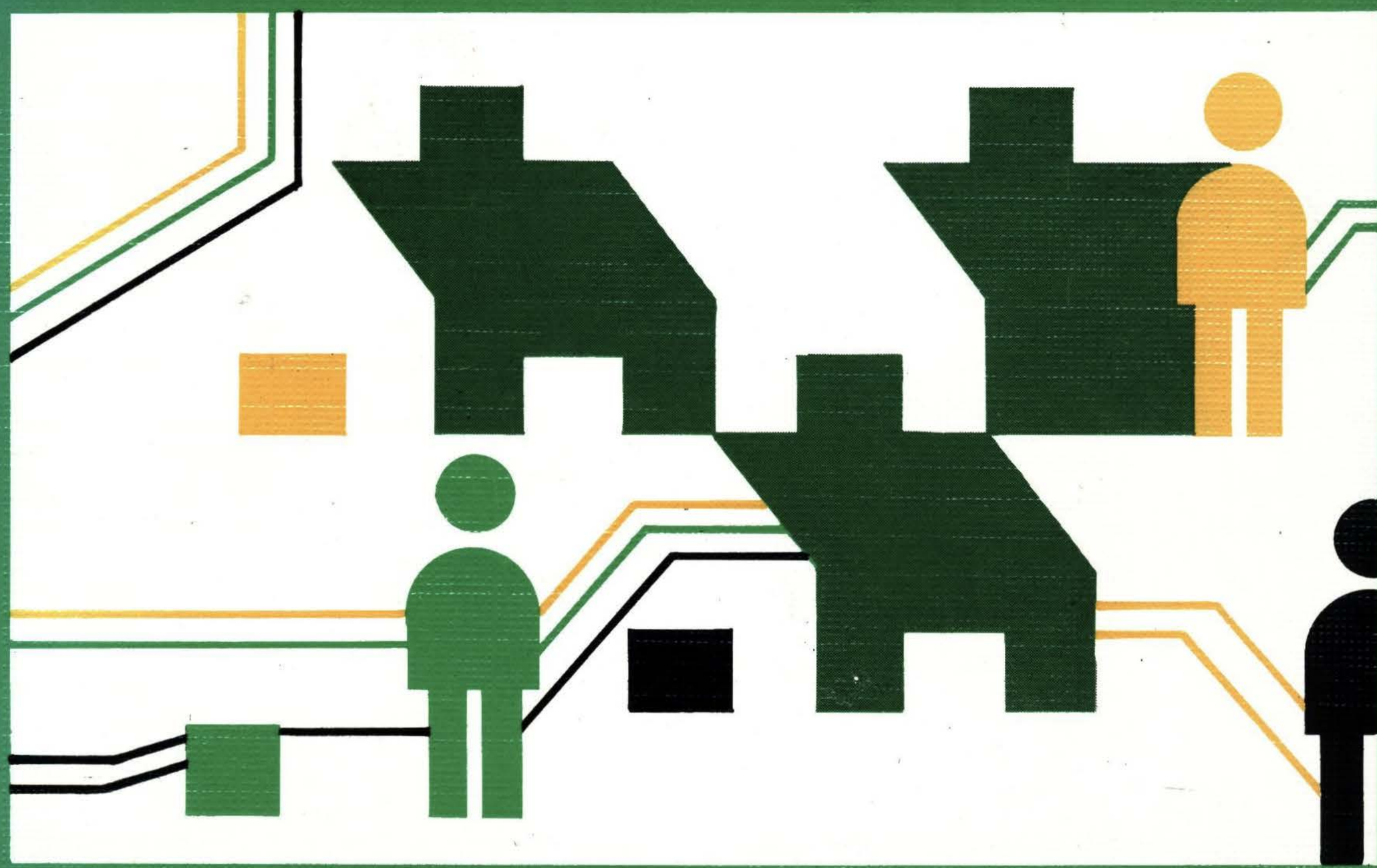

SOCIAL IMPLICATIONS OF COMPUTERS IN DEVELOPING COUNTRIES

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Social Implications of Computers in Developing Countries

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Preface

Availability of inexpensive but powerful personal computers/workstations and advances in telecommunication which have made networked applications possible are reshaping the manner in which enterprises are managed and run in the industrial societies. The ripples of these changes are also reaching developing countries. Some developing countries are now embarking on ambitious programs to use information technology for accelerating socio-economic development. For many others with limited foreign reserves, high unemployment rates the decision to acquire and use IT is as painful as is the decision of self exile from the IT community.

To generate a discussion on some of the important issues faced by developing countries in the use of information technology in developing countries an International Conference titled **Social Implication of Computers in Developing Countries** was organized in Nairobi, Kenya from March 23-25, 1992. The conference explored the following issues.

- Can developing countries evolve successful transition strategies to absorb the new technology in their socio-cultural context?
- What role can the governments and national policies play in promoting effective use of IT?
- Are there examples of IT application which have created a socio-economic impact in developing centres?
- Are their design approaches and methodologies which are especially suitable for promoting diffusion of IT applications?

The conference was organised by the Working Group 9.4 of International Federation of Information Processing (IFIP WG 9.4) which was set up in 1989 to focus attention of the IT professional on social implications of information technology in developing countries. One of the objectives of the working group is to compile and publish authentic documents on the status of information technology in developing countries. Towards this goal the working group had organized its first conference on Impact of Information Systems in Developing Countries, in New Delhi in 1989. In August 1991 a Workshop was organized on Information Technology Manpower Needs in Developing Countries. The conference in Kenya was the third major conferencing activity of the working group.

The conference was attended by fifty participants from twenty countries. Participants were evenly distributed between developing and industrialized countries. Thirty five papers were accepted by the International Program Committee from seventy submitted papers. Most of the selected papers were presented in the conference. The presentations were organized in the

following six sessions:

(i) Social Implications of Information Technology
(ii) Strategies and Policies for IT Development
(iii) Human Resources Development
(iv) Frameworks and Methodologies
(v) Impact of IT Applications
(vi) Health Informatics

In addition to IFIP and Kenya Computer Institute, many organisations lent support to the conference. The Commonwealth Secretariat provided partial travel support to eight authors from developing countries.

This book is a compilation of the papers submitted for the conference. The book includes 28 papers which have been organized into four sections. The first section on **National Policies and Socio cultural Perspectives** includes eight papers discussing a variety of aspects such as appropriate technology, socio-cultural issues, problems of development and the role of IT. The papers take a broad perspective on these issues. The second section on **Country Profiles** groups nine papers which discuss an important issue in IT with reference to a specific country. The issues covered range from socio cultural issues, indigenizing IT production, IT education, gender difference in employment and sectoral applications of IT. Some authors present an overview of IT applications in their specific country. The third section on **Case Studies** groups seven papers which describe specific applications. The papers focus on the process of design and implementation and the socio-economic impact of the applications. Four papers in the last section discuss **Applications in Health and Education.**

Putting together a volume like this requires a lot of effort from a large group of people. Unfortunately, everyone cannot be duly recognized here. One person who deserves a special mention is E.V. Narayanan who has very conscientiously keyed in many papers and formatted them in a camera ready form for the publishers. In the later stages of the work Ms. Shilpi Pillai also assisted in the preparation of the manuscript. They have done an excellent job.

