (or paths) should be completed within the length of time shown in Figure-7.4.

7.7.1 Physical changes

As shown in the diagram, the first priority should involve the physical changes where more connections are still needed on the campus before the development of the ATM network system can take place. The physical changes require the greatest time to build/upgrade the campus network in comparison with the other two changes - organisational and user. The former changes takes about 33 to 60 months as a minimum and maximum accumulated time. In the start-up situation shown in Figure 7.4, on-campus connections need more time to be fulfilled. Cabling, digging, installation and funding availability, all affect the time required for executing the whole network design. Two years is the average time span to connect all four buildings and the university mainframe. Upgrading to a new ATM network also need considerable time. Enquiries, project study, evaluation process, vendor, etc., require 12 to 18 months (as minimum and maximum
timescale), whilst 9 to 12 months is needed for vendor selection and completing the contract. Thus from the start-up situation, minimum and maximum times of 3 to 5 years are essential to build a campus network system.

The follow-up situation should be looked at differently. As soon as the network is developed and completed in and between the campus buildings, other factors, such as more connections, IT equipment, evaluation, vendor selection, etc., should be completed within two years. The first year should be given to campus departmental investigations and the second to evaluation, recommendations and execution. However, since the SA plan is based on a five-year development plan activity and since all university funding is dependent on government support, these networking plans should be adjusted to run within the Five Year Development Plan of the university.

7.7.2 Organisational changes

Figure 7.4 shows that planning ahead for a new organisational IT committee structure may take between two and two and half years, depending on the availability of funding, personnel, etc. The new position of Pro-Vice-Chancellor for IT may need some time to be established, since the government must approve the creation of this position. After the position is filled, the person appointed will need some time to establish himself. Similarly, the user committee structure needs some time to get established. Although academic
computing representatives exist in some departments, there is a need for further qualified technical persons to be appointed (see Chapter 6), which might also take some time.

Generating collaboration, meeting schedules and so on needs sufficient time and is not an easy task. Information system development involves computer specialists, who will build the system, and users, for whom the system is being built. It will take time to train those people in order to make them ready for the new information system. Furthermore, developing IT policies, such as a hardware policy, a network policy, etc., by the university also needs time. At least two years is likely to be needed to develop the university structure adequately to operate new campus-wide information systems. This planning should again be carried out within the university Five Year Development Plan.

7.7.3 User changes

As in the case of organisational changes, user changes (training programmes) also need to be considered within the Five Year Development Plan. The timescale needed to train people at university is greater than for organisational changes in SA, due to the unavailability of skilled and knowledgeable people. Thus 2 - 3 years is likely to be required to establish and exploit appropriate training facilities.
From Figure 7.4, it appears that training programmes need longer in the start-up situation where all computing staff and librarians need more training to get enough knowledge and experience of the new information network system. Appropriate training here includes different training activities related to the trainees' background, ability, education and so on [43], which is another reason why it takes time.

In the follow-up situation, Figure 7.4 shows a different timescale. In this, the training programme is on-going, and the timescale is related to the academic year. The calendar year in SA universities consists of three terms - Winter, Spring and Summer terms - each taking four months. Thus the training programme in the follow-up situation will be based on the term.

7.8 Cost estimate

Costs for the development of a campus network are not easy to estimate, since campus network development differs from one university to another in terms of size, data traffic flow, LANs, etc. For the purpose of this research, costs have been estimated for typical ATM equipment and peripherals available provided from NETCOMM Limited, UK, in 1993. The KSU campus network has been selected as a typical example for the development of ATM. The reason for choosing KSU is partly because it already has a developing campus network layout. The other reason is that all campus buildings (nine of them) are already networked via LANs.
Figure 7.5 shows the campus buildings diagramatically, including the ATM switch connections between all nine buildings. It portrays the ethernet and video codec connections to all faculty buildings required to provide multi-service network information.

Figure 7.5. Network model for use in cost estimate

1 = Agriculture Building  2 = Engineering Building  3 = Science Building (1)  
4 = Science Building (2)  5 = Pharmacy and Dentistry Building  
6 = Medicine Building  7 = Arts Building  8 = Education Building  
9 = Administrative Science Building
This is a simplified network topology consisting of eight main ATM switch connections and 18 ethernet and video network branches to illustrate the modelling and analysis process. Since the price of the ATM switches depends on the network traffic design, the price for the ATM switches and interface control cards varies from one building to another as shown in Table 7.1 below. This provide a general outline of the costs.

`| Item     | Unit price | Quantity | Subtotal |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ATM</td>
<td>8000</td>
<td>9</td>
<td>72000</td>
</tr>
<tr>
<td>Ethernet</td>
<td>5000</td>
<td>9</td>
<td>45000</td>
</tr>
<tr>
<td>Video</td>
<td>5000</td>
<td>9</td>
<td>45000</td>
</tr>
<tr>
<td>Subtotal</td>
<td></td>
<td></td>
<td>162000</td>
</tr>
<tr>
<td>UPS</td>
<td></td>
<td></td>
<td>7920</td>
</tr>
<tr>
<td>Installation</td>
<td></td>
<td></td>
<td>0000</td>
</tr>
<tr>
<td>Maintenance</td>
<td></td>
<td></td>
<td>16200</td>
</tr>
<tr>
<td>Cabling</td>
<td></td>
<td></td>
<td>8100</td>
</tr>
<tr>
<td>Grand total</td>
<td></td>
<td></td>
<td>194220</td>
</tr>
</tbody>
</table>

Table 7.1. Development cost for ATM switches

Three cost elements are used in the table: (i) entry cost for the ATM switch which involves one DV2 chassis, one PSU and one DV2XP; (ii) interface control cards for ethernet; and (iii) interface
control cards for video. The subtotal and grand total costs are shown in the table. An uninterruptable Power Supply (UPS) has been added to each switch to avoid problem when power is off. Although it is optional it is important in the case of SA universities where fluctuation of the electricity supply often occurs. The costs for maintenance and cabling have been based on 10% and 5% of the total amount of ATM equipment, respectively. The costs in the table represent a five year contract. Installation cost is zero because, in SA, the local vendors are expected to install the system free. The total amount is 194220 (UK pound), equal to S.R. 1165320 Saudi Riyals.

The actual cost may be more or less depending on the actual needs within the buildings. For example, in the case of video, the price in the table is for only two video codec connections. A department may wish to input 5 or 10 video sources from the site to the codec. In this case, additional funds are necessary for the expansion of the video sources. Some departments may have more than one ethernet LAN connection, so that the cost of ethernet will double and so on.

Human costs must be considered, too. At least three academic staff and two technicians are needed for the management and operation of the new ATM network system. Decision-making, consultation and advisory activities are needed to implement the system successfully. If people with good experience in ATM advanced technology exist within the campus, this cost can, of
course, be reduced. Thus the table shows the straightforward costs of ATM equipment, UPS, maintenance and cabling only.

Summing up all the above considerations, universities in SA must have a properly cost plan for IT equipment to cover all campus-wide network expenditures. There are three reasons for this. First, all academic IT equipment needs are supported by the university computing centre. Second, all university computing centre needs are supported by the university budget system. Third, the university's budget system depends directly on the government support. This means that academic computing departments put their bids to the university computing centre and the university computing centre puts its bid to university budget system. Thus the funding support system in an SA university is a pyramid reaching from the bottom level (academic, computer centre, university) to the top level (government budget system) with demand from the bottom and delivery from the top level. Hence it is crucial for the university computing centre to have considered all the funding requirements for the campus carefully. Additional costs, such as the maintenance contract, training needs and so on should be considered in relation to the estimates. For example, local vendors usually provides a one year warranty only for maintenance. However, it is better to try and negotiate a three to five year contract with the vendor and include this cost within the budget system to avoid future maintenance funding problems.
Cost problems may arise due to the lack of an effective IT plan and lack of highly qualified staff to handle a campus-wide network budget system. As Sutten [39] has said: "One accepts entirely the current financial problems of many universities, and the consequent caution with which new initiatives must be regarded. It is even more important in this situation that, if money is to be spent on any major IT resources, that there is some plan against which to assess the relevance and utility of such expenditure". In SA universities, the situation in this respect is bad because there is no broad policy plan for IT. Most IT purchasing is based on tangible costs, as for PCs, printers, etc., whilst intangible costs, such as maintenance costs and training programme costs, are often ignored.

Changes in costs can also come about because of alternative available methods of connection. In Figure 7.5, for example, eight ATM switches were used instead of nine switches. Thus, it is possible to reconfigure the system so that fewer switches can be used. There are also many different interface control cards for ATM switches. Some of them produce a higher number of bits than others. For example, DV2MP and DV2XH are both used as switch fabric cards. The difference between these two switch cards is that the first one, DV2MP, provides a connection operating at 200 Mb/s in both directions simultaneously and supports a maximum of 3.2 Gb/s throughout, whilst the second one, DV2XH, provides connection operating at 400 Mb/s in both directions simultaneously and supports a maximum of 6.4 Gb/s throughout.
The costs of these two control cards are different. The campus may need DV2MP instead of DV2XH. So consideration of these differences may save money. Another example of potential saving comes if an Apple networks is installed [40]. "There is an alternative available to the Apple supplied LocalTalk connectors. The PhoneNet connector, produced by Farallon Computing Company has now used the umbrella term PhoneNet for all of its networking products, LocalTalk or ethernet. This product, like the Apple-supplied product, attaches to the Macintosh network port, but instead of shielded cabling, employs unshielded twisted-pair cabling with standard R-11 connector. Since the PhoneNet system use standard unshielded telephone wire, it is possible to use the installed telephone wiring in the building. The use of modular telephone wiring in some areas greatly simplifies installation and keeps costs down". Since all academic buildings at KSU have been installed with telephone jacks, this kind of technique might help reduce overall campus-wide network costs.

7.9 Between-campus networking developments

Having looked at planning on-campus networking, we now look at networking between universities. In the USA and UK, government, industry and universities are collaborating and co-operating together to establish an electronic network infrastructure around the country to link universities and other organisations in terms of providing high performance network systems. How might this apply to SA?
7.9.1 USA experience

In the USA, the NREN (see Chapter 2) has been installing Integrated Service Digital Networks (ISDN-voice and data) on a national or regional scale to increase the transmission speed of academic network systems. Research is being conducted on service up to 1 Gb/s. The reason for this is that within the coming five years (1998) more than 50 campus area networks will be operational at speeds approaching 100 Mb/s.

To estimate the network bandwidth needed to support research and teaching at a major installation, the kinds and volume of traffic have been estimated. Three models were used to compute three independent estimates of the requirements for (1) bandwidth needed by type of work, (2) information needs by type of user, and (3) information flowing at the installation boundary. In each model, the peak bandwidth was estimated for each type of service. The results indicated that in the first model, for a researcher to receive full colour and full-motion high resolution images, 30 Mb of information was required so that a display rate of 30 frames per second requires a bandwidth of nearly 1 Gb/s. In the second model, a research university with 35000 students and 3000 faculty and research staff using a mix of bandwidths again requires an aggregate bandwidth of approximately 1 Gb/s. In the third model, where typical facilities included supercomputers, particle accelerators, and centres for images and/or animation, an aggregate bandwidth of 1 Gb/s is again needed. Thus three
independent means of estimating bandwidth arrived at nearly the same requirement for a large research installation and 1 Gb/s can confidently be used as a lower bound on the bandwidth of a national research network.

The USA national network plan has three stages: stage 1, upgrade and interconnect existing agency networks into T1 (1.5 Mb/s) by 1990; stage 2, integrate the national network into T3 (45 Mb/s) backbone by 1993; and stage 3, make a technological leap to multigigabits, 3 billion bits per second (3 Gb/s), starting in the mid-1990s.

7.9.2 UK experience

In the UK, too, the SuperJANET (see Chapter 2), which uses high performance optical fibre ISDN technology for transmitting voice, data and images, is another example of a high performance networking system developed in Europe. The advantages of the new network lie in its speed and types of application that it can support. SuperJANET transmits up to one billion bits of information per second (1 Gb/s) as is the case in the USA. This high speed allows the transmission of highly sophisticated image and voice communications in addition to data.

The installation and implementation of this network has undergone two phases. Phase one (1st half 1993) is to upgrade the existing network at 2 Mb/s including video connection. This is to
be interconnected at 34 Mb/s using subchannels of the 140 Mb/s SuperJANET site access ports. This will be used to carry data streams and video/audio streams over the same multiplexed, physical links. The second phase (1st half 1994) is the move to SDH (Synchronous Digital Hierarchy) with site access at 155 Mb/s to further allow connections which will support ATM.