Subhash Bhatnagar
Mayuri Odedra

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I

INFORMATION TECHNOLOGY AND SOCIO-ECONOMIC DEVELOPMENT: SOME STRATEGIES FOR DEVELOPING COUNTRIES

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ABSTRACT

Many developing countries have achieved a high rate of growth (for example Indian IT industry has grown at 40 per cent annually in the last 5 years [1]) in their IT industry in the last decade. This growth has been based largely on the popularity of the PC in government, private and educational institutions. In spite of this growth the penetration of IT in developing country organizations continues to be low in comparison with the industrialised countries. On indicators such as kilo mips per billion dollars of GNP even IT-wise advanced developing countries like Brazil, India, China have penetrations which are 10 per cent of the industrialised countries [2]. This means that the investment in IT has to grow ten fold for such countries to catch up with industrial powers. There are wide variations in IT penetration within developing countries. Some African countries have penetration levels which are 1.0% of the industrialised countries. Naturally with such low penetration the impact of IT on socio-economic development is low in these countries. This paper discusses major areas of potential impact and current status of IT use in these sectors. Although some countries have used IT in a few specific sectors very effectively when taken in its totality the current impact of IT applications is low. One can conclude that developing countries have not been able to harness the potential of this emerging technology. Some of the bottlenecks are identified. On the basis of the experience of some developing countries a few strategies are suggested.

1. MAJOR AREAS OF POTENTIAL IMPACT

With the advances in IT such as: miniaturization of IT products and the consequent portability; availability of software packages which make it easy for end-users to design applications; fusion of tele-communication and computers which support networking of computers, information technology offers a vast potential for improving the efficiency and effectiveness of organizations. Organizations can now plan better, carry out monitoring and control activities more effectively and can communicate across time, space and organizational hierarchy.

In the last decade the focus of IT applications in developed countries moved beyond routine transaction processing to supporting key managerial tasks. Organisations are now building Decision Support Systems, Executive Information Systems and Expert Systems to provide greater support to managerial activities. Networking and E-mail is revolutionizing internal and external communications of organizations. In developing countries this shift on emphasis is not visible. Applications are largely driven by vendors, consultants and aid agencies. These applications tend to mimic computerisation in similar organisations in industrialized countries. The maximum impact of IT can come from applications which focus on the key needs of developing countries. It is difficult to generate a common list of sectors where performance improvement is critical for every developing country. Some key social and economic sectors where a few developing countries have used International Technology effectively are discussed below.

1.1 Administration of Social Services Sector

Most developing countries share common problems such as need to control population, high illiteracy rate particularly amongst women, shortage of drinking water supply, and large proportions of poor population and an overburdened judicial system. Table 1 presents some comparative data on key indicators of performance in these areas. Investment in IT in these sectors is insignificant. The attitude of different developing countries to these problems is different. Some countries are attempting to tackle these important problems through higher allocation of resources and improved management of government programmes. In the process IT has been used effectively as a tool for micro planning and detailed monitoring. For example China has effectively used IT in tackling its population problems. As far back as 1988, China was using more than 60 computers at various administrative levels to collect and process performance data for their birth control programme. Thailand has made effective use of computers in analyzing village level data to segregate backward and developed regions. Similarly, India has focused on the use of computers for its poverty alleviation programme. However, in general, IT has not been used for the key socio-economic sectors in developing countries. It offers significant possibilities for improving micro level planning as well as monitoring of programmes.

1.2 Utilization of Scarce Capital Resources

Examples of poorly utilized capital equipment abound in developing countries. The capital is scarce, and much of the equipment for industrial activity is imported from other countries. The utilization of these equipments is poor because of poor maintenance, poor operational control and lack of operational planning. For example, in India, inadequate electricity generation is a key bottleneck for industrial activity. India looses 25 per cent of total generating capacity in line losses. It would be possible to use computers in billing and monitoring of energy inflows to identify sectors which incur large looses. It may then be possible to develop mechanism to control these losses including physical surveillance for preventing theft. Similarly in railways and road transport the use of rolling stock is not optimized. Experimental use of computer based planning tools has indicated savings of 5 to 10 per cent [3], yet there is hardly any use of IT for such purposes. Many public utility undertaking can benefit from the use of IT for operational planning and control.

1.3 Efficient Economic Administration

Most developing countries struggle with budgetary deficits and are known to have large parts of their economies which are not covered by the taxation system. Processing of direct and indirect tax collection and follow up can widen the tax base and improve compliance. Tax collection is a routine data processing application which has been implemented in several countries which are industrially advanced. In most developing countries, the use of IT in this sector is minimal and can lead to improved collection of revenues through tighter monitoring.

1.4 Industrial Competitiveness

Today most developing countries have been forced to adopt a policy of economic liberalisation. Their industry must begin to compete internationally. This would require efficient production systems which can be operated flexibly to meet the needs in the market. It would also need improved capability of design which can minimize cost of production, materials and yet satisfy the customer. Quality control needs to be improved and distribution costs will have to be minimized. Through CAD/CAM and routine transaction processing, cost improvements can be made in several of these areas. In any case industry in developing countries will have to adopt standards to move data electronically in their operations if they have to integrate into an international network of buyers and sellers.

1.5 Export of IT Products and Services

Some countries which have developed a reasonable IT infrastructure have realised the potential of exporting products and services which are based on IT [4,5]. Through communication networks, it is now conceivable that clerical activity does not have to take place physically in the premises of a company as long as it is possible to transfer documents and processed information over communication lines. There are several examples where data entry is being done off-shore. There are also examples where whole departments such as accounting departments activity is being done off-shore. A few developing countries have also recognised the potential of exporting software since it is manpower intensive. These countries have large pools of trained and inexpensive manpower giving them a competitive edge in this industry. Since the value added in IT products is high, such exports can be extremely valuable to developing economies which are starved of foreign exchange.

1.6 Open Information

Perhaps the most significant socio-economic impact of information technology can come from its ability to provide a wider and freer access to information which was hitherto buried in heaps of physical paper records. For example widely publicised analysis of school performance from the examination processing data which is already being captured can lead to public pressure on poorly performing schools and can provide a clear guidelines to students seeking admissions. Similarly computerisation of admission processes can make them less corruptible. Vast amounts of data collected by government is currently not analyzed because it is not accessible to institutions or individuals. It should be possible on a routine basis to nationally publicise regional disparities between education, incomes and poverty levels at a disaggregate

(say district) level so that public pressure can be mounted to take corrective action in terms of resource allocation or to improve the functioning of government departments. If democracy has to survive and market economies have to work, a culture of open information would need to be built.

2. BOTTLENECK IN HARNESSING FULL POTENTIAL OF IT

The table on the next page identifies critical bottlenecks in using IT in the six sectors/application areas identified earlier.The bottlenecks relate to user awareness, training of IT professionals, non availability of infrastructure or inappropriate government policies.The response of different countries to information technology has been quite different. In fact countries like organisations have viewed IT with different perspectives.

Critical Factors

Areas of Key Concerns	Constraints/Issues in IT Use
Improving Administration of social services sector	•Decentralised application •Training of users •Maintenance support in field
Open information	•Legislation •Communication infrastructure •Agencies which can analyze and disseminate information
Making domestic Competitive industry	•Training of information analysts •Training of users •Top Management Awareness
Effective utilization of scare capital resources	•Capabilities of building DSS •Support from administrators
Export of IT products and services	•Infrastructure •Government policy of encouragement •Training of professionals •Access to hardware and software
Efficient economic administration	•Capability of building OLTP in a networked environment •Support from Administration

Some of these differences are discussed next. Clearly government can play a major role in promoting effective use of IT. The nature of the role and some key enabling tasks that need to be performed are discussed below.

3. GOVERNMENT ROLE : A LIST OF KEY ISSUES

3.1 Existence of an IT Policy

Some countries have given IT a central role in their economy whereas others have given it a peripheral role. Countries like Singapore have a declared policy of using information technology as the engine for economic growth. Other countries like India have not gone so far but have set up independent ministries/ departments to deal with information technology industry. Several other countries (for example in Africa [6])have no stated policies or plans for this industry. This section discusses a few possible strategies that developing nations can adopt to harness the full potential of IT for the socio-economic development.