Thus the availability of NREN in the USA and SuperJANET in the UK over the next few years, puts the USA and UK academic and research community in a unique position to exploit the new services offered by these advances in network technology.

7.10 Situation in SA

With the pace of development in the IT area within the last 10 years, the SA government has provided policies as part of its long-term plans (1980-1995) to build up a national information network research system to meet the Kingdom's needs. Therefore KACST was established in 1977 and during the Third Development Plan [41] (1980-1985) the government established policies (see appendix V) to develop scientific and research technology programmes around the country.

Furthermore, during the Fourth Development Plan [42] (1985-1990), more attention was given to enhancing research in science and technology as a continuation of the Third Development Plan (see appendix V). The government's support for KACST was to
facilitate the application of science and technology in furthering the Kingdom's long-term development goals. To implement these policies, KACST established programmes based on the development plan. The first programme established was to support research and development projects focusing on fields of particular relevance to the kingdom's development, such as the economy and human resource developments. The second programme was to respond to technological problems. Elements of this programme included establishing industrial technology databases, organising a network of engineers and scientists to provide technical consultation, analysing technology transfer needs and establishing a national system to protect patent rights. The third programme included the building of the KACST campus. The last programme included the improvement of administrative structure and technical services within KACST. Parts of the programme included the upgrading of computer support systems and databases and extending the capability for computerised translation of scientific and technical documents and publications from sources outside the kingdom.

Today, we see that all of these programmes have been implemented in acceptable form. For example, KACST recently moved to its huge new campus. Computer information technology has been established at the KACST centre, for which a new administrative structure was created under the name of "General Information System Department" to deal with all computing services.
At present, the most prominent technology issues facing the kingdom are the shortages of human resources and the lack of coordination between universities. Accordingly, the government during its Fifth Development Plan [43] (1990-1995) has proposed some policies (see appendix V) to overcome these problems. The focus was on the design of a network to facilitate the intercommunication of computer terminal equipment in local and national areas. So conducting and promoting research activities in computing, enhancing computer usage at all levels of education, establishing a good training programme and creating more computing vocational institutions have been the government's concern in order to increase skill levels in computing and alleviate manpower problems.

What these plans tell us is that the government has been trying to build up a powerful IT infrastructure to fulfil its long-term objectives in the kingdom as the whole. Now after ten years development at KACST, the city has become a huge central organisation for science and technology development. The connection of KACST with the BITNET and EARN international network systems, and the creation of GULFNET within KACST to serve as a central function for all universities and research institutions in the Kingdom of SA are examples of KACST's growing responsibilities.

The Kingdom of SA is thus also undertaking the development of a national network system. GULFNET (see Chapter 2) was established
in 1985 to provide a good electronic network communication system to serve not only the SA universities, but also the Arab Gulf Countries (AGC). However, not very much progress has been made since then. The network programme should be acting as a catalyst in providing an environment that can obtain major advantages from improved communications. Such sharing of computing facilities, e-mail, video, voice, picture, etc., will help encourage users. SA needs to upgrade GULFNET and develop an advanced national network system to support communications between universities and other organisations. It was noted earlier that the government's main objective in the Fifth Development Plan (1990-1995) is the establishment of good collaboration and co-operation between industry and university. This is the form of developing scientific and technology research activities in order to meet SA government needs. Thus a co-ordinated national research network system based on very high bandwidth links is needed in order to provide a rapid and responsive information service to scientists, engineers and researchers across the country.

The existing national GULFNET system is not, however, providing the information service needed by academics and industry. It is a network based on a central node serving all SA and AGC. It is supposed that now and in the coming two or three years universities, research institutions and government organisations in the Gulf countries will join the GULFNET. To be effective, many more nodes will therefore be needed as geographically distributed centres around the country. The SA universities, the KACST
organisation, the Ministry of Post, Telegraph and Telephone (P.T.T.) and other organisations from the Gulf countries will have to cooperate in developing and implementing a shared advanced broadband switching platform for an upgrade of the GULFNET system.

In the UK case, as the demand for the development of the SuperJANET high-speed network increased, a new joint network team was established. UKERNA (the United Kingdom Education and Research Networking Association) took over the existing Joint Network Team (JNT) which originated the setting up and running of the JANET system during the early 1980s. This team with BT, SERC and other organisations has worked together to design and implement the SuperJANET system. The new network team is needed to support advanced applications requiring a mixture of voice, data, image and video communications.

In the SA situation, a new organisation must be created to replace the existing GULFNET organisation to design and implement the new SuperGULFNET system. This means that several different organisations must be brought together to form a joint network team to create a single unified high-speed network performance from several existing separate networks.
7.11 Factors affecting between-campus network

7.11.1 Physical factors

ISDN technology

The recent development in ISDN technology - the B-ISDN intelligent wideband networks, which has been used with fibre optics cabling technique on the university campus - has helped many universities in the developed countries, especially in the USA and UK, to provide higher speed network performance between campuses. This technology has also pushed telephone companies in both countries to develop digital communication systems to provide better services to their users.

In the USA, AT&T introduced a range of ISDN technology in 1989. It was designed for ISDN services when connected via existing local lines to an AT&T switch at a digital exchange. In the UK, British Telecom (BT) launched "ISDN 2" to digitise telephone networks in 1989 [44]. With the use of this technology, BT has moved towards a full ISDN user service. This should allow public telephone network users to meet their communication needs for data, text, graphics, video and voice over a single high-speed digital connection.
These technological advances in the developed countries will help international communications within and between these countries without major problems in physical environment.

**Satellite technology**

Most recently, between-campus networks have seen the use of satellite systems. Again, this is due to the recent advancement in ISDN technology development, which has allowed satellite systems to be designed to provide new facilities for computer communication activities. One of the advantages of the satellite over the traditional long-distance data communication media (fibre optics) is its high bandwidth availability. For example, the satellite business system (SBS) has the ability of transfer digital services at a speed of up to 3 Mb/s, whilst the highest speed available on dataphone digital service is 56 Kb/s basic rate interface (BRI). The other advantage is that satellite networks can provide a point-to-multipoint communication whilst fibre optics provides point-to-point communication. In other words, in the satellite network a single transmission from a source station may be received simultaneously by several destination stations. Finally, there is its ease of installation: it can be set up in a relatively small space and short time without the problems of digging up the campus.

In the case of SA, although fibre optics are being used in KACST to enhance GULFNET capability, the transition to ISDN will create a
much greater need for a satellite network for a wide variety of existing and new applications and services. So the designers of GULFNET, when trying to upgrade the system facility must consider such techniques to better provide national as well as international network communications between campuses.

7.11.2 Organisational factors

In the USA and UK, several organisations and universities are using satellite networks to provide fast and better information services between campuses. In the US, for example, the National Technological University (NTU) offers a wider range of programming by live satellite transmission, video instruction including interactive courses, and teleconferencing. Courses may be for credit, leading to an accredited Master's Degree, or for audit, depending upon the student's needs and interests. Furthermore, companies have operational programmes with universities. This offers industry an addition to educational programmes delivered from local universities, and courses taught on campus by colleges, universities and technical schools. In the UK, the Open University (OU) is using a satellite for the delivery of in-service training to tutors in the use of computers at the OU centres to prepare them to teach on information courses [45].

This means that, in the developed countries, such as the USA and UK, there is a move to the use of advanced technology, such as
ISDN and satellite networks, in the educational system to provide better telecommunications between campuses.

**Saudi Arabia**

In SA, satellite systems have been used since 1977, but the degree of use in the educational network systems is small. The country has membership of the international satellite organisations, and INTELSAT, INMARSAT and ARABSAT are being used in SA [46]. Thus it would be to the advantage of SA universities to connect to the ARABSAT network, or others, to provide fast and reliable national telecommunication services between campuses as well as between the latter and other organisations. This could help in distance teaching, where delivery of courses and training programmes with the presentation of voice, pictures and graphics would be available between campuses. Furthermore, since the USA, UK and many developed countries are using the ISDN technology within a satellite network system, the developing countries, especially SA, will be forced into the ISDN era to provide effective international communications with other countries.

A good organisational environment is needed to develop, manage and operate the satellite network system effectively. We have seen previously (Chapter 2) how NREN and SuperJANET organisations in the USA and UK, respectively have, been developed to establish national networks.
To implement this in SA, KACST must extend its organisational structure functions to provide better management and operation of new network systems around the country.

KACST

At present, KACST faces various obstacles inside and outside its campus. Internally, maintenance, spare parts, staff development, training programmes and number of qualified technical assistants are all inadequate for KACST to fulfil its programmes. Externally, most universities are not yet connected to the city's network facility to make co-operation between universities effective. This, in turn, makes communications between universities either difficult, or impossible. Even in those universities (the three universities involved in this survey) which are connected to the city, most of the academic staff offices are not yet connected for communication activities. This absence of interconnections within and between universities is limiting the extent to which geographically dispersed colleagues can reliably use the network to communicate and collaborate with each other, so, in effect, delaying government policies which were to be fulfilled within the 1995 plan.

The present the organisational structure of KACST, with regard to the computerised information system services, is shown in Figure 7.6.
Figure 7.6. Information system organisational structure

This shows that four departments dominate all computing and network information system environments in the Kingdom. Though the existing structure has become increasingly flexible in recent years, the introduction of advanced technological development suggests that this organisational structure must accept change. More sections (e.g. for hardware, software and training) could be created within the existing organisational structure of KACST as a means of moving towards a more decentralised network organisation. The hardware section, for example, could control all KACST computing operating systems as well as maintenance difficulties. It could provide suitable hardware systems, purchasing consortia to negotiate favourable discount agreements with local suppliers, technical advice for mounting and adopting software, access to hardware for the new and emerging technologies and so on. The software section could collaborate in the evaluation of available products with centrally
negotiated software licences. They can be the basis for selecting software and acquiring site-licences.

The reason for having these such sections created separately within the organisation relates to the probable expansion of the KACST centre in the near future. Since the city is going to be the only centre for science and technology to cover all the Kingdom's needs, and the centre for national and international networking, it will be overlooked unless there is organisational reform.

In addition, a training department needs to be created to provide regional support for training and development. The training department should provide staff development programmes and training opportunities for the KACST computing staff to increase computer-literacy especially in the areas of networking and telecommunication systems. Roseveare [47] has looked at the demand for skills from the viewpoint of a continuing spread and growth in the use of IT. With more people of all types using terminals and having access to a computer system as a natural part of their work, the information system needs skilled people to provide maintenance of existing co-operative systems, project management, technical assistance, management and utilisation of the corporate data centre and effective management and utilisation of communication networks. Thus the information system department at KACST needs a comprehensive training programme to establish it as "a centre of excellence" to provide...
skilled people to manage the whole integrated computerisation system.

The creation of these three sections within the KACST organisational structure would help form a more decentralised system. Winfield [48] has commented, in such an organisation management control over the delivery of work will be greater and measuring outputs will be considerably easier. This is true especially when an organisation works on a huge campus such as is the case at KACST.

7.11.3 User factors

Training

Among the important training programme initiatives for between-campus communication will be one to enhance managers' and users' skill in using networks and communications computing technologies effectively. Since the users will be of varying levels of sophistication, there will have to be help at a number of different levels. The appointment of staff development officers/directors/coordinators in each department in each university will help and increase user support. These officers/directors on the campuses can work as part of the national unit's staff to support academic users' needs. Between the campuses a wide range of posts (managers, advisors, directors, etc.,) needs to be developed for collaboration
and co-ordination in providing effective training materials across the campuses.

It is suggested that national university training programmes can be developed using the satellite network system. This would allow computing companies such as IBM to collaborate in providing training courses to users. Also training programmes could be established between industry and university and vice versa to increase employees', administrators', staffs' and students' skills.

Information services

Although satellite networks have been used in the USA and UK for some years, the advent of ISDN has enhanced and increased the transfer of information in educational systems. Thus the use of satellite networks technology between campuses has allowed new delivery of information services and applications. Information delivery [49] are:

- conveys information quickly and uniformly;
- allows for simultaneous communication to a widely dispersed audience (being particularly good for in-service training, vocational training, etc.);
- allows specialists to present a single telecast rather than appear at multiple meetings (valuable for presentations by experts at international professional seminars);
- helps stimulate and motivate students in the use of new technology (e.g. remote sensing activities provide students with 'hands-on' opportunities to deal with real experiments and problem-solving situations);
- offers a participation vs. a passive learning environment with multi-media interaction via video, voice, data, graphics, etc.;
- provides alternative methods of meeting educational needs.

7.12 Between-campus network design

7.12.1 Physical design

From to the previous discussion, it is evident that SA must plan for a national network now. This means that more nodes should be created, using ATM technology. It was mentioned previously that the disadvantage of a central node at KACST to serve all campuses is that, when that system is down, the entire network is cut off. Thus decentralised distribution is needed in SA to provide faster and better information services to all campus users. The plan proposed here suggests that four sites are necessary: King Abdulaziz University (KAU), King Fahd University (KFU), Kuwait University (KU) and King Abdulaziz City for Science and Technology (KACST). These four sites have been chosen to provide a properly dispersed geographical distribution, and because they are large universities with many computer and network facilities.
Each site must develop an initial 140 Mb/s backbone connection to provide a multi-service network. Plans for the development of ATM and connections to support data and video connection should follow the same pattern of physical design layout as at the KSU campus described earlier in this chapter. As soon as an initial 140 Mb/s ATM switch is completed at each site, testing for data and video connections between campuses should start. Each site should develop 34 Mb/s lines for pilot testing purposes between sites as shown in Figure 7.7. These lines must be configurable so that any desired interlinking of sites can be made. A SDMS (Switched Multi-megabit Data Service) interface, for example, would be appropriate. It is an advanced wideband dial-up digital service capable of producing 1.5 to 45 Mb/s bandwidth available on demand [50]. Such dial-up advanced telecommunication technology does not exist in SA at present. There will need to be agreement with the Ministry of T. P. P. to provide the necessary interface connection lines. This should fit in with current Ministry of P. T. T. policy to create a telecommunication network of the highest quality to meet the Kingdom's development strategy. According to the Fifth Development Plan (1990-1995), the objectives include: (1) to provide a digital long-distance transmission network, a digital telephone network and new advanced services such as electronic mail, teletext and data
Figure 7.7. Between-campus ATM pilot configuration connections
transmission services for all standard speeds and interfaces; (2) to provide a video conference service between major cities within SA, and between SA and other countries, in addition to ISDN services; (3) to provide hybrid satellite facilities to carry domestic and international telecommunication traffic and direct broadcast television channels to home users. Thus negotiation with the Ministry should provide for collaboration in the study of the transition of the SMDS service to an ATM platform. When this occurs, it will enable interconnection to be made in an efficient way between campus networks, and it will also then be possible to link in local ATM networks on the SMDS sites to the national ATM infrastructure in an efficient manner.

As researchers and technology move to higher speeds of up to 155 Mb/s, the move to SDH will be needed for further development of the ATM platform. The SDH technology offers high speed point-to-point circuits in a more flexible manner than current technology, so it might be asked why ATM packet switching is required as well? The key reason here is to provide a single multiplexing and switching technology to support all forms of traffic, so laying the foundations for support of future multimedia services.

ATM is based on the concept of a very high switching rate for standard fixed size packets (53 bytes, a 5 byte header and a 48 byte user data). The reason for the choice of 48 bytes is a compromise between the requirements for two important uses of ATM switching, namely voice and data. Data prefers larger packets
to minimise processing overhead, whereas voice prefers shorter packets, with the associated lower packetisation delay, to reduce the problems of echo, particularly over long distances involving multiple switches. The technology has been established for these activities in the developed countries. In the USA, for example, Bell Communications Research (Bellcore), has created a standard SMDS providing 1.5 to 45 Mb/s bandwidth on demand. AT&T has introduced BNC-2000, which is a family of Synchronous Optical networks (Sonet), capable of operating at 155 Mb/s to support all the interfaces in use today, such as X.25, ISDN and SMDS [51]. In the UK the contract with the BT has started to cover the transition of the SMDS service to an ATM platform. This takes the form of a 140 Mb/s backbone in which 34 Mb/s can be used as a sub-channel for video and data testing. In time, the 140 Mb/s connections will be replaced by 155 Mb/s SDH connections, which will support ATM. Table 7.2 below shows the trunk transmission rates used in Europe and North America.

<table>
<thead>
<tr>
<th>Europe</th>
<th>N. America</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1 2Mb/s (2.048)</td>
<td>T1 1.5Mb/s (1.544)</td>
</tr>
<tr>
<td>E2 8Mb/s (8.448)</td>
<td>T2 6.0Mb/s (6.312)</td>
</tr>
<tr>
<td>E3 34Mb/s (34.368)</td>
<td>T3 45.0Mb/s (44.736)</td>
</tr>
</tbody>
</table>

Table 7.2. Trunk transmission rates in Europe and N. America:

Thus in the SA situation, transmission network interfaces, such as 2/1.5 M b/s, 34/45 Mb/s and 155 Mb/s for the ATM platform,
should be developed between sites for the system to be operated effectively in presenting video, data, image and voice. The opportunity exists to deploy LAN and WAN technology most suited to the support of multimedia working. Pilot studies need to be carried out between those sites to test the implementation of ATM equipment. More sites could be connected in the future.

Large universities, such as KSU and KAU, with several campus branches located in the North and the South of the country, must consider satellite networks rather than cable networks on cost grounds. Ackroyd [52] has demonstrated that the overall cost of satellite operation (time-scale 25 years) using Intelsat (including capital costs and running cost) as compared with the total cost of optical fibre cable (including cabling, installation and running cost) is 34.1 to 30.7 million pounds sterling, respectively. When compared on a corrected cost-effective basis, the satellite method is better on a per channel basis. The other factor that makes it reasonable for an SA large university to use a satellite network, in addition to the cost benefit is the environmental factor. In both South and the North, there is a shortage of telephone communication facilities. In addition, heat, dust, humidity and other physical factors make the use of a satellite network more reliable. Thus designing a plan for a network on a large university campus must consider both fibre-optic communications to all buildings on the main site and a satellite communication network system at the subsidiary sites.
In terms of the whole development plan for SuperGULFNET between campuses: (1) each university should establish an initial 140 Mb/s ATM platform, then (2) an initial 34 Mb/s development should take place between campuses for data and video testing; furthermore, (3) the development should move to SDH technology to provide an initial 155 Mb/s for further development of ATM equipment; lastly (4) there is the need to consider a satellite network system. When these physical developments have been completed between sites, SuperGULFNET should provide multi-service information communication to all users in terms of LAN, WAN and international networks as shown in Figure 7.8.
Figure 7.8. Multi-service Network
7.12.2 Organisational design

An organisational structure is required that allows for communication between each university in SA (see Figure 7.3). In this case, external organisation can involve university committees, campus committees, and users' committees in each university. For example, one university can develop courseware for teaching students whilst another prepares a good training programme. Thus all universities can share in the process of development. The external organisation will include the Pro-Vice-Chancellor for Information Technology at each of the universities, the General Directorate of Information Systems and the Directorate of the National Network Department at KACST and one highly ranked person from each of the government bodies, such as Ministry of P.T.T. (for discussing telephone and cabling affairs), Ministry of Planning (for discussing planning activity), Ministry of Higher Education (for discussing educational technology development) and Ministry of Finance (for discussing financial affairs). This can be regarded as a "National Joint Network Team" as shown in Figure 7.9.
These people can work together for the consideration of overall planning including funding. The programme should be managed by a Chairman appointed from the academic area. It is also possible to include other people from industry (IBM and Apple and other computing market representatives) for further consultation.

Figure 7.9 suggests that an ATM technical advisory group should be established. This group would help to (i) study options available for the early development and implementation of a
prototype ATM-style service for SuperGULFNET; (ii) identify standards (or their lack) necessary for such a service, taking into account current broadband ISDN standardisation and the need to plan for early adoption of international standards by SuperGULFNET; (iii) recommend interim procedures to be adopted for such a service in those areas where standards are currently lacking or are insufficiently advanced to be of immediate practical use; (iv) formulate an initial plan for participation in such a service, by invitation, of technical experts drawn from industry and academic areas and liaison with relevant groups with similar concerns or remits elsewhere in Europe and USA.

7.12.3 User design

Training

As SuperGULFNET starts to produce new technology services, users of the network should be given special attention to enhance their experience and knowledge in dealing with the new network system. Researchers, scientists and engineers in universities, industry and government organisations will use the national network system. Although network users in these organisations share common characteristics (e.g., level of expertise, goals of network use) there are also significant differences between them. In the academic environment, for example, the reason for using the network is for the advancement of knowledge. Researchers and scientists in government laboratories work to contribute to human
understanding. Industry and other organisations, on the other hand, use the network system to make a profit. This indicates that areas of potential conflict exist among the users of a national network system. Consideration of various users' factors must be included in the design of a national network system, so that a variety of training programmes can be established to meet users' different needs.

7.13 Implementation

Again, the Gantt chart and PERT diagram are used here to represent the timescale needed to develop a national network system in SA. The Gantt chart shows activities in relation to time as in Figure 7.10. It emphasises their movement through time so that the layout chart helps to plan work to make the best possible use of the available people and machines. The PERT diagram, on the other hand, is a control method used to fulfil programme objectives on time. In Figure 7.10 the PERT diagram relates to (i) planning and scheduling a programme and (ii) better communications between IT activities. Thus the first step of the PERT diagram in Figure-9 indicates that planning physical activities should start first. Evolving from this will be a work plan which broadly expresses the organisational structure development approach and a timescale for the entire programme. The time estimates here originate from UK experience in developing a network system and from the five year development plan which exists in SA.
7.13.1 Physical changes

The physical activities that are needed to develop the new system are described in Figure 7.10. It uses Gantt charts and PERT diagrams for IT activity planning for between-campus development. [S]P1, [S]P2 and [S]P3 in the Gantt charts represent the physical change required to develop ATM equipment. The figure shows that these three physical changes could be provided within five years. However, the development of an initial 140 Mb/s ATM at each site, an initial 2 Mb/s for video connections and an initial 10 Mb/s development for lower band ethernet and X.25 connections are assumed to have been developed and upgraded at each site (see on-campus section). If we consider the Five Year Development Plan (1995-2000), then these 140 Mb/s, 2 Mb/s and 10 Mb/s backbone trunks should have been completed by 1997/1998. The two remaining years can be given to between-campus development.

As soon as the megabits streams are completed at each site, the development of the initial 34 Mb/s sub-channels must start for video and data testing between campuses. This is shown in the Gantt charts as [S]P2. It might take one to one and half years for implementing and testing. Compatibility, operability, efficiency, etc., will be examined in this process. This means that the process should start in early 1998 and be completed by 1999. Furthermore, after the completion of the initial 34 Mb/s links, each site should further develop ATM equipment. This corresponds to a movement...
Figure 7.10 Gantt charts compared with PERT diagrams for IT planning activities that can be accomplished between campuses.
to SDH technology. The SDH roll out is due to start early in 2000 to enable higher bandwidths intersite applications to be supported. This might take two years development, so that the completion can take place by 2002.

In the PERT diagram, the overall physical requirements imply a seven year development plan. This is the maximum time scale. It might take as little as five years, if everything (funding, support, development, etc.,) runs smoothly, and the installation and implementation of ATM technology system on-campus and between-campus occurs without delay. So the development plan may take five to seven years. Experience in the developed countries shows that five to seven years is practical for a long-range objective such as developing a national network system.

7.13.2 Organisational changes

The organisational changes for the development of an IT committee structure between campuses is shown in Figure 7.10. It looks somewhat different from on-campus development because the organisation gets larger and larger as more sites are involved. In the beginning, where [S]O4 represents the development of a national network joint team, the organisation will grow slowly because the people will be learning. Collaboration with the Ministry of P.T.T., government bodies and other organisations also needs some time to develop. The Gantt charts show that between one and two years should be given to establish the organisation
and to implement the new system. This timescale be longer or shorter depending again on the availability of people, funding, etc.

A technical advisory group committee, represented by [S]05, must be established to advise on technical development and related financial affairs. This committee again will involve different people from different organisations, but most of the technical advisory people should be from the academic area. Again the Gantt charts suggests one to one and half years should be given to establish this committee. In the PERT diagram, the events 10-30-50 are joined to indicate the chronological order of event accomplishment. These lines indicate the interrelationship and sequence of events as well as work effort required between events. Any delay in IT activities on this route will result in delay to the ultimate completion of the national network system. Conversely, any speeding up of activities on this path will (other things being equal) enable the development to be completed earlier.