3.2 Direct Action Versus Creating an Enabling Environment

One dimension on which the role of government can vary considerably is direct action versus creating an enabling environment. This debate has taken place in industrialized countries as well and different countries have adopted different stances [7].National IT plans have also differed in their action orientation in different developing countries. For example, Singapore has an IT plan which is action oriented. There are specific goals to be achieved in creation of infrastructure and manpower development in a phased manner. There is a very specific objective to be achieved which is to transform Singapore to a paperless society. On the other hand IT policies and plans in a country like India have changed course during the past decade. Initially the focus of IT plans was on indigenisation of production and control over multi-national vendors. There was strict licensing of import.A great amount of control was exercised even on the plans of individual organisations particularly in the public sector. Subsequently when the economic environment was liberalising the IT policies also became more open and liberal.

3.3 Guarding Against Technology Push

Developing country organizations face a constant pressure from aid agencies, multi-national vendors, international consultants and local technologists who are interested in trying to push use of the latest technology irrespective of the local needs. It is important to develop need based IT applications. It is known that information needs for planning and control are very much dependant on strengths and weaknesses of individual organisations. Organisations differ in their strengths and weaknesses and competitive environment even within a country. It is therefore unlikely that information technology applications can be transplanted from other countries without assessing local needs. In most cases the impact of IT is low not because advanced technology is not available but because of a lack of understanding of what needs to be done. Most developing country governments treat IT as an end in itself rather than a means to improving managerial/ administrative practice. Very often advisory bodies in developing countries are packed with technologists who have little understanding of economics or organisations.

3.4 Free Access to Technology to the User

Having argued earlier that access to latest technology is not always the bottleneck, it is still important that the user has the final choice of which technology is used. Most developing countries have viewed IT as just another sector and have been preoccupied with policies governing manufacturing/ imports/exports etc. The role of IT in improving efficiency of other sectors of economics has not been accorded due significance. Countries like Brazil and India had protectionist policies to promote indigenous industry, denying the user access to new technologies [8]. Local prices were generally 200 - 300 per cent of international prices due to high import duties.

For organisations which are a part of an international network it may be important to keep abreast in terms of hardware and software. For example access to latest technology was the key determinant for the successful software export industry. The policy orientation should be such that the access to technology is free but organisations have the internal capability to assess technology and make considered choices.

3.5 Need for Consultancy Services

Since the impetus for use of IT in developing countries comes from sources which are external to the organisation it is important to have a consultancy organisation which can be approached for advise. Such an organisation can complement the services provided by extremely aggressive vendors/consultants. Since a large proportion of the aid driven IT is meant for government organisations, it would be worthwhile to create consultancy services which are affordable and easily accessible to such government organisations. However, it is important that these organisations operate at arms length from the government and work for a reasonable fee. Typical government organizations meant for playing this role degenerate into controlling organs which can only impede the diffusion of IT.

3.6 IT Infrastructure Development

In most developing countries a few metropolitan towns dominate the use of IT. The use of IT in small towns and rural areas particularly in government offices is extremely low. This is primarily because of a lack of maintenance support in the field as well as the problems of electricity and other supplies. In developing countries the telecom infrastructure is outmoded and expensive to use. It is therefore difficult for large organisations to build strategic information system which rely on transferring data across physical regions. Such a bottleneck was identified for software export as well as making local industry competitive. Creation of telecom infrastructure, and a reasonable pricing policy is of crucial importance to developing countries which have large industrial economies.

3.7 Manpower Development

Perhaps the most important and often neglected aspect of IT strategy is development of IT manpower. The most important contributor to poor choice of applications of IT in developing countries is the lack of awareness of IT amongst managers and the non availability of IT

professionals who can bridge the gap between management and technology [9]. It is easy to train programmers because the content of training is largely technical. When it comes to training software project managers or information analysts, inter-disciplinary programmes have to be designed. There are very few programmes oriented to such needs. Developing countries need to harness private enterprise, the university system and in-service training institutions for training IT professionals. Even in technical courses, non-technical inputs must be provided, as most computer professionals have to work in teams and interact with clerical workers and managers. Training and reorientation of teachers who train IT professionals is extremely important as the technology and its applications are changing rapidly.

3.8 Decentralised Application Development

It is important for the governments to play a major role in computerising their departments. In most developing countries the role of government is significant in promoting economic and social development. In India the annual budget of the government is about 40 per cent of the GNP. It must therefore lead by example. However, the approach taken in computerising government departments tends to be centralised and oriented towards control of field units. Earlier the major bottleneck in computerising government programmes was identified as DSS oriented planning applications. Many of these applications can be developed more effectively in a decentralised fashion. Therefore a decentralized approach to a developing IT applications in government is strongly recommended.

3.9 Fostering Competition and Co-operation in Industry

In a hurry to computerise government departments, several governments have created agencies which have been over burdened with the huge task of computerizing government departments. Direct involvement in R&D projects, creation and management of all new infrastructure in public sector can create a large financial burden. In general, governments can be criticized for over playing their role rather than under playing.In most of the developing countries the IT industry is very fragmented. A large number of companies compete for a small market. With their small size, they are unable to plough back enough funds into local R&D to adapt the technology to the local needs. Their relatively small size and consequent dis-economies of scale leads to expensive hardware and software. If the economic system is opened up, in the long run intense competition may weed out small operators. In several areas such as software export, competition comes in the way of co-operation within the industry. When several firms from a country bid for the same international project, prices get lowered, sometimes at the expense of quality and delivery. Perhaps there is a need for industry associations to develop an accrediting organisation so that unscrupulous vendors of doubtful quality are not allowed to sully the image of entire industry in international markets.

4. CONCLUSIONS

Many of the problems that developing countries face in utilizing IT in an effective manner stem from the lopsided attitude to technology by their professional elite. Either technology is completely ignored or it is placed on a pedestal. IT has become an end in itself and not a means for improving organizational performance. Implementation of IT is seen as a passive

process, whereas it actually impinges on a variety of stakeholder's interests. Administrative and managerial innovations are attempted for the visibility that such innovations bring to the innovator and not for the positive change that takes place in the organization. Information technology being new is a visible tool for innovation. In a sense IT is being 'used'. When applications get identified with individuals there is a resistance from peers in similar organisations to implement such well publicized innovations. That is why some innovative IT applications never get diffused beyond the original site.

We need a change in the administrative/managerial culture. We need motivation for bringing real improvements in the performance of our organizations. We need to recognize that gains from IT are greater when the organization using it is already performing well. IT is not a substitute for failure in management. IT professionals need to bring about these attitudinal changes through programs of awareness and education.

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Table 1 *Countrywise Key Social Indicators*

COUNTRY	POP MILL	PER CAP GNP BILLION USD	BIRTH RATE PER 1000	INFANT MORT. PER 1000	ILLI-TERACY (%)	URBAN POP %	GOVT EXPND. % OF GNP	GDP BILL $	EXPRT AS % OF GDP	IMPORT AS % OF GDP	EXT DEBT BILL $	ACCESS TO SAFE WATR
India	833	340	31	95	57	27	18(3)	235	6.6	8.1	62	50
China	1114	350	22	30	31	53		417	12	14	44	
Bangladesh	111	180	37	106	67	16		20	6	17	11	
Malaysia	17	2160	30	22	27	42		37	66	60	18	76
Thailand	55	1220	22	28	9	22	15(19)	69	28	36	18	66
Kenya	24	360	46	68	41	23	28(22)	7	15	29	5.6	21
Tanzania	24	130	47	112		31		2.5	10	33	4.9	
Nigeria	114	250	47	100	58	35	28(3)	28	31	12	32	
Ghana	14	390	45	86	40	33	14(25)	5.2	19	17	3	39
Zimbabwe	10	650	37	46	26	27	40(23)	5	24	20	3	
Brazil	147	2540	27	59	22	74	30(4)	319	10	5	111	

A PERSPECTIVE OF CONTEXTUAL, OPERATIONAL AND STRATEGY: PROBLEMS OF INFORMEDIATION IN DEVELOPING COUNTRIES

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ABSTRACT

The problems of informediation in developing countries are varied and various. The state of a country to evolve transitions through progressive levels of information technology capability will depend on its ability to mitigate the problems of informediation. This paper argues that problems of informediation may be grouped into three generic classes which may be described as operational, contextual and strategy problems. An analytical exposition, a critical context and an integrative synthesis of problems in the selection, adaptation, adoption, application, production (including manufacture and assembly), maintenance and transfer of information technology is presented in respect of developing Anglophone countries. The countries are assumed to be at various levels of information technology capability and to be characterized by diverse cultural settings, differing political environments and widely ranging economic perspectives. The study builds on elements of locality-specific a survey research carried out by the author in single firms, various sectors and various Anglophone developing countries, to give an integrative synthesis of the problems of informediation as confronted today by countries making ingress or progress at various points of the information technology capability 'spectrum'.