7.13.3 User changes

In terms of the network operation and management, each participating node will handle a portion of the technical and administrative burdens. In Figure 7.10, the Gantt charts indicate that nine months to one year is needed to develop the required skills to operate the new system. In the PERT diagram the training programme 10-40 may vary in time. For example, people who have already finished the training programme in event 40 still not
be ready to operate the new system. In this case, additional time is required (event 50-60 in Figure 7.10).

Since all sites will share in different parts of the operation of the new system, the training programme must vary between sites. The training programme for the university node sites has been mentioned before in the on-campus section. At the KACST site, the training programme in the start-up situation needs more time, than the follow-up. More training programmes are needed on the university side. One reason for this is that new academic staff and students are coming in continuously and on-going training is needed. On the KACST side, once the individual is trained effectively he is unlikely to need more training immediately. Thus in the start-up situation between nine months and one year is needed. The follow-up situation, on the other hand, depends on demands and needs.

7.14 Cost estimate

The literature offers little guidance regarding the level of funding required for ATM network development. But it does indicate that networks can make network users (scientists, engineers and researchers) more efficient and productive. Table 7.3 shows the estimated cost for ATM equipment development between the proposed four sites. It shows that a total of 775895 (UK pound) is required to build up the system. ATM equipment for the four sites costs 652500 (UK pound). Maintenance cost comes in at 10% of
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ATM</td>
<td>8000</td>
<td>9</td>
<td>KAU</td>
<td>7200C</td>
<td>8</td>
<td>KFU</td>
<td>6400C</td>
<td>KU</td>
<td>8800C</td>
<td>1</td>
<td>KACST</td>
<td>8000</td>
<td></td>
<td>23200C</td>
</tr>
<tr>
<td>Ethernet</td>
<td>5000</td>
<td></td>
<td></td>
<td>4500C</td>
<td></td>
<td>4000C</td>
<td>5500C</td>
<td></td>
<td>5000</td>
<td></td>
<td>14500C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Video</td>
<td>5000</td>
<td></td>
<td></td>
<td>4500C</td>
<td></td>
<td>4000C</td>
<td>5500C</td>
<td></td>
<td>5000</td>
<td></td>
<td>14500C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workstation</td>
<td>4500</td>
<td></td>
<td></td>
<td>4050C</td>
<td></td>
<td>3600C</td>
<td>4950C</td>
<td></td>
<td>4500</td>
<td></td>
<td>13050C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UPS</td>
<td>880</td>
<td></td>
<td></td>
<td>7920</td>
<td></td>
<td>7040</td>
<td>9680</td>
<td></td>
<td>380</td>
<td></td>
<td>2557C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td>20250</td>
<td></td>
<td></td>
<td>1800C</td>
<td></td>
<td>2475C</td>
<td>2250</td>
<td></td>
<td>65250</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cabling</td>
<td>10125</td>
<td></td>
<td></td>
<td>9000</td>
<td></td>
<td>1237C</td>
<td>1125</td>
<td></td>
<td>32625</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtotal</td>
<td>24079€</td>
<td></td>
<td></td>
<td>21404€</td>
<td></td>
<td>29430€</td>
<td>2675€</td>
<td></td>
<td>77589€</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grand total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>77589€</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7.3. Development cost for between-campus ATM switches
the total amount of ATM cost at each site, whilst 5% is added for the cabling facility. This cost is based on NETCOMM company prices in the UK. In this case, the cost for the development of ATM equipment on the three sites in SA would be 2,889,540.00 Saudi Riyals. The cost at the Kuwait University site would appear to be 147,152 Kuwaiti Dinars (K.D.). In addition, there are other costs, such as the project development cost, planning and piloting cost, etc. SuperJANET development costs in the UK comes to 22 million pounds for the two year development of ATM. It was distributed according to the following categories: 53.20% for network services; 13.05% for development cost; 7.14% for co-ordination; 6.53% for planning and piloting; 20.07% for local procurement. This means that 66.25% has been devoted to network development and services and 33.75% to other costs (Joint Network Team Report, 1992).

For the Five Year Development Plan in SA, if we consider the first three years (1995-1998) as accounting for the physical network development and service, then the last two years (1998-2000) should be devoted to co-ordination, project, piloting and testing and local procurement. If we consider the same percentages as for to the SuperJANET facility would appropriate to SuperGULFNET, then an additional cost of 261,864 (UK pound) should be added to the total amount for the ATM facility. In this case the total amount for work on the network appears to be 1,037,759 (UK pound).
REFERENCES

(Details of publishers are included in the bibliography at the end)


2. Ibid., p. 45.


5. McDonough, ref. 3, p. 51.

6. Harris, ref. 1, p. 46.


8. Ibid., pp. 334 & 337.


13. **Brindley, ref. 10,** p. 2.

14. **Bawden, ref. 11,** p. 164.

15. **Gardner, ref. 7,** p. 341.


27. Elbert, ref. 25, p. 92.

28. Elbert, ref. 25, p. 94.

29. Elbert, ref. 25, p. 8.


31. Wilson, ref. 22, p.92.


38. IBM. *PERT.....a dynamic project planning and control method*, 1969, p. 1.


40. Harken, ref. 34, p. 25.


49. Silverman, ref. 45, p. 43.

50. Elbert, ref. 25, p. 104.


Chapter 8

Overview, conclusions and recommendations

8.1 Introduction

Investigation of the impact of networking and IT on the university campus, especially in countries with advanced computer development such as Britain, has produced insights relevant to the university campus in developing countries, especially Saudi Arabia. It can be seen from Chapters 5 and 6 that several problems have slowed down the growth of IT in SA universities. These can be divided into three categories: physical (e.g., network, compatibility, hardware, connectivity), organisational (e.g., structure, management, policy, funding) and user (e.g., information-handling activities, services, training).

This chapter summarises current computing activities in both UK and SA situations, and draws baseline conclusions about initiatives required for SuperGULFNET development starting in 1996 (based on the next SA five year Development Plan 1995-2000).

8.2 Academic view

The trends in information handling in the UK indicated by this study cover a number of particular points of interest - use of computers, electronic communication, use of IT in different
activities, types of computer used with these activities and sources of advice on computers.

Use of computers for handling research data was already fairly well advanced in the UK by the mid-1980s. As computer capabilities have become more sophisticated over the past few years (especially in terms of graphics), more opportunities for their application in research have appeared. Correspondingly, such activities as data analysis, word processing, etc., have spread more widely throughout the scientific community, until it is reasonable to expect to see saturation of usage in these areas within the near future.

The position with regard to electronic communication is different. The requirements here include access to a good network; something that has become much more readily available since the mid-1980s. It was initially expected that networking would be used particularly for exchanging data files between scientists. Though, as the results of this study show, such electronic data exchange has, indeed, expanded, the more important development has been the growth of electronic mail (with bulletin boards now also beginning to attract attention). However, this deviation from anticipated usage was soon noted, so the dominance of electronic mail recorded here is hardly unexpected.

More interesting is the way in which IT is being used for personal information retrieval. The steady growth in such activities as
searching on-line databases, using a personal bibliographic index, etc., is noteworthy. There has been speculation that networking might lead to the direct retrieval of electronic information by end-users (rather than retrieval via intermediaries). The figures presented in Chapter 5 do give some backing to the idea that the scientific community is becoming increasingly interested in automated information-handling. However, the moderate growth-rate suggests that it will be some time before personal information retrieval of this type becomes the norm.

The data concerning which computers are used by scientists indicate that there has been a continuing move towards networked micros (each with access to external computing facilities). Other equipment - such as stand-alone micros and minicomputers - has correspondingly decreased in importance. Despite recent developments in the provision of workstations, the results of this survey do not indicate a major trend, as yet, towards integrating all computer-based activities onto a single terminal. One reason may be that the range of activities has expanded too rapidly to allow this. However, the data do reflect very clearly the move towards distributed computing in British universities.

Methods of obtaining advice about the acquisition and use of IT seem to have been fairly stable over the past few years. The most noteworthy change has been the appreciable decrease in reliance on university computer centres. When the responses are broken down by subject, it is found that biologists still use computer
centres for advice as much as ever, but there has been a marked
decrease in use by physicists and chemists. The probable reason is
that physics and chemistry departments now have more widely
spread internal expertise in computers than many biology
departments can manage. Scientists involved in research
collaboration via networks are beginning to use these as a source of
advice. A number of respondents indicated that they had obtained
some of the advice they required from colleagues in other
institutions.

In SA, the situation is different in some important respects. In
terms of information handling via computers there is still a need
for the provision of more equipment and the more efficient use of
computers within the academic community. Access to computer
activities has tended to concentrate on one type of computer,
usually the microcomputer, which is not networked in many
academic departments. The smaller range of usage of computers
by SA staff, as compared with UK staff, can be explained in good
part by this. For example, use of electronic communication (e­
mail, etc.,) was by a small percentage, all amongst engineers.

Methods of obtaining advice in SA about the acquisition and use of
computers varied. One reason concerns the availability of software
which can be found on the market without manuals, but which is
copied and sold very cheaply. Thus it was found that books and
departmental colleagues are the most frequent sources used by
engineers and scientists in SA universities. A breakdown of the
sources of advice by subject areas between engineers and scientists did not show statistically different significances.

Saudi Arabian scientists make extensive use of computers (though still appreciably less than their peers in the UK). However, their use is less flexible than in the UK. More importantly, Saudi Arabian universities are still in the early states of implementing networks (both LANs and WANs). Their situation is thus rather similar to the position of British universities eight years ago. A comparison of the data given here for the current IT activities of Saudi Arabian scientists with those for UK scientists in the mid-1980s suggests that Saudi Arabian scientists in the 1990s will follow a similar path, in terms of IT use, to that already followed by British scientists.

There is an important proviso. Unlike many developing countries, Saudi Arabia has sufficient funding available to provide its university scientists with reasonable access to computers. At the same time, and in common with most developing countries, Saudi Arabia does not have adequate skilled manpower to run computer systems with maximum efficiency. At the current level of activity, this is not crippling: if a stand-alone micro fails, it can always be replaced by another. However, at the networking level, it is essential that the system be kept running. For example, electronic mail must work reasonably well and quickly, or it is not used at all. It may therefore be that Saudi Arabian use of IT for communication purposes will develop more slowly than has
occurred in the UK. It should be added that Saudi Arabian scientists and engineers are typically prepared to access and use English-language sources. The same is not necessarily true of non-scientists in Saudi Arabian universities. Consequently, use of some networked facilities may grow even more slowly for this latter group.

As a generalisation, automated information-handling in universities can be seen as passing through three stages. The first is concerned with stand-alone activities. It overlaps with the second stage, which involves networking. This, in turn, overlaps with the third stage - the provision of information services over the network. All these stages require expenditure of money, but the second and third stages also require a continuing input of effort by skilled manpower. From the viewpoint of a developing country, networking may therefore represent a jump in complexity which is as difficult to bridge as that involved in the original introduction of computers.

8.3 Management view

From the management viewpoint this study suggests that the development of IT on UK university campuses is linked to the existence and development of a good organisational IT committee structure including the merging of library, academic computing departments and computer centre under a single banner. This helps the flow of computing activities to be handled smoothly
within universities. It also assists in the developing and reviewing of major policy issues, hardware/software compatibility, training programmes, etc., between universities, and saves effort, time and money.

With regard to the SA situation, there is evidence that, although the mid-1980s saw much network development on SA university campuses, constraints are still hindering the effective utilisation of these IT facilities. There is absence of any IT committee structure within the university organisation. The university computer centre was the only department with an IT committee structure within the university organisation. Communication between academic departments and the computer centre is in most cases not well established, and is typically very limited and unstructured.

Absence of network facilities from most of the academic departments and staff offices, and lack of appropriate training programmes, have limited users' (staff, students, and administrators) awareness of, and ability to use IT equipment. Thus integrated computerisation has yet appeared on the campus. Connection with the mainframe computer has not been made, and conditions have militated against establishing campus-wide network systems.

When comparing SA and the UK we can pinpoint some of the issues that may have slowed down the growth of IT in SA. Computerisation in the UK started more than a decade before it
began in SA. It seems that the earlier introduction of computers in the UK has helped build up the computer infrastructure by making university users (staff, students, administrators and faculty members) more aware of the technology and more computer literate. Significant associations between the extent of computer technology and organisational structure exist in the UK universities. Significant numbers of institutions have recently set up IT committees which have, as their main role, the development and overview of IT strategies. The Director of Computing, Librarian (or Director of IT), and Director of Management Information Services (where such a post exists) are always members of such a committee. This has helped UK universities to built up consistent committee structures to improve network communication to all the university information systems (teaching, research and administration as well as library). Thus an IT committee structure plan is urgently needed in SA universities to develop an IT infrastructure on the university campus. Good communication between the academic, library and central computing services is required to alleviate the existing (users', networks, etc.,) problems on the campus.

8.4 Conclusions

From the previous discussions and results of comparative studies between the UK and SA, it appears that SA universities will need to devote a lot of effort and time to establishing an effective IT and networking in the country. If universities do not start this
development immediately, they will face more problems due to the spread and diversification of the IT and networking appropriate for use on campuses. In UK universities use of IT has changed considerably in recent years. Electronic communication has risen between scholars, and IT usage has diversified. It is this growth in usage, together with extensive discussions between central government, the IT industry and universities that has led to agreement concerning the recent development of SuperJANET. This interaction of government, industries and universities provides a good example of how to set up a successful system. In SA, there is a need to develop an effective national academic network system along similar lines. In general terms, a plan for SA must envisage that IT will become integrated into every academic staff office, from which there will be immediate access to computing, network and information activities. As has been discussed in previous chapters, extended use of IT has implications for the planning of future teaching, research and communication with colleagues.

The SA government will, correspondingly, need to focus its activity on the key issue of developing national network planning. Although national networks, primarily GULFNET (supported by the government) exist at present, they are not providing all the necessary information services needed by scientists, engineers and researchers. One of the reasons is that not all universities have yet been connected to GULFNET, and for those which are, the connections do not yet involve the entire campus. Another reason
is that the existing speeds on GULFNET are insufficient for effective communication between scholars in a national network setting. Finally, GULFNET currently has only a restricted range of services.

National planning entails the provision of a high-speed network between campuses so that all scholars can interact with each other in a more efficient way, and access a wide variety of information activities. Thus the existing GULFNET must be upgraded to meet this requirement. This means that the connection of regional networks, which include interconnections between LANs of educational institutions, libraries, research institutions and other organisations, must be appropriately organised. Many of these changes will have an impact on IT development both on campus and between campuses, as is occurring in the UK. This is the reason for designing a framework model (mentioned in Chapter 7) for establishing a network system in SA.

8.5 Recommendations

In the light of the foregoing summary, the recommendations in this study consider two aspects - the campus and the national. The campus includes the three universities involved in this survey KAU, KSU and KFU, and the national includes the government and KACST. Although networks in both categories are already established in SA, there is need for expansion. The following recommendations relate to this need and to the results of fulfilling it.
The campus aspect

1. Develop fully effective networks with access available in and between departments, all offices, teaching rooms and laboratories. The network systems must have the ability to interconnect all kinds of computer-based information services (e.g., library, computer centre).

Each university should centrally determine standards in the area of systems and networking to ensure compatibility, etc., on the campus. Senior people from the computer centre, library and academic computing departments will coordinate activity in this area.

2. All staff and campus students must possess basic skills associated with the use of information technology.

It should be the responsibility of each department to ensure that an appropriate basic level of skill is attained by its students and that the regulations of each undergraduate and postgraduate course of the university state the skills in IT which will be taught and assessed.

3. Each university must move towards one desk workstation per member of staff.
At present most staff do not have a workstation in their offices. Each university needs to address methods by which an increase in this provision is resourced. The workstation must have hardware, software, extensive graphical capability and connection to the campus network.

4. Make greater institutional efforts to support development of the new teaching and learning tools that will be possible with the application of the new information technologies. This may be provided by the courseware development (e.g., CAL) in different subjects.

Each university should expand the level of resources available to support the use of computers in teaching, for instance, by establishing a unit such as a Centre for Computer Based Learning. From this centre, library, computer centre and academic computing departments can cooperate to provide courseware and training materials for staff and students to enable them to use computers in their teaching/learning environment.

5. Provide the students and academic staff with an appropriate training system to ensure hands-on application of computer-based learning materials.

Each university should support an initiative on courseware which will include a request for funding training infrastructure.
for IT-based learning materials across the university. Funding should be allocated to computing services such as library, computer centre and academic computing departments for training purposes.

6. Develop and implement fully-integrated IT policies and procedures for the whole campus. This will guide the universities in exploring new avenues for, purchasing, planning and funding IT and services.

Putting this relationship in place would force each university to do some of the necessary thinking about the funding of IT and the expectations of service. People from different organisations - the Director of Computer Centre, the Dean of Library, the Director of Audiovisual Centre and the Head of Department of Computer and Information Sciences - can contribute to policy development by cooperation.

7. Develop a university organisational IT committee structure, based on well-defined functions, duties and responsibilities, to attain campus IT goals and objectives. This should lead to an examination of the value of appointing a single head of IT within the new organisational structure to ensure the necessary cooperation between IT-related groups.

Each university must undertake this development through the merging of computer centre, library and audiovisual centre
in one integrated body with one head, namely the Vice-President for Information Technology. This should lead to closer interaction between academic, library and computing centre information services. This new position must be submitted to the Cabinet to be studied, approved and signed.

On the national side

8. The planning for the development of a national network system must define exactly what the national network should be, and how it relates to the existing GULFNET (e.g., sites).

Policy makers and network designers need to have national data that identify and describe, as a minimum: the number of network users, the demographics of network users, equipment currently being used with/for network access and applications, the types and frequency of network use, the nature of the information and communication needs that networks satisfy, and the existing policies and procedures governing the operation and management of various networks.

The KACST and the government should quickly fund an initiative into the methods of upgrading GULFNET, namely to SuperGULFNET, and universities should be discouraged from making major initiatives in this area until results are forthcoming.
9. Establish different nodes within the new national system so that accessing the national network can be done via more than one path. (For example, in this study four sites have been suggested).

The KACST network manager will have to cooperate with each university representative in setting up such systems, and they are likely to get involved in nontechnical questions regarding access, security, data integrity, etc. As the applications evolve, network managers will be part of the process of planning new services.

10. Provide effective educational and training programmes for the users of the national system.

Each university should invest and allocate enough funding for national training and education purposes. Staff who are interested in using the national network system must be trained appropriately in basic IT skills. This may be provided by extended computer centre and library courses. The courses must produce an easy familiarity with the relevant hardware, keyboard skills, and training in e-mail, online searching and so on.

11. Create a National Joint Network Team to help plan the development of a national network system. This team can
review and support IT policy, planning, strategy, etc., including giving advice on funding.

The team should include people from different organisations such as KACST, Universities, Ministry of P.T.T., Ministry of Planning, Ministry of Higher Education and Ministry of Finance. It will act a promoter engine of methodological and technological change, and provide the highest quality and effectiveness of national network system.
This appendix has been compiled for this research. It contains the list of acronyms and transcription or definitions of the acronyms. These terms are used in connection with NREN in the USA, JANET and SuperJANET in the UK and GULFNET in the SA. The materials was obtained from the NREN manual text, JANET Starter Pack and from the GULFNET User Services Department, associated with textbooks.

AFRC. Agricultural and Food Research Council in the UK.

ARABSAT. Arab Communications Satellite Organisation. It is the consortium of twenty-two Arab states.

ATM. Asynchronous Transfer Mode. It is a basis for broadband (B-ISDN) services. It has been defined to run over and make use of the new interfaces and speeds associated with the SDL. It is a fixed standard size packets (53 bytes) can be carried in SDL frames transmitted at speeds of 155 Mb/s and higher.

Bandwidth. The size of the range of frequencies that are utilised in sending transmissions. The greater the bandwidth, the greater the number of channels it can carry and the greater the probability of transmitting data without error or distortion.
BITNET. Because IT's NETwork. A large network in the USA, which with EARN in Europe, NETWORTH in Canada, and GULFNET in the Middle East is technically a single network where each part has a different organisational structure.

Bridge. Hardware and software used to connect two LANs using the same logical link central but possibly different medium central.

Broadband. It is a full-motion digital resource telecommunication networks such as ISDN, SMDS and B-ISDN.

CB. Computer Board in the UK.

CCITT. Comite Consultatif International Telephoniquee Telgraphe; international organisation of the United Nations through which national telecommunications organisations coordinate their activities.

CD-A. Compact disc audio. One uniform standardised format used around the world.

CD-I. Compact disc interactive. It is a new multimedia system based on the compact disc launched in 1990. It can include high quality pictures, graphics, text and sound. The system is self-contained, so no additional computer is needed. Application software is held on disc in the form of files. The system can play
hi-fi music from existing CD-A discs and display text and graphics from CD-ROM discs. In addition, it can provide high quality video in still and moving pictures, photographs and computer graphics.

CD-V. Compact disc video.

CHEST. Combined Higher Education Software Team in the UK. They obtain commercial software for the UK Higher Education and Research Community at low price and advantageous licence terms.

CODEC. Compression and Decompression equipment used for transmitting video and voice over limited bandwidth lines.

Coloured Books. A set of interim definitions for the different aspects of networking developed and used by the UK academic and research community to allow for open system communication before the definition of international standards. The different protocols are commonly referred to by the colour of the publication cover.

CREN. Corporation for Research and Educational Networking in the USA. Organisation that operates the networks BITNET and CSNET.

EARN. European Academic and Research Network. It is technically the same as BITNET differing only in management.
ETHERNET. A high speed LAN using CSMA/CD. It was developed jointly by Xerox, Intel and Digital Equipment Corporations (DEC).

FDDI. Fibre Distributed Data Interface. An emerging standard for LAN network technology based on fibre optics.

Fibre-optic transmission. Thin filaments of glass or other transparent materials through which a light beam can be transmitted for long distances by means of multiple internal reflections.

Frame. Token ring network data packet.

FTP. File Transfer Protocol. The TCP/IP standard protocol for transferring files.

Gateway. Computer which allows communication between different networks, providing translation between different protocols and naming and addressing conventions. It lets users on a network access resources on a different incompatible network.

GULFNET. It is a computer network open to all universities, educational, academic and research institutions in Saudi Arabia as well in the Arabian Gulf Countries.

INMARSAT. International Maritime Satellite Organisation.
INTELSAT. International Telecommunications Satellite Consortium. It was formed by COMSAT (Communication Satellite Corporation) in 1964 as a global communication system in which nation-states become members by buying stock. It provides services for most of international telecommunications.

Internet. The global collection of interconnected regional and wide-area networks which use IP as the network layer protocol.

IP. Internet Protocol. The network layer for the Internet.

IPSS. International Packet Switch Stream, now known as GNE, Global Network Service. IPSS connect the UK public data network PSS to other national networks operated by PTT's.

ISC. Information System Committee of the Universities Funding Council, and took over the functions of the Computer Board.

ISDN. Integrated Service Digital Network. It is as a network to be evolved from the existing telephone network which will provide end-to-end digital connectivity to support a wide variety of services. These will include voice, picture, video and data.

ISO. International Standard organisation. The organisation which promotes and co-ordinates the development of international standards in many different fields.
IXI. International X.25 Infrastructure. The IXI network is a backbone X.25 network linking together national networks in Europe.

JANET. Joint Academic NETwork. The private packet switched network for the academic community in the UK. It is managed by the Joint Network Team for the Information Systems Committee of the Universities Funding Council on behalf of the Secretary of Education.

Joint Network Team. The UK Joint Network Team. The group funded by the UFC, PCFC and Research Councils, through the ISC, to manage the provision of a computer communications network for the higher education and research community.

LAN. A Local Area Network is one which spans a limited geographical area and interconnects a variety of computers and terminals, usually as very high data rates.

MOTIS. Message Oriented Text Interchange Service. The ISO standard for a message handling system which is nearly the same as the CCITT recommendation.

Multiplexer. It is a device that combines data streams from several sources to use a high-capacity digital ink efficiency. In other word, it is an equipment or device that combines a number of message signals on to a single tributary.
MVS/VM. It is an IBM operating system. It enables MVS support TSO which provides interactive access to MVS batch job submission and output facilities. This provides minimal access to GULFNET.

NERC. National Environment Research Council in the UK. It is managed by the Joint Network Team (JNT) for Information System Committee (ISC) of the Universities Funding Council (UFC) on behalf of the Secretary of State for Education.

NREN. The National Research and Education Network. It is a high-speed network system developed in the USA to replace or upgrade Internet system.

NERC. Natural Environment Research Council in the UK.