1. INTRODUCTION

Information Technology (IT) has become a vital instrument in various aspects of human endeavor and practices in the West. In the context of Developing Countries, IT is a technological revolution whose application, production and applicability has been somewhat limited but whose potential for diffusion holds great promise in national development. In confrontation with the needs requirements and praxis of *other cultures* and *value systems*, the introduction and applicability of Western models have been questioned, both in their role as solutions worthy of imitation and as adequate descriptions of reality.

Studies carried out by various researchers have identified a number of issues confronting IT users in Developing Countries [1,2,3,4,5]. A number of studies have focused on general levels, with some *albeit* little distinction made between different computer applications or between characteristics that separate different Developing Countries from each other [6],[7],[8]. Others have identified the problems at the level of locality-specificity, such as firms or have related

the problems to different levels of society [5,1,9].

This paper seeks to classify the issues of information technology diffusion into three generic problem areas of informediation, according to the following definitions:

- Operational Problems, as problems of informediation due to *technical* and *economic* constraints and *lack of skilled personnel*;
- Contextual Problems,as problems due to *weak fit* between models of Western design and applications in Southern contexts, semantic discrepancies in the wording and understanding of phenomena as well as references to different *value systems* and different *concepts of rationality*;
- Strategy Problems, as problems relating to local, national or regional policy initiatives, as rendered manifest through institutional intervention mechanisms of *influence, regulation* and *implementation.*

Technology diffusion models essentially describe the extent to which the usage of a product or service emanating from a new technological innovation spreads in a given population or society. Models for technology diffusion have therefore tended to help in understanding the pattern of acceptance of end products of technology development [10]. An alternative diffusion model could be developed from analyses of the extent to which a region, a country or firm is able to mitigate associated operational, contextual and strategy problems.

2. OPERATIONAL PROBLEMS

2.1 Skilled Human Resource Deficiency

Analyses of the labor capacity in Anglophone developing countries show that the stock of scientists, engineers and technicians in the majority of the countries form a substantially low proportion of the labor force.

A recent survey by the National Institute of Higher Education, Research, Science and Technology (NIHERST) in Trinidad & Tobago in the Caribbean reveal that scientists, engineers and technicians comprise only 1.3% of the labor force and that the majority of Trinidad & Tobago's quality manpower is in the area of liberal arts [11,12]. A similar exercise carried out by Singapore shows that as at 1980, the proportion of engineers stood at 1.4% of the total workforce, technicians 6.6% and skilled workers 22% [13]. A similar recent appraisal by Vanuatu in the South Pacific shows that the labor force is marked by a low level of general education and training, with the result that technical skills are weak and deficient in quality and are short in quantity [14]. In Hong Kong while the literacy rate is very high at 88% and education standards are improving, only 4.5% of 17-20 year-olds seek tertiary education, which is bound to limit capability of the society to understand and thereby actively use IT [15].

A sequel to the observations above is the general shortage of human resources with requisite technical expertise, background and experience in the areas of design, development and implementation of sophisticated electronic systems; electronics, maintenance, telecommunications, systems integration and software engineering and several other aspects

of IT [16]. In particular, there is general dearth of computer maintenance expertise in a number of countries, shortage of skilled personnel for operation of available computers, shortage of applications design expertise, scarcity of programmers shortage due to migration or brain drain to developed countries, lack of expertise in contract negotiation to ensure optimum use of equipment and transfer of technology, lack of interest in R&D by the private sector and lack of investment incentives in a majority of the countries [16], [17], [18], [19], [20]. There is also little indication of widespread use of project management tools and simulation type applications or optimization techniques and the lack of knowledge and expertise and attitude in the inevitable cultural change from indigenous to advanced technology [18]. The observed lack of skills does not only refer to professional IT skills but also to the management skills required to plan, co-ordinate and manage the introduction of the technology [21].

A number of factors have been isolated as prime causes of these deficiencies, including ingress at a relatively advanced stage of the technology revolution, a high turnover of skilled staff because of low wages and unsettled working conditions, lack of counterpart training under technical assistance packages, prevalence of an under-population which manifests in manpower deficiency in a large number of areas needed for development, and professional isolation among scientists, technologists and computer scientists [20,22,23,24]. In Hong Kong there continues to be shortage of IT personnel to meet the needs due to the shortfall in the output of the tertiary institutions and emigration of people with training and qualifications in IT [15].

There is evidence that some countries are unable to provide technicians and managers who can use electronic technology to maximum effect [28]. As a result certain activities such as international banking, communications and other related services are manned by expatriate staff and computer operation personnel are predominantly telecommunications engineers [25]. The predominance of packaged software in the majority of the countries appears to have its own regressive effect. There are correspondingly fewer analysts and programmers in a number of countries, with the experience that comes from having designed and programmed their own in-house systems [18].

2.2 Power and Telecommunications Utility Deficiency

Electrical power utility has been intermittent and the inconveniences caused have not been negligible [22,26]. It is necessary to equip all systems with an Uninterruptible Power Supply (UPS) to protect equipment against voltage variation and power failures.

Related problems pertain to the deficiency in the local telecommunications utility, which has in turn resulted in a lag in the development of national data communications networks. The establishment of data communications has variously been the responsibility of Government and NGOs [21]. Singapore, for example, has laid the foundation for an Inter-Departmental Network (IDNet) to link Government ministries, several government departments and statutory boards to each other and to external networks [27]. Voice grade telecommunication lines in a number of countries have not been very useful for data communications, making computer users very reluctant to hook up on such networks [28]. A number of countries plan to use the public packet switching data network (PSDN) for data communications. The PSDN

is able to provide a variety of services such as data/text communication, telex, videotext, facsimile and electronic mail, among others.

2.3 Economic Constraints

Major obstacles restricting the applications of IT include the non-existence of reliable background statistical information, inadequate capital to finance microelectronics-based products for agricultural applications, as well as inability of Central Government agencies to procure computers especially when they are not budgeted for in approved expenditure schedules [18],[29]. In NICs such as Singapore, commitment of more resources to implement, and train and retrain IT specialists and users for sophisticated systems requiring complex on-line database, data communication and networking technologies, is a significant constraint.

Needless to say, however, is that for the majority of the Anglophone developing countries, new IT is being introduced in the course of a period of economic recession and great social problems. In the light of economy, restriction and moderation, financial uncertainties have prevailed in respect of the development and promotion of various national sectors of economic development including the telecommunications and power utilities subsectors.

3. CONTEXTUAL PROBLEMS

3.1 Public Sector Core and Peripheral Applications Dichotomy

The scope of application of microelectronics and information technology varies between countries and between sectors in a country. Two generic, somewhat dichotomous, IT application types may be differentiated, namely, *core* applications, which relate to sector-specific, development-oriented applications and *peripheral* applications, which are characteristically trans-sectoral, and generally playing the role of word and text processing, data processing, so-called business graphics and spreadsheet computing [30]. Peripheral IT applications are generally used to support office automation and to improve and back-up administrative management.