Network. A set of interconnected computers, peripherals and terminals. Its purpose is to enable each computing service to be accessed from other computers and terminals.

NSFNET. The US National Science Foundation Network. The national backbone network in the US for research applications. It is funded by the National Science Foundation and operated by the MERIT Corporation. It is used to interconnect regional networks, and is part of the US Internet.

Optical fibre. It is the optical transmitter to send messages through either a light emitting (LED) or a laser source.
OSI. Open System Interconnection. An architecture of communication based on vendor independent standards, in which the aim is to remove technical impediments from the process of communication between unlike systems.

Packet. A block of information with a defined format containing control information and data. The form in which data is transmitted over a packet switched network.

PAD. Packet Assembler Disassembler; the hardware or software interface between a user's terminal and packet switching network. A PAD assembles the user's input characters into packets for network transmission, and disassembles packet of output characters into their component characters for output on the terminal. It is a software running on a general purpose machine.

PBX. Private Branch Exchange. A private telephone switching system usually located at the user's premises.

Protocol. A formal description of message formats and the rules two computers must follow to exchange those messages.

PSDN. Public Switched Data Network. Typically a digital network especially suitable for data communications and operated by a PTT.
PSN. Packet Switched Network. A network where individual packets of information are routed independently to their destination. The equipment making up the network is shared by all users at all times, packets from different terminal being interleaved throughout the network.

PSS. Packed Switched Stream. British Telecom's packet switched network.

PSTN. Public Switched Telephone Network. The voice network generally reached by dialling a telephone. In the UK the PSTN is operated by the PTOs, namely by Public Telecommunications Operators.

RARE. Reseaux Associes pour la Recherche Europeenne, the association of European research networks and their users.

Relay. A host which is used to forward terminal characters, files, or electronic mail, making any necessary protocol transformations.

Repeater. Hardware and software required to join two LAN segments using the same protocols but possibly different physical media. On a broadband LAN repeaters are called amplifiers. Repeater operate at the physical layer of OSI protocol suite.
**Routers.** Hardware and software used to connect two LANs that have the same network architecture through the first three levels of the OSI model.

**SDH.** Synchronous Digital Hierarchy. It is a digital transmission technologies that enable higher bandwidth intersite application to be supported.

**SERC.** Science and Engineering Research Council in the UK.

**SDH.** Synchronous Digital Hierarchy.

**SMDS.** Switched Multi-megabit Data Service. It is an advanced wideband dial-up digital service for the integration of high-speed LANs.

**SMPT.** Simple Mail Transfer protocol. The TCP/IP protocol for e-mail.

**SNA.** System Network Architecture. A network architecture conceived by IBM, but adopted by a number of computer manufacturers.

**SuperGULFNET.** An initiative similar to SuperJANET to create a high-speed network performance to support SA higher education and research organisations.
SuperJANET. An initiative to create a high performance wide-area network based on optic fibre technology to support UK higher education and research.

Switch. It transfers blocks or packets of digital information from one particular incoming channel to a specified outgoing channel. It is in contrast with multiplexer.

TCP/IP. Transport Control Protocol/Internet Protocol. This is a common shorthand which refer to the suite of applications and transport protocols which run over IP. These include FTP, Telnet and SMTP.

Telnet. The TCP/IP standard protocol for remote terminal connection service. Telnet allows a user at one site to interact with a remote timesharing system at another site as if the user's terminal was connected directly to that computer.

Transponder. A receiver-transmitter combination that retransmits the received signal, greatly amplified and at a different frequency. Communication satellites usually contain several transponders.

UFC. University Funding Council (formerly was UGC) in the UK.

UGC. University Grant Committee in the UK.
WAN. Wide Area Network. A network where the services may be a long way apart, e.g. SuperJANET.

Wideband. It is similar to broadband such as ISDN, SMDS and B-ISDN.

X. Windows. A protocol for carrying bits mapped terminal sessions across a network.

X.25. The CCITT recommendation defining the interface between a computer or terminal and a packet switching network.

X.28. The CCITT recommendation defining the interface between the terminal and the PAD.

X.400. The CCITT recommendation for a message handling system protocol.

X.500. The CCITT recommendation for directory services.
The accompanying questionnaire on computer usage is a repeat of one originally circulated in 1985. We hope that, by repeating the questionnaire in a very similar form, it will be possible to assess how automated information/data handling by university staff and research students has changed since the mid-1980s. At the same time, the data collected from this questionnaire will be matched with data being collected from overseas to provide a comparative picture.

Obviously, the more questionnaires are returned, the more certainly we can define any changes that have taken place. The questionnaire has been designed to be as short and simple as possible. I hope you will feel able to complete it and return it. As you can see, you are not required to identify yourself, so the information supplied will certainly be confidential.

I look forward to receiving your reply. May I thank you in anticipation for your help.

A. A. Bukhari
Department of Information and Library Studies
Loughborough University of Technology
Appendix I

COMPUTERISATION OF INFORMATION QUESTIONNAIRE

Please fill in brief answers alongside the questions or tick the box with the correct answer.

1. (a) Are you a member of the academic/research staff or a postgraduate research student?
   Staff ☐ Research student ☐

   (b) Please indicate what department

2. During the past 12 months, have you personally used a computer for any of the following:

   Collection of data from experiments ☐
   Statistical analysis of data ☐
   Graphical display of data ☐
   Wordprocessing ☐
   Electronic sending/receiving of mail ☐
   Electronic exchange of data with researchers outside your university ☐
   Reading/writing on academic bulletin boards ☐
   Searching an on-line database ☐
   Holding an electronic diary/scheduler ☐
   Holding a personal bibliographical index ☐
   Holding a non-bibliographical index/database ☐
3. If you hold an electronic index or database, please give a rough indication of its contents, e.g. 'address lists' or 'list of experimental methods'.

4. (a) If you use the same computer for all the tasks mentioned in Question 2, what type of computer do you use?

- Stand-alone microcomputer
- Networked microcomputer
- Minicomputer
- Mainframe

(b) If, on the other hand, you use different computers, please specify the types of computer used and the tasks performed on each computer:

5. If you do use a computer in your research work, from where/whom did you get advice and information about computerisation?

- University computer centre
- Local Computer shop
- Departmental colleagues
- Departmental superiors
- Program/computer manuals
- Books
- Computer magazine article
- Academic journal article

Other (please specify): _______________________

-424- Appendix I
المملكة العربية السعودية
وزارة التعليم العالي
جامعة الملك عبد العزيز
كلية الآداب والعلوم الإنسانية
قسم المكتبات والمعلومات

سعادة عضو هيئة التدريس
أخي الزميل بالجامعة

سلام عليكم ورحمة الله وبركاته ...
واعد ان الاستبيان الذي أمامك سوف يساهم مساهمة فعالة في تحديد الدور الذي يقوم به الحاسب الآلي (الكمبيوتر) في سير العملية التعليمية والبحثية لدى الإكاديين العاملين في الاقسام العلمية بالجامعة، وأيضًا 
ليساعد على فهم أكبر لبعض المشاكل والتي قد تواجه مستخدمي الحاسب الآلي في بعض الاقسام العلمية في حالة استخدام شبكات الحاسب الآلي المختلفة والتي تكون الجامعة قد وفرتها لمسيرتها.
أرجو التكرم منكم بتعبئة هذا الاستبيان المرفق ومساهمتكم هذه السعيين الباحث بذان الله في الحصول على نتائج قيمه ورافييه وبالتالي إيجاد طريق مجدبه ومرضيه عن كيفية تقديم خدمات أفضل لمستخدمي الحاسب الآلي بالاقسام العلمية في الجامعات السعودية
شاكراً لكم هذا التعاون المثمر وبالله التوفيق

-425-
Appendix I
استبيان عن استخدام المعلومات في الحاسب الآلي

فضلاً إكمال الإجابة باختصار مع وضع علامة X أمام الإجابة المناسبة داخل المربع أمام كل عبارة.

(1) ما هي رؤيتك في الجامعة؟

☐ (أ) عضو مينة تدريس
☐ (ب) باحث
☐ (ج) طالب دراسات عليا
☐ (د) القسم المعنوي إليه

(2) هل استخدمت الحاسب الآلي خلال السنة الماضية في أحد الأغراض التالية؟

☐ لا

☐ если كانت الإجابة بنعم فضلاً وضع علامة واحدة X أو أكثر حسب ما تراه مناسب:
☐ جمع معلومات أو بيانات عن تجارب أجريتها
☐ تحليل إحصائي للنتائج
☐ نماذج وتكاملات رقمية
☐ رسومات بيانية للنتائج
☐ تصميم
☐ عمل تطبيقي متطرف مثل
☐ عمل برامج نافذات مثل
☐ استخدام معالجة الكلمات
☐ عمل بريد الكتروني
☐ البحث مباشر (Searching an on-line database)
(3) إذا كان استخدامك للأغراض السابقة في السؤال الأول على جهاز حاسب إلي واحد (نوع واحد)، فما هو نوع الجهاز الذي استخدمته؟

| □ | (Stand-alone Microcomputer) حاسب آلية مستقل |
| □ | (Networked Microcomputer) حاسب آلية متصل بشبكة داخلية / خارجية |
| □ | (Mainframe) حاسب آلية متصل بشبكة الجامعة الموسعه |
| □ | (Others) حاسبات آلية أخرى |

(4) إذا كان استخدامك للأغراض السابقة الذكر في السؤال الثاني على جهاز حاسب إلي آخر أو مختلف، فضلاً حدد نوع الجهاز والعمال الذوي انجزتها في كل جهاز؟

| □ | مركز الحاسب الآلي بالجامعة (Manuals) دليل الحاسب الآلي |
| □ | محلات بيع أجهزة الحاسب الآلي |
| □ | كتاب ومراجع من زملاء بالقسم |
| □ | مجلات ومقالات الحاسب الآلي |
| □ | مشرف له الخبرة في الحاسب الآلي |
| □ | دوريات علمية متخصصة |

مصادر أخرى:

شكراً لمساعدتكم ومشاركتكم في تعبئة هذا الاستبيان؟

-427- Appendix 1
Appendix II

University computing centre director interview

1. Do you think that the existing IT resources (hardware equipment, software applications, etc.) provided by the computer centre match the present needs of the university users (students, faculty, staff and administration)?

2. What sort of policy do you have for deciding what new equipment (IT of all kinds) to purchase?

3. Are budget allocations for (1) acquisition and (2) ongoing operation of IT services in the computer centre sufficient? Are they consistently maintained from year to year?

4. What connection is there between the funding for the central computing and the funding for departments?

5. To what extent is the computer centre networked to other departments/units in the university?

6. What is your policy with regard to extensions of networking in the future?

7. What kind of services does the computer centre provide (1) face-to-face and (2) via networks?

8. How do computer centre staff keep up-to-date?
9. How is the university trying to provide effective communication between the computer centre and other campus activities, such as the library, faculty, administration and so on?

10. What sort of forward planning is the university as a whole doing with regard to the use of IT in (1) teaching, (2) research and (3) administration?
أسئلة المقابلة الشخصية
مركز الحاسب الآلي

هل تعتقدون بأن الأجهزة التكنولوجية الموجودة في المركز (حاسبات
الي، عدد الحاسبات، طابعات، الشبكات... الخ) تتوافق أو تناسب مع
احتياجات المستفيدين (اكاديمي، باحث، اداري، طالب... الخ)؟
إذا كانت الإجابة بلا؟ ماهو مقدار النقص أو العجز في ذلك؟

ما هي السياسة المتبعه لإتخاذ القرار في عملية شراء أجهزة جديده؟

هل حصص الميزانية لتشغيل الأجهزة و صيانتها كافيه؟ وهل تمون
ثبتات من سنة اللي اخري؟

هل توجد هناك صلة أو علاقة نسبيه بين ميزانية مركز الحاسب
الاولي والحاسب الآلي في اقسام الكليات الاخري؟

الي أي مدي وصل توسعة شبكة الحاسب الآلي المركزي بالاقسام
أو بالوحدات الاخري في الجامعة؟

ماهي السياسه المتخذه حيال توسعة الشبكة الداخلية والخارجيه
للمستقبل؟
ما هي الخدمات التي تقدمها مركز الحاسب الآلي من خلال
شبكة الحاسب الآلي، 2-وجها لوجه للمستفيدين؟

كيف يقوموا موظفوا المركز بنمو معرفتهم تجاه استخدام أجهزة
المركز (حاسبات، طابعات، برامج، اتصالات...الخ)؟

ماهي نظرة الجامعة تجاه تجهيز وتعميد أجهزة الاتصالات
التكنولوجية بين مركز الحاسب الآلي والأقسام الأخرى مثل المكتبة
المركزية، الكليات، الأدارات؟

ماهي الطرق أو الأساليب التي تنظر إليها الجامعة للخطط الأمامية
و المستقبلية تجاه استخدام تقنية المعلومات في التدريس، في
الإبحاث، وفي الأدارات؟

Appendix II
Departmental computing representative interview

A. General

1. What computers and terminals (numbers and main types) are available within the department?

2. What other computers are accessible to users (e.g. via the computer centre)?

3. What arrangements are there for networking? What other forms of IT are available?

B. Policy

4. Is there a policy to acquire equipment on a regular basis, or by occasional major purchases?

5. Who within the department (1) decides and (2) is consulted about IT purchases?

6. Does the department have an overall acquisition policy, or do staff have individual freedom to decide?

7. To what extent is your future acquisition policy determined by past purchases?

8. Do you feel that you can provide adequate financial, personnel and physical resources to support your departmental IT?
9. Who determines how/when/where your equipment is used?

10. Do you feel that the potential of your equipment is being fully exploited?

C. User

11. Does everybody in your department use your equipment? Do they all make equal use of it?

12. Do your staff have an adequate knowledge of IT for their needs?

13. Do users receive any training on computers, or do they mainly teach themselves?

14. Do you think that job roles, or the organisational structure of the department have changed at all because of computerisation?

15. Has computerisation altered the style of working (e.g. of teaching) within the department? Has it altered efficiency at all?

16. Do you think that integration of computer activities (e.g. use of a multi-purpose workstation) is increasing? What are the advantages and disadvantages?

17. Are there any particular factors that you feel are holding back computerisation within the department?

18. To what extent are you in touch with the computer centre? Do you think you can obtain all the advice and assistance you need either from there, or from some other external source?
البيان:
ما هو نوع وعدد الحاسبات الآلية والبرمجيات الموجودة في القسم؟
ما هي الحاسبات الآلية الأخرى المتاحة للمستفيدين والممكن استخدامها عن طريق شبكة مركز الحاسـب الآلي بالجامعة؟
هل يوجد هنا تمريـب أو استعداد لربط أجهزة حاسبات القسم بشبكة داخلية أو شبـكة الجامعة الموسعـة؟
سياسة القسم:
هل للقسم سياسـة أو قاعدة عامة في شراء الأجهزة (حاسبات، طابعات، الخ) أم أنها تدعم من داخل المشترى والمصادر العامة بين الفينه و الفينه؟
من من داخل القسم 1 يقرر 2 يستثمار في شراء الأجهزة؟
هل القسم لديه سياسه عامة في تمويل الأجهزة لأعضاء القسم أم ان الأعضاء لديهم الحريـة
الإنترادي في ذلك (مثلا: استعارة جهاز حاسب للتدريس، شراء
جهاز حاسب آلية، استعارة معمّل حاسب آلية
للتدريس...الخ) ؟

الي أي مدى وصل استغلال القسم من سياسة
المشتراطات السابقة (حاسبات آلية، طابعات، توسعة
الشبكة...الخ) والاستفادة منها في سياسة الشتاتروات
المستقبلية؟

هل تشعّر أنكم تستخدمون جهّيز الموارد المالية
والإداريّة (الوظيفيّن) والفنيّة (الفنيّيّن) في تدعيّم
القسم؟

من يقوم بإتخاذ القرارات لكل من 1- كيف 2- متّن
3- وأين تستخدم الأجهزة؟

المستفيد:

هل تشعر أن الأجهزة الموجودة في القسم تستخدم بفاعلية؟

وتقوم بإعطاء الغرض المطلوب للمستفيد؟

هل كل شخص في القسم يقوم بإستخدام الجهاز؟ وهل تعتقدون أن
هناك مسأئآ في استخدام الأجهزة؟

هل أعضاء القسم (اكاديميين، اداريين، الخ) لديهم المعرفة الكافية
في استخدام الأجهزة لاحتياجاتهم؟

Appendix III
هل هناك برامج تدريبية تعتمد للمستفيدين (أكاديميين، إداريين، باحثين، الخ) أم أنهام يقومون بتدريب أنفسهم؟ وإذا كانت هناك برامج تدريبية فهي يقوم بتجهيزها؟

هل تعتقدون أن قواعد العمل أو التنظيم الإداري في القسم تغير بسبب استخدام الحاسب الآلي ومشتقاتها؟

هل الحاسبات والأجهزة الآلية غيرت في أسلوب العمل داخل القسم (مثل: التدريس، الخ)؟ هل غيرت فعالية العمل؟

هل تعتقدون أن استعمال الحاسب الآلي لغرض القيام بعدة وظائف يزيد من فعاليته؟ وماهو فوائده وماهو الاضراره؟

هل هناك أي مشاكل خاصة تعوق من استخدام الحاسبات في القسم؟

ما مدى حجم إتصالكم بمركز الحاسب الآلي؟ هل تعتقدون أنكم تستطيعون الحصول على كل المعلومات والاستشارات التي تحتاجونها من مركز الحاسب الآلي أو من مصادر خارجية أخرى؟
1. What general policy planning is there in Saudi Arabia which may affect the provision of information technology in higher education?

2. What plans are there for an expansion of networking in higher education?

3. What limitations on the use of computers and networks may affect higher education in the future?

4. What plans are there for training users and for encouraging the use of information technology?

5. Will training be given equally to (1) staff, (2) research students, (3) other students?

6. What further provision of networked services is likely to take place over the next few years?

7. To what extent is there a demand for more information technology in higher education (or is the demand following the supply)?
أسئلة المقابلة الشخصية
 مركز الملك عبدالعزيز للعلوم والتكنولوجيا

ماهي السياسة أو الخطط العامة الموجودة لديكم بهدف توفير و تطوير واستخدام تكنولوجيا المعلومات على مستوى التعليم العالي؟

ما هي الخطط الموجودة لديكم لتوسيع شبكة الحاسب الآلي في مجال التعليم العالي؟

ما هي العوائن التي تحد من استخدام الحاسبات الآلية وشبكات الحاسبات الآلية في التعليم العالي؟ وما تأثيرها مستقبلاً؟

ما هي الخط المتبوع لتدريب وتشجيع المستفيدين من استعمال تكنولوجيا المعلومات (الحاسبات، الشبكات، الخ)؟

هل فرص التدريب تمنح بالتساوي لكل من: 1-الإداريين 2-الفنين 3- الباحثين؟

ما هو تصوركم تجاه مستقبل الخدمات التي سوف تصل إليها شبكات الحاسب الآلي في خلال الخمس السنوات القادمة؟

ما هو مدين الطلب على استخدام تكنولوجيا المعلومات في التعليم العالي؟ هل الطلب يتبع لسد الحاجة؟

Appendix IV
Details of the people interviewed in SA and the UK during the course of this research project.

<table>
<thead>
<tr>
<th>Name</th>
<th>University</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>In the UK</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mr D C Hogg</td>
<td>LUT</td>
<td>Director of Computer Centre</td>
</tr>
<tr>
<td>Professor P H Ford</td>
<td>NU</td>
<td>Director of Computer Centre</td>
</tr>
<tr>
<td>Mr J Wilson</td>
<td>LU</td>
<td>Director of Computer Centre</td>
</tr>
<tr>
<td>Mr P. Blake</td>
<td>LUT</td>
<td>Departmental Computing Representative (Business School)</td>
</tr>
<tr>
<td>Mr G. B. Samrah</td>
<td>LUT</td>
<td>Systems Manager (Computer Studies)</td>
</tr>
<tr>
<td>Mrs B. Hollett</td>
<td>LUT</td>
<td>Departmental Computing Representative (Civil Engineering)</td>
</tr>
<tr>
<td>Mr A Schappo</td>
<td>LUT</td>
<td>Departmental Computing Representative (Computer Studies)</td>
</tr>
<tr>
<td>Mr G F Sargent</td>
<td>LUT</td>
<td>Departmental Computing Representative (Information and Library Studies)</td>
</tr>
<tr>
<td>Ms A Braithwaite</td>
<td>LUT</td>
<td>Departmental Computing Representative (Chemical Engineering)</td>
</tr>
<tr>
<td><strong>In the SA</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr Nassar Sheikh</td>
<td>KFU</td>
<td>Director of Data Processing Centre</td>
</tr>
<tr>
<td>Dr Abdulhalim Mazi</td>
<td>KSU</td>
<td>General Manager for Computing and Information Processing</td>
</tr>
<tr>
<td>Dr Abdullah Jifre</td>
<td>KAU</td>
<td>Director of Computer Centre</td>
</tr>
</tbody>
</table>
Dr Mohamed Al-Taieb  
KFU  
Head of Faculty of Engineering and Computer Science

Mr Mohamed Kamal  
KSU  
Departmental Computing Representative (Faculty of Administrative Science)

Dr Omer Hamid  
KSU  
Head of Computer and Information Sciences

Dr Abdulaziz Al-Misfer  
KSU  
Departmental Computing Representative (Library and Information Science)

Mr Atif Kattan  
KAU  
Departmental Computing Representative (Library and Information Science)

Dr Abdulghani Al-Gasmi  
KAU  
Departmental Computing Representative (College of Engineering)

Dr Roshdi Gholam  
KAU  
Head of the Department of Computer Science

Mr Mohamed Al-Tasan  
KACST  
General Manager for Information Systems

Mr A Rahman Al-Moamer  
KACST  
Director of National Networking

Mr A Rahman Al-Rezehi  
KACST  
Director of Computer Department

Keyword

LUT: Loughborough University of Technology
NU: Nottingham University
LU: Leicester University
KFU: King Fahd University
KSU: King Saud University
KAU: King Abdulaziz University
KACST: King Abdulaziz City for Science and Technology
This appendix includes the Development Plan in the Kingdom of Saudi Arabia for fifteen years starting from the period of (1400-1415 A.H.) (1980-1995 A.D.). The third development plan (1400-1405 A.H.) (1980-1985 A.D.) is not included here in detail. Thus the objectives and policies have been selected from the fourth development plan manual book.


Objectives and Policies:

The objectives and policies within the third development plan were to increase the student population in the SA universities, and to overcome the shortages of manpower in the human resources in general. Policies included: encouraging enrolment for secondary students to come to university for higher education, and providing enough students in all educational fields, but in science and technology in particular to meet the Kingdom's need.

In science and technology, policies covered the following activities: promoting scientific research in the Kingdom, establishing
information services at KACST to serve all sectors of the Kingdom and arranging international scientific and technical co-operation with many databases at KACST in different scientific fields (such as engineering, science and medicine). So the emphasis during the Third Plan was to build up central research databases to serve all sectors of the Kingdom.


A. Strategy in Higher Education

Objectives:

- To continue to pursue each institution's chartered purpose;
- To improve instruction and research programme quality;
- To achieve co-ordinated staff development over the long-term, in order to meet the Kingdom's needs for university trained manpower and university centred research more effectively.

Policies:

- improving administrative staff services and devising more efficient systems and methods of work;
- reappraising priorities for expanding programs of instruction, research, and services. This may include finding new ways to co-ordinate activities with other institutions to achieve
economies of scale in human resources of particular urgency to the Kingdom.

- achieving more national resources as needs exist. The supporting policy directs each higher education institution and the Ministry of Higher Education to collaborate in the preparation of a policy framework or 'master plan' for higher education development.

Programmes

Administration and General Control: This programme aims for improved educational services through more effective and efficient administrative services. Specific elements of the programme concern improvements in manpower utilisation, accelerated progress toward Saudisation of staff, and adoption of modern techniques to facilitate administrative functions.

Instruction and Research: Improvement in instruction quality and applied research. The policy seeks to institutionalise a commitment to systematic evaluation and empirical trial as the surest way to improve policies, programmes and practice. The research programme includes both basic research and research applied to practical problems faced by public or private sectors, or both.

Recruitment and Staff Development: The focus of this programme is on improving the performance of institutional staff
in all categories. Such activities as on-job training, seminars, and scholarships to support individual study will be implemented as means for increasing the productivity of staff.

**Maintenance:** The maintenance programme covers the functions of operation and maintaining educational facilities (e.g., building, research areas).

**Construction:** The construction programme provides for design, construction and installation of capital equipment in new facilities.