Studies carried out by the author show that IT core applications in the Anglophone developing countries, as exemplified by the developing Commonwealth countries, are limited: relatively predominant in the tertiary sector, less predominant in the primary sector and least predominant in the secondary sector [30],[31]. Ostensibly, the primary sector provides the mainstay of the economies of most developing countries. The same studies partly link the observed discrepancy in core IT applications between the three generic sectors to the characteristic nature of the predominant *raison d'etre* for first computer installations by Government Ministries and/or Parastatal Organizations in the late 1960s and early 1970s. Almost invariably, the three main reasons for first computer installations in the majority of over 40 Anglophone developing countries studies relate to: (i) the need to meet the requirements for telecommunications and power utilities, (ii) the need to meet central data processing requirements under the auspices of the Government Treasury and (iii) the need to provide central statistical facilities for the processing of national population census [30],[31].

Invariably,the three main reasons for first computer installations all relate to the tertiary sector. Thus for example, office automation in many of the medium-sized and large organizations has proceeded rapidly over the past decade, but process automation has lagged substantially [29].

It is not surprising that to date the tertiary sector continues to take the lead in core IT applications in the developing Anglophone countries, such capability having been built on past experiential knowledge and practice. Contrary to all expectations, core IT applications are relatively less predominant in the primary sector, which has the traditional primacy of the basic needs of food, fuel and shelter.

This is illustrative of the observation that the introduction of a new type of technology into a sector with a long-standing traditional existence will need a relatively larger threshold of effort and drive as well as a re-acculturation of practice to overcome the inertia of tradition and therein adapt to the routine brought to bear by its introduction. Core applications in agriculture, forestry and livestock farming are thus relatively rare. The impact of this observation manifests in the lesser role to date being played by IT in rural development.

3.2 Private Sector Intervention

For a long time, the promotion of IT in the private sector was in the hands of the local distribution agents of computers, namely, IBM, WANG, ICL, NCR and OLIVETTI, to mention a few. As their operation in the countries were principally business oriented, the application they promoted was limited to business and office automation systems [32]. This explains further the predominance of IT applications in the tertiary sector.

3.3 Fuzzy Agricultural-to-Information Society IT Leapfrog Effect

A predominant deficiency of IT core-applications in the secondary sector of the development economy of the various countries conform to the observation that the countries are essentially an agricultural society, and as such, attempting to leapfrog into an information society without the experiential benefits of an industrialized (or newly-industrializing) society. The transition from a goods-producing society to a service-producing society represents a transition from an industrial to a post-industrial society, whereby the "transforming resource" is information instead of energy,and the "crucial variables" are information and knowledge [33,34]. Hence, a post-industrial society is primarily information-producing, and its development implies revolution in the organization and processing of information and knowledge. To Bell, "post-industrial society is an information society" [33].

In general, maintaining a balance in economic returns in the agricultural, secondary and tertiary and information technology sectors of the economy is a major socio-economic problem.

3.4 Model Mismatch

Another general observation indicate that quite often wrong choices of technology were made, that technology was often wrongly adopted or adapted to the circumstances of an enterprise

and that essential elements of technology transfer agreements such as training, were not implemented or that there was generally a lack of suitable model to emulate [29]. Local operating units of multinationals have models of IT applications in their group companies in other countries. The government sector, some statutory boards, local companies and small and medium enterprises start from scratch. In the absence of suitable models to emulate, these organizations have to go through the process of learning by trial and error.

A corollary to this is that by transferring only techniques and the knowledge of how to operate those techniques, it was not sufficient to bring about the incremental technical change for increasing efficiency [29]. Government policy with regard to the acquisition of technology by enterprises currently presents a major constraint in the procurement and upgrading of IT production systems to make them more productive and more efficient.

The majority of the software installed in the Anglophone developing countries is packaged software, with most of it developed outside the user countries. It is reported, for example, that Barbados in the Caribbean has a large number of packaged software as compared to a relatively smaller proportion in Jamaica and in Trinidad & Tobago, where computerization appears to have started much earlier when packages were a rarity [34]. The implication is that countries in which first computer installations took place during a time when packaged software packages were a rarity have tended to continue with their experiential tradition of customized software development.

It is also observed that much of the microelectronics based industrial automation in the countries was acquired as turnkey systems. Not much has been done to adapt the technology to the local needs, and in some cases has led to its non-optimal use and hence reduced profits to the user [29].

An underlying factor in the above contextual issues points to the observation that Anglophone developing countries were historically structured as markets for manufactured products from developed nations and most infrastructure that exist are geared towards this end - distribution. As a result the only sector of economic development that was encouraged until recently was agriculture. Consequently, this area of application has not been considered as economically viable by the local agents of computers in the various countries.

3.5 Industry Structure Mismatch

The structure of the industry is also perceived to be a major constraint in application of IT. In Honk Kong, for example, about 50,000 manufacturing facilities employ 875,00 workers, which works out to an average of 18 workers per facility [15]. There are only 137 units which employ over 500 people and only 49 units employ over 1,000 people. The result is that there is no critical mass in a large percentage of organizations to afford the expertise necessary to fully exploit IT. There is no significant and systematic government mechanism to assist small and medium enterprises to exploit IT.

3.6 Conceptual Inadequacy of Top Management

Conceptual inadequacy of the top management personnel in small and medium enterprises in

the public, parastatal and private sectors have been related, *inter alia*, to situations where micro-computers have been acquired but little or no significant effort has been made to use them to satisfy information needs at the strategic level or macro-level planning for reasons of lack of awareness at the top management of the varied use and benefits of the computer and other microelectronics-based products and lack of top management awareness for IT long-term planning [16,23,24,35].

A somewhat related factor is the perception of computing by Government as a management and administrative tool and not as an industry capable of generating employment and possibly income from exports [21]. This has an overall effect of mitigating the development of initiatives directed at core applications of IT at the macro-level. Another inhibiting factor relates to the perception policy makers, who often reflect biases towards particular social effects of IT instead of presenting a comprehensive view [36]. The characteristic dominance of the technology *per se* has itself led in the past to inappropriate use of the technology, wasted expenditures and no clear indication as to the benefits to be derived from adopting IT. Also, the rapid rate of change in the technology has given rise to uncertainties regarding the technology which, unless viewed under the auspices of an overall framework for economic development, does not provide enough clarity for policy making. A sequel to this is that new users in organizations have mixed feelings about IT - some are overly enthusiastic and set unrealistic expectations; others feel uncertain and insecure over the impact of IT in the work place. Furthermore, new work methods resulting from the application of IT in offices and factories requires major readjustments on the part of the workforce. New work methods lead to new procedures, job content, and job specifications which require retraining and redeployment.

3.7 Psycho-Cultural Influence

The use of IT as a new and emerging high-technology is new, particularly in the smaller developing Anglophone states. Fear generated by advanced technology with respect to loss of the need for manual labor have been variously expressed but not proven. In Hong Kong barriers and constraints arising from attitudes manifest in several forms. Owners and managers of small and medium enterprises refuse to recognize and adopt IT as a tool to improve productivity and performance. They lack a systems view of their business, they have limited strategic thinking and focus on short-term profits at the expense of long-term growth.

3.8 Language Constraint

Language is a major constraint in the further development of and assimilation of IT, particularly in the rural sectors, where the level if adult literacy is relatively low. In Hong Kong, the situation is even more complicated by the increased use of Chinese. The methods of inputting Chinese characters is not as highly developed in China or Taiwan.

4. STRATEGY PROBLEMS

Some strategy problems are discussed in this section.

4.1 State of Flux in National Informatics Policies

The formulation of an IT policy, the planning of strategies, mechanisms and modalities for the implementation of an IT policy and the actual implementation and monitoring of an IT policy are a main source of strategy problems, requiring substantial resource backups and relevant organizational setups. Pertinent dependent factors include a country's perception of IT in the light of the multi-faceted aspects of IT, a country's IT level of capability, the degree of suitability of IT applications modelled on the basis of Western perceptions of IT, the amenability of various indigenous tasks to IT application and the social, political and economic temper of the country to informediation including mechanisms for bottom-up mobilization of IT, modalities for top-down intervention strategies and labor market response to informediation; determining the social consequences of IT including effects on economic variables such as productivity, economic growth, balance of trade and employment and, inversely, the effect of the social and cultural factors on development of IT; and devising instruments with which the government can achieve desirable and avoid undesirable consequences. Varying degrees of government intervention in relevant aspects of informatics and informatics-related areas have given rise to three generic modes of informatics-related initiatives, or IT polices, which may be described as *non-existent*, where governments elect to remain indifferent to the need, if any, for the formulation of mechanisms and strategies for introduction and enhancement of IT; *implicit*, where governments are an active participant in IT but elect to work under the auspices of combined informal co-ordination mechanisms and implementation strategies for IT; and *explicit*, where governments are an active driving force in IT and have elected to put in place mechanisms for IT policy formulation, strategies for IT implementation and programs for IT popularization and assimilation. Except for a few countries, the status of national IT policies are in a state of flux, the way forward being characteristically dependent upon whether or not IT is perceived first and foremost as an essential factor of a country's economic development. The government of Hong Kong, for example, plays what may be called a "positive non-intervention" role in the application of IT [15].

The government strategy is to use its resources and influences as catalysts for change, rather than to be directly involved in the process of change. A good example of this catalytic role is the Hong Kong productivity Council (HKPC), a government supported organization responsible for promoting industrial productivity in Hong Kong. Other governments play a pro-active role in promoting IT, with the establishment of lead policy bodies for IT as in Singapore, where government has developed a set of co-ordinated government strategies, plans and mechanisms which encourage adoption of IT in all sectors of their economies.

4.2 Absence of a Transitional Framework at the Initial Level of IT Capability

A typical strategy problem that has been found to be generally associated with countries at the initial level of IT capability relates to an inherent absence of an enabling framework for progressive capability transitions. Typical factors may be illustrated by the state of prohibition, by government, of computer importation during the early years of ingress into the technology [37], inertia on the part of the early pioneers (generally ministries of finance or the treasury) of computing to sustain long term lease over the first computer installations, as in Uganda

during the period 1979-86 and aggravated by a condition of political instability over most of the same period, and the institution of a long-standing general trade embargo on country, as was the case of Zimbabwe (then Rhodesia) during the period of the Unilateral Declaration of Independence (UDI) between 1970 and 1979 [19]. In Pakistan, progress after first computer installation remained extremely slow, mainly due to high cost of hardware, scarcity of resources, fear of unemployment and lack of computer awareness [28].

Hardware and software non-standardization due to the non-existence of institutional guidelines, the imposition by bilateral donor agencies of own proprietary right type computing systems to recipient countries or institutions, lack of control over the private sector computer systems acquisition, lack of central agency for Government computing, dormancy of the Computer Steering Committee, non technical nature of Computer Policy Committee and no procedures for government to validate procurement of IT equipment [16, 20,23,24,25,35,38].

4.3 Education and Training

Education and Training occupies a central role in both implicit and explicit IT policy initiatives. A survey of the IT education and training (IT E&T) infrastructure in the developing Commonwealth countries show that the highest echelons of the IT E&T infrastructure are represented by Institutes of Computer Center and Departments of Computer Science, generally backed up by traditional-like Computer Centres [30]. The study of IT E&T programs of the various countries are made possible in three generic forms, namely, as part of mathematics and mathematical main subjects, as a study built into and attuned to non-mathematical main subject (management informatics and administrative informatics) and as a main subject or discipline of its own. Distinctly absent or lacking have been IT specialist areas including telecommunications science and technology, CAD, CAM and related areas. In Botswana there are intentions to include a computing component in all existing programs offered by the University [21]. In Singapore, the Government manpower objective is to produce high calibre IT manpower essential for building an information society [27]. A typical finding of the survey reveals the existence of a general lack or total absence of the link between IT E&T institutions with industry. The result has been the proliferation of IT peripheral applications and less of the IT core applications skills. Furthermore, one recognizable constraint for further development of IT industry and IT applications is the large discrepancy between the supply of specialized manpower in IT and IT-related areas and the market demand.

4.4 Research and Development Deficiency

In most developing economies, as exemplified by the developing Commonwealth Countries, the main agent for transforming scientific and technological capabilities into new products, new processes and new services is essentially the governmental system. Scientific research institutions of higher learning is generally provided by the Governments, international foundations and international outreach agencies of more developed countries [30]. Institutional interventions in IT in the Anglophone developing countries are essentially independent initiatives of Government, international outreach agencies such as IDRC, UNIDO, ILO, ESCAP, APDC, WIPO, UNESCO, ITU, WAITRO and the Commonwealth Secretariat and,

somewhat insignificantly, the private sector. TNC intervention in co-operative research is rare, however, to be found in Singapore [13] and Malaysia [39].

The foregoing contrasts sharply with the conditions pertaining in developed market economies where the responsibility of research and development devolves heavily on Government, as in the United States and Western Europe and/or on the private sector [43]. It also contrasts sharply with the tradition of international co-operative research of the kind to be found in Western Europe, which has generally focused on expensive and difficult research areas as in ESPRIT.

It is, however, interesting to note that Japan's economic progress was made possible through "learning by doing" that did not require substantial in-place bodies of scientific and technical know-how [41],[42]. Does this imply that Developing Countries could evolve through Japan's path of economic progress without the necessity of substantial *surplus* infrastructure? This could be an area for case study research.

Private sector research initiatives in developing economies remain generally aloof with regard to the promotion downstream of science and technology, particularly in information technology. International co-operative research in IT with focus on developing country context is generally limited to IT-applications related research , IT policy related research, IT impact related research and IT applications in the rural sector [43],[44],[45],[46], [47],[48],[49],[50],[51].

4.5 IT Equipment and Repair Infrastructure

There is a general lack of policy initiative in the Anglophone developing countries with regard to the evolution of national, regional or sub-regional centres of higher level technician systems expertises for local installation, maintenance and repair of IT and related high technology equipment [33]. The need for IT equipment maintenance and repair infrastructure remains central.

4.6 Centres for IT Design and Manufacture

Centres of IT Design and Manufacture are a rarity in the developing Anglophone countries. This is attributed to the general lack of policy initiatives for the establishment of such a center, particularly at the regional level. Furthermore, the establishment of such a center is resource-intensive and generally no single country would offer to run on its own as a national institution. The concentration of IT manufacturing knowledge in a single center, on a regional basis could, however, merit support for various reasons, including the following (i) that expertise in the field IT/microelectronic design and manufacture and associated disciplines is limited to so few people that fragmentation would be disastrous; (ii) that economic life of the highly complicated and capital-intensive design and manufacturing equipment has to be replaced after a short time by more advanced, still more expensive, nevertheless indispensable equipment; and (iii) that a center which is powerful and of excellent quality can prevent IT/microelectronic industries from getting great difficulties and making them independent on foreign countries in an important field.

The absence of such centres is a reminder of the apparent comparative advantage that transnationals enjoy in the area of design and manufacture on a global scale, of course, to the detriment of the development of the IT industry under the aegis of local agencies.