**B. Strategy in Science and Technology**

**Objectives:**

- to intensify the transfer, development, adaptation and use of advanced technology;
- to strengthen research and development capabilities within the Kingdom;
- to support the development of scientific and technical manpower within the Kingdom;
- to enhance its own performance through improved management systems and physical facilities.
Policies:

- complete all of the long-term policy and plan for science and technology by mid-1407 (mid-1987);
- implement procedures for annual reviews and revision of the plan from 1408 (1988) onward;
- increase effort to co-ordinate research activities at the universities and direct them towards the Kingdom's development needs;
- assist industry in building its own science and technology capabilities, working closely with the universities;
- stimulate and monitor research and development projects in fields relevant to the Kingdom's needs.

Programmes

Support of Applied Research and Development (R&D) Projects: This programme focuses on research and development efforts in fields of particular relevance to the Kingdom's development. One aspect of the programme involves research grant support to individual scientists and research institutions. Another aspect is national R&D programmes of an interdisciplinary nature that affect economic and social development. The third aspect of the programme concerns means for accelerating the application of R&D findings.
Technology Transfer to Producing Sectors: This programme will respond to technological problems and requirements of the producing sectors of the economy. Programme elements include: establishing an industrial technology database; organising a network of engineers and scientists to provide technical consultations; analysing technology transfer needs; and establishing a national system to protect patent rights.

Science and Technology Development Plan and Improvement of Public Awareness: National policies and long-term plans for scientific and technological development have been in preparation for some time. A major goal of the Fourth Plan is to complete this work, including mechanisms for periodic review and refinement of policies and plans. Part of the programme will also be directed towards increasing public awareness and understanding of science and technology through television and other media.

Building SANCST Campus: This programme will concentrate on stages in the construction of physical facilities appropriate to SANCST's mission. Immediate projects concern a 'science community' adjacent to King Saudi University. Another element of the programme is the preparation of feasibility studies for national laboratories, either as central facilities or in conjunction with those of the Kingdom's university system.
Improvement of Administrative Structure and Technical Services: This programme aims to improve SANCST's overall performance capabilities. Specialised elements of the programme include the upgrading of computer support systems and database, and extending the capability for computerised translation of scientific and technical documents and publications from resources outside the Kingdom. Research centres at the universities will ensure the application of this research for the overall benefit of society, with the co-ordination and co-operation of SANCST.

Fifth Development Plan (1410-1415 A.H.) (1990-1995 A.D.)

A. Strategy in Higher Education

Objectives:

- to improve the curriculum which encourage the development of problem solving skills and creativity, and to introduce computer education as an integral part of the curriculum at the intermediate level, and as an awareness programme at the elementary level;

- to produce additional alternative training opportunities to make more widely available by establishing closer linkages between the education and training systems.
Policies:

- Improve students' attitudes and expectation by achieving good computing skills and provide professional skills to meet Kingdom's manpower computing needs.
- Improve the quality and efficiency of the universities training programmes, such as linkages between higher education institutions and private sectors (e.g., company, industry).

Programmes

Education Process and Development: This programme provides computing education services to all levels of the system and it covers the education process and its development. It will provide to the best and brightest Saudi professionals opportunities to develop into world professionals, and will strengthen linkages between the universities, the private sector and government.

Professional Competence of Training Personnel: This programme includes the preparation and co-ordination of training programmes between universities and training systems to upgrade academic staff training in accordance with the responsibilities, whilst university graduates will be attracted into the early stage of education with adequate preparation.
Management and Operation: This programme includes administration services and the use of new technology in providing a cost effective administrative system.

Operation and Maintenance: This programme covers the expenditures on staff and materials necessary for the maintenance, cleaning and operation of all building in the higher education sector.

Construction: This programme aims at constructing, equipping and expanding buildings and laboratories in order to meet the continuing increase in the number of male and female students.

B. Strategy in Science and Technology

Objectives:

- to develop necessary human resources for science and technology;
- to support and promote R&D activities in the private sector;
- to consolidate the science and technology infrastructure.

Policies:

- conduct and promote R&D activities oriented towards the development needs of the Kingdom;
- consolidate the research infrastructure that supports scientific and technological activities;
- promote the development of highly qualified manpower;
- strengthen international co-operation in scientific and technological fields;
- to intensify and deepen public awareness and understanding of science and technology

Programmes

**Long Term Plan for Science and Technology:** This programme concerns the development of a long term master plan for science and technology in the Kingdom, based on studies of existing R&D activities and available resources. The master plan will focus on appropriate future directions of R&D, the longer term needs of Saudi society and the full co-ordination of multi-sectoral activities relating to science and technology.

**Supporting Services for Science and Technology:** This programme aims to consolidate the infrastructure for science and technology by up-grading computerised information services and providing the necessary patent services and legal framework for the introduction of new technologies. An important aim of the programme will be to establish a technology development and transfer system to facilitate the adoption of new technologies in the private sector, thus enhancing the competitiveness of Saudi
industries in international markets. The construction of KACST's campus, including basic service facilities, will be continued.

**Science and Technology Awareness Programme:** This programme will mobilise numerous means and opportunities, such as the mass media (TV, radio, newspapers), symposia and exhibitions, as well as education at all levels, to deepen the public's awareness and understanding of science and technology. Technology-related news, programmes, publications, and seminars will be made more widely available to people in general, while 'Science Clubs' and other functions will be organised for young people interested in science and technology.

**International Co-operation:** This programme aims to advance the level of science and technology through the introduction of technology from foreign countries for further development in the Kingdom. Special efforts will be made to make such technological development appropriate to the particular circumstances of Saudi Arabia. Further international collaboration, in terms of joint Saudi-foreign R&D activities, will be promoted through grants from KACST in conjunction with the Offset Programmes. International information services will be strengthened through linkages with GULFNET, BITNET, EARN, and other computerised communications networks.
IT policy development

As a part of the study of IT policy in British universities, relevant documentation was obtained from each of the universities investigated. At Loughborough University, the main source of policy was a report of the Information Technology (IT) Group Policy at Loughborough University, submitted to the Resources and Planning Committee. It described the strategies that had been examined and a series of proposed mission statements which might form the basis for an institutional strategy on information technology. A similar report 'Information Technology Strategy' was obtained from Nottingham University. This included a discussion of IT strategy and policies for developing IT on the campus. At Leicester University, a brief overview of 'IT Strategy and Guidelines' formed the basic policy document. This offered advice on the establishment and review of an IT strategy.

These materials were collected at the same time as the interview were carried out. Their contents were considered in the light of the needs of SA universities. This led to the suggested prototype policy document for SA universities which now follows:
A. Hardware policy

Procurement policy

The service will:

- Work with computing representative groups to provide advice for bulk acquisitions in the preparation and handling of a specification of requirements.
- Undertake evaluations of hardware to meet specific needs and/or to meet generic needs to an agreed standard. Will keep report of evaluations and findings.
- Maintain a list of recommended hardware and standard configurations and preferred suppliers.
- Operate an acquisitions service on behalf of clients and departments including the testing of equipment upon receipt.

Support policy

The service will:

- Develop and maintain staff expertise to fully support hardware on a recommended list.
- All hardware obtained on behalf of campus departments will be offered a minimum of a third-party maintenance agreement.
- All equipment on the approved list will be the subject of comprehensive maintenance agreements either through bulk contracted (third-party) maintenance arrangement or through an in-house maintenance team.
B. Maintenance policy

The service will:

. Arrange maintenance service contracts through a third party or an in-house team on hardware which falls within the categories of machine under the agreed support policy.

. In arranging such contracts, endeavour to obtain best-price terms consistent with service quality considerations. Periodically the contract schedules will be put out for competitive tender.

. For machines of a common generic form, carry a spares holding and provide service through an in-house maintenance team. This team will be required to be competitive in fixing contract prices.

. Maintain an inventory of available IT facilities across the institution which can be used to provide schedules for contract purposes.

. Renew contracts annually but at least six months' notice will be required to terminate cover for specific equipment.

C. Software policy

Procurement policy

The service will:

. Assist the campus departments in assessing the need for, and suitability of, software.
Contribute to the selection process, taking into account the following criteria:

a) purpose
b) suitability
c) alternative supported products
d) commercial viability of supplier
e) relevance to the course objectives
f) support requirement

Undertake an evaluation service to contrast requirements with functionality offered to include:

a) ease of use
b) configuration requirements
c) peripherals required
d) quality of product
e) update service
f) compatibility with other products

Identify software needs when preparing specification of requirements.

Maintain lists of preferred suppliers based on best terms and support offered for a supported range of software products.

Regularly review the preferred supplier list against best terms criteria.
Support policy

The service will:

- Maintain a contact with a supplier 'hot-line'. The department would be advised to subscribe to a supplier support and maintenance service if expertise is not available within the university.
- Make available relevant news letters/journals circulated by the software vendor or vendors.

D. Network policy

The service will:

- Maintain a campus-wide data network for the provision of computing connectivity.
- Provide computing terminal connectivity to all academic offices on demand.
- Maintain a link to the GULFNET for remote communication via KACST.
- Provide network access at all times, excepting previously notified interruptions for maintenance.
- Provide access to the Library OPAC catalogue.
- Maintain a central server for electronic mail and file transfer.
- Provide relaying of electronic mail to suitably supported host systems.
E. User policy

The service will:

- Procure, install, and set up hardware and software for node laboratories and academic staff offices.
- Provide the media supplies (paper, ribbons, ink, toner, etc.) that are needed to support the operation of laboratory equipment.
- Provide details of services: opening hours, staffing, resources, that will be regularly updated and made available to campus users.
- Facilitate communication both within the university and with colleagues in other universities.
- Provide access from the desktop to all types of information services, ranging from automated library facilities to electronic databases held locally (e.g., on CD-ROM), nationally and indeed internationally.
- Ensure availability of all types of computing facilities that might be needed to support research and teaching.
- Provide a modern telephone exchange which can effectively support the work of the university. This implies adequate provision of individual lines; direct-dial facilities where appropriate.
Training and information service policy

The service will:

- Provide a range of documents which will give training in the use of specific applications, hardware or services (e.g., e-mail), currently in widespread use within the campus.
- Provide a variety of technology based training (TBT) products for individual use.
- Provide a collection of information about courses and training materials available from external sources.
- Provide documentation relating to services and facilities available, software and training material.
- Provide information for dissemination to the whole campus to impending changes, current events, and special hardware/software initiatives.
- Provide an advisory service to assist and advise in the use of facilities, software, in-house expertise, etc.

Staff support policy

The service will:

- Provide hardware/software resources to meet documented course requirements.
- Provide individual assistance with software and hardware use in node laboratories.
- Provide a higher level of support in areas of computing services staff specialisation to staff undertaking research.
Provide information and advice on all specific and general IT related queries.

Provide researches to support the production of teaching materials, individual learning and the development of professional skills.

Provide informal training sessions and assistance with specific software where applicable.

Develop teaching software material and assist with questionnaire and data analysis in support of curriculum developments and research.

**Student support policy**

The service will:

- Provide individual assistance with software and hardware use in node laboratories.
- Provide a higher level of support in areas of computing services staff specialisation to students undertaking projects and assignments.
- Provide informal training sessions and assistance with specific software where applicable.
- Provide information and advice on all specific and general IT related queries.
- Provide resources to support individual learning and the development of professional skills. (This could include graphing packages, CD-ROM resources, and other related general interest and software applications).
Provide associated resources: magazines, books, journals.
BIBLIOGRAPHY


ALBANESE, A. Service negotiation among network management entities. *Computer Communications*, 1993, 16(2), 128-133.


BAKER, J., ed. The subject enhancement of OPAC records and the need for multilingual access. Vine, 1993, (90), 33-35.


BENFORD, S. Building group communication on OSI. *Computer Networks and ISDN Systems,* 1991, (23), 87-90.


-Bibliography-


FINNEGAN, P. Planning for information systems resources. *Journal of Information Technology*, 1993, 8(3), 139-150.


GARDNER, N. Two reports on the computer literacy workshop held at the University of Durham. *CTISS File*, 1991, (11), 50-53.


-475- Bibliography


RICHARDSON, T. The implications of new educational technologies on educational accommodation and systems in the next 5-10 years. *Computer Education*, 1993, (73), 6-11.


SOFI, W., ed. Support of computer IT in the development of administrative procedures at King Abdulaziz University (KAU): Symposium held on 24-27 November 1990 at the College of Administrative Sciences. Riyadh: King Saud University (KSU), 1990.