4.7 Absence of Free Trade Zones and Strategies

Except a few countries of South East Asia, free trade zones, licensed manufacturing warehouses or investment incentives in IT are generally lacking or are absent in the IT initiatives of the various countries. Ingress by countries to IT manufacturing technology, in particular, would particularly benefit from the evolution of such initiatives as this is bound to require, *inter alia*, availability of abundant cheap labor force or the availability of affordable semi- or full- automated 'production line' equipment and systems (MTs, NCMTs, CNCs, DNCs etc), market demands that are able to absorb high volume production and to enhance scope for production diversification, existence of coherent national policies to attract the right type of investment, and the existence of a strong industrial synergism.

4.8 Procurement

Public procurement strategies, particularly on IT hardware (including computer equipment, peripherals and accessories) are generally existent, *albeit* in a somewhat protectionist environment that generally lack the supporting infrastructure of local manufacture or assembly. Import policies on IT equipment have more than limited and dis-enhanced the procurement of IT equipment. Such traits in IT policy (eg high import pronouncements on items of computer software, hardware and related digital equipment and accessories and peripherals) are void *unless* (and this is generally rare or non-existent) tied to an overall industrial policy of technological self-reliance or production of indigenous IT equipment or is backed by special incentives to promote domestic hardware assembly, design or production and/or software industry.

4.9 Rural-Urban Sector Dichotomy

A widespread strategy problem relates to the rural-urban sector dichotomy of national economic development of developing countries. The majority of member countries have a large agricultural and rural sector. The policies of high economic growth have created a high-income and high-technology urban class and widened the gap between the rural and urban areas and the low-and-high-income class. IT does not seem to have benefitted the low and middle urban people and the rural sector. Achieving a balanced economic and technological development of the urban information sector and the rural sector and distributing the benefits of IT is a challenge.

5. CONCLUSION

The capability of Anglophone developing countries to select, acquire, adapt, adopt, manufacture, assemble or maintain information technology in the face of operational, contextual and strategy problems is a challenge that could provide a framework for an articulation of factors of diffusion from the standpoint of the capability of the countries to

mitigate these problems. Nonetheless, the classification of the myriads of problems associated with informediation into the three generic types should provide a model framework for analyses of problems of technology diffusion in general.

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EXAMINING THE APPROPRIATENESS OF INFORMATION TECHNOLOGY

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ABSTRACT

Despite the widely acknowledged significance of information technology for economic growth and social development, few of the poor countries have succeeded in exploiting this developmental potential. On the contrary, in many developing countries there are serious concerns about the negative consequences of investing in information technology, such as wasting scarce hard currency on projects which may not pay off, a new form of dependency on countries and companies which produce and maintain the know how of the new technology, cultural distraction, or loss of control of their resources. We need, therefore, to develop the capacity to assess whether specific types of information technology are appropriate for specific socio-economic and organizational circumstances.

In this paper we explore the concept of 'appropriate technology' in the development studies' literature, and draw relevant lessons for the application of information technology. We identify issues of appropriateness to be considered at two different levels: in national or international institutions responsible for the formulation of information technology policies, and in organizations, as part of planning and developing information systems.

1. INTRODUCTION

Uncertainty about the appropriateness of information technology (IT) for achieving development goals is often expressed by development theorists, politicians and even IS specialists. Modern IT (i.e. computers, microelectronics and telecommunications) is a complex and expensive technology which has been developed to serve the needs of economic growth of the industrialized North and it is supplied mainly - even though not exclusively - by the rich industrialized countries. Therefore, many argue that this technology is inappropriate for poor countries with large rural communities, limited foreign exchange, and massive chronic underemployment.

Some stress the need to give priority to rural development, and therefore not to spend scarce resources to import the technology which supports unsustainable industrialization. Others point out the failure of large scale, capital intensive manufacturing installations in the urban

areas of developing countries, which led to a mass exodus of people from their rural communities into towns in a search for jobs, resulting in the destruction of the social fabric and questionable overall economic growth [5]. Some also point out that the availability of cheap labour is one of the few competitive advantages of developing countries and remark that it is foolish to spend scarce financial resources for automation. Moreover, automation entails the danger of aggravating the social problem of unemployment. The governments of several countries adopted the rationale that IT is inappropriate and imposed severe restrictions to the import of IT during the 1970's and the 1980's [35].

Even if the potential beneficial contribution of IT to development is accepted, there remains the problem that the results that have been achieved with computerization in developing countries are noticeably poor. This led many authors and practitioners to raise the question of appropriateness of particular choices of IT applications, without seeking to label information technology once and for all either appropriate or inappropriate. Rada [36] pointed out that "the blessings from new (computer) technology today still, to a great extent, exist on paper only". It becomes gradually recognized that the impact of computers in developing countries depends largely on the ability to develop IT applications to meet local circumstances.

In this paper we examine the literature on appropriate technology to understand the concerns conveyed by the notion of appropriate technology and to draw relevant lessons for an effective approach to IT based systems in developing countries. We argue for the need to apply the 'appropriate technology' approach to the case of IT and suggest two levels where such approach is inescapable: at the level of Government IT policy formation and the level of IT strategy for individual organizations, both in the private and public sector.

2. APPROPRIATE TECHNOLOGY IN THE LITERATURE OF DEVELOPMENT STUDIES

There is general agreement among development scientists that technology is one of the key factors to development. However, there is continuing debate over technological choice. In most developing countries technology has to be imported. The process of the transfer of skills and supporting hardware that make up a technology, often creates situations fraught with potential conflict. Development programmes often import in developing countries technologies that cannot be subsequently sustained. This observation led many development scientist to question the appropriateness of the technologies originating in the industrialised countries.

Various terms have been used to describe the required technology in developing countries. Schumacher [1973] coined the phrase 'intermediate technology', Marsden [30] 'progressive technology', Baldwin and Brand [3] 'soft technology'. Common terms among economists are 'labour-intensive' or 'low cost' technologies. Dickson [8] has promoted the idea of an 'alternative technology'; he is primarily concerned with technologies applied in industrialised countries, but many share his concern with finding alternatives for industrialised as well as developing countries. More recently, Bhalla and James [4] proposed the term 'technological blending' to suggest the need to combine new and traditional technologies.

At the very least, all the variants of the notion of appropriate technology convey the

recognition of the need to include social as well as economic and technical criteria when devising technical solutions to existing problematic situations. Few would argue against this need, but in practice, most development programmes are driven almost exclusively by economic and technical considerations. The most frequently used development planning methods are based on technoeconomic development models and do not accommodate effectively social factors [15,40]. The notion of appropriate technology provides a very useful reminder that technological options should be sought by considering the needs and conditions of local communities rather than according to deterministic technical and economic criteria.

More specifically, a common feature in all appropriate technology literature is the argument that the capital-intensive, centralised, complex technologies of the rich countries are very often inappropriate for poor countries, and especially their rural communities. It is therefore suggested that, to meet the needs of the developing countries, different technologies must be devised that lie between the traditional and the modern.

However, this argument has been applied within two different perceptions of development and gave rise to two different interpretations of what characteristics appropriate technology should comprise. The most widely held view of development is as economic growth through industrialization. Within this ideology, appropriate technology means a strategy for economic growth. The term often features in documents of international development groups such as The World Bank or the United nations agencies. Within this context appropriate technology is an approach of technology transfer. It suggests avoiding the direct transplantation of advanced technologies of industrialized countries, selecting those which can be afforded and making the effort to adapt them to the conditions of developing countries. In other words, small, simple, labour intensive technology is not a goal in itself, but a stepping stone, or a tactic to build the capacity to utilise effectively more complex and capital intensive technologies.

An alternative view of development gives priority to the satisfaction of basic human needs. Based on the criticism that economic growth policies have failed to eliminate poverty, and, in many cases, they led to widespread unemployment and inequality, proponents of the 'basic needs' ideology suggest an approach to development which focuses on empowering small local communities to be self-reliant. Many influential proponents of appropriate technology, such as Gandhi and Schumacher, converge on a perception of development as the satisfaction of 'basic needs' of food, shelter, drink and clothing, and suggest that it can be achieved by creating employment opportunities in rural communities. Appropriate technology took the form of a movement in support of this ideology. Diwan and Livingston [9] make clear that appropriate technology which can support an 'alternative development strategy' to the conventional economic growth strategies. Appropriate technology, in this case, suggests self-reliance, self-sufficient social units, human-enhancing labour, harmony with nature, cultural autonomy.

It is important to be aware of the different ideological positions behind the different notions of appropriate technology, because the literature tends to generalise on what features a certain technology should possess to be judged as appropriate or inappropriate. Authors are more concerned with supporting particular principles of development rather than the capacity of

technology designers to take account of the socio-economic context and be responsive to local conditions. They tend to express what is appropriate technology by suggesting lists of criteria that technical choice should follow [44]. Some authors compile criteria of appropriateness as reminders of general desirable aspects which experience has indicated are needed for a technology to be adopted and, therefore to lead to economic growth [7,10,12]. Others stress the features which are viewed as necessary for covering immediate needs of the poor. In this way, a normative attitude to the choice of technology is promoted rather than an analytic or diagnostic attitude. Yet, to understand the validity of the proposed criteria we need to understand their ideological biases.

In summary, the notion of appropriate technology is used with two fundamentally different (although often in the literature confusing entangled)meanings:

a) As an approach to selecting or developing technical systems which fit in their socio-economic context and can lead to further technological, economic and social development. This approach can be followed as a tactic of searching for feasible technical solutions and may serve various development objectives.
b) As a preferable objective of development. While it is used as a necessary complement to conventional perceptions of development as economic growth, it is more widely identified with the perception of development based on the principles of promoting self-reliance of poor rural communities through traditional technologies. As such, it "encompasses deep scepticism of both the legitimacy and efficacy of technocratic authority, the benefits of urban life, and the commitment to capitalism and socialism to progress defined as bigger and better technology" [9].

3. IT AS APPROPRIATE TECHNOLOGY

What lessons relevant to the application of IT can we draw from the appropriate technology literature? If we understand appropriate technology with the first meaning identified about, as a technology that fits in a socio-economic context and provides a stepping stone for further technological development, we can neither say that IT is an appropriate technology, nor that it is not. The essence of this argument of appropriateness is that there is no predetermined form of IT which can be a *priori* characterised as appropriate or inappropriate. Certainly, the idea that early generations of computer technology by being simpler are more appropriate is false. But, similarly, the argument that microcomputers are appropriate because they are small and relatively cheap is a dangerous generalization, and the idea that certain high tech systems such as expert systems are inappropriate has no validity. Socio-economic conditions vary from country to country, and even within a country from region to region. It is not possible to decide what technology is appropriate without analysis of the development objectives an IT project is intended to meet, and the socio-economic context within which it will be implemented.

This notion of appropriate technology is compatible with the socio-technical approach to systems development. It supports the perspective of information systems which comprise interdependent technical, social and organizational elements. From this perspective, the development of effective technology is pursued in parallel with the design of organisational

change and the monitoring of social change. This view of technology is compatible with the research results reported in the literature of technology transfer, which has repeatedly emphasized that one cannot usefully consider technical systems separate from the organizational forms and the social context required for them to function [35]. What is therefore needed is not a general list of criteria according to which the appropriateness of a certain system will be decided, but a general strategy for introducing sustainable technical and socio-economic change within a development programme.

If, however, we understand appropriate technology as a movement which is seeking to support an alternative view of development, based on self-reliant communities and wishing to avoid the complex large scale structures of the production of technology, goods and services that are associated with modern industrialized societies, IT can hardly be considered as 'appropriate'. Many have tried to argue the opposite. It has been suggested that IT in its most recent forms can serve the purpose of such an ideology. It is pointed out that microcomputers are inexpensive, they are user-friendly and do not require particular technical skills, they can promote decentralization, and do not require the sophisticated infrastructure of a modern industrialised country in order to function. Additionally, many authors point out the potential of IT to serve social development objectives. It is suggested that education of the poor in remote rural areas can be improved through advanced communication technology, or even computer based tutoring systems that assist inadequately trained teachers. Similarly, it is suggested that the application of expert systems can contribute to health services improvements, for example by assisting health workers to make better diagnoses when they visit rural communities [17]. Such computer applications, it has been argued, fulfil the main criteria of appropriate technology.

The ideology of development as empowering humans to improve their life conditions in self-reliant communities may be a moral imperative as well as a practical necessity for their survival. Nevertheless, the suggestion that such an ideology can be realised with IT is utopian. There is a logical contradiction in the claim that certain IT applications are appropriate within this particular ideology. If a community acquires the capacity to command control of the IT applications that support its activities, that is the capacity to develop or adapt them use, maintain and expand them according to their needs, it has already taken a very significant step towards modernization. For example, it must have established elaborate technology development and training facilities and it must have created resources of sophisticated expertise. For even if microcomputers are user friendly to operate, they are not so simple to build, program and maintain. To reach such a state of technical capacity, a community must have devoted considerable financial resources. If, however, the community does not develop the capacity to develop and maintain its IT resources, the goal of self-reliance of the local population is not fulfilled, and the technology proves inappropriate. The worst scenario for the 'alternative development' ideal is to flood developing countries with 'appropriate' technology goods which are produced, marketed and supported by the multinationals of the industrialised countries.

Such self-contradictory arguments are based on the mistaken assumption that technologies can be separated from the driving values of their contest and successfully transplanted to serve different development principles. Computer and modern telecommunications technology

is a product of advanced industrialized societies, conveys their rationale and requires their resources. The rationale which created it and continues to exploit it in all fields of activities is economic growth. The electronic cottage is a dream of rural Californians, not of rural Africans. This rationale is the incentive to invest the financial and human resources for developing it, mastering it and using it flexibly. The artificial separation of some 'beneficial' information handling from the broad information use and decision making philosophy that gave rise to it may be successful in laboratories, but there is little evidence that it is socially feasible.

In summary, we have argued that a) The perspective of appropriate technology as the matching of technical capability with its socio-economic context, highlights the need to build the capacity of responsiveness to local developmental needs and constraints. From this perspective, the general question whether IT is an appropriate technology or not is meaningless. b) IT is not an appropriate technology for the ideology which aspires to the preservation of simple rural activities and the anti-technocratic movement.

In the following sections we will consider the first of these two meanings of appropriateness and will examine what strategies can be adopted to lead to appropriate IT systems in this sense. We will examine the process of transfer and development of IT in developing countries at both macro and micro level decision making and actions. At the macro level national governments and international development assistance agencies play a significant role though policy making. At the micro level, individual institutions undertake the challenging task of exploiting technical possibilities and meeting socio-organizational objectives.

4. POLICY MAKING FOR APPROPRIATE IT

Each country is unique and has to determine from the available options the policy likely to serve it best. Hence all we can provide is some guidelines on the options which may have to be considered. In its nature such a list cannot be comprehensive, or provide a total prescription on how to determine an appropriate policy.

For countries seeking development within the international economy, there are a number of policy decisions regarding IT. The first is where the country has some obligation in international law because of treaties with other countries and needs specific IT capabilities to fulfil its obligations. In practice many of these obligations stem from defence arrangements, but they can also be components of commercial or political agreements. As the world coalesces into regional groupings such obligations are constantly increasing.

The second is concerned with standards of services and products. To the extent that a nation wants to participate in international economic activity it must be prepared to accept the IT applications which support or drive these activities. Thus if the indigenous airline wishes to participate in a global air reservation system it must be prepared to adopt the IT components and infrastructure required by the GALLILEO or AMADEUS systems. Also, if a nation does not want to cut itself off from international developments in IT it has to make policies with regard to the adoption of international IT standards. A country may also have to decide whether it merely accepts the given standards set up by such bodies as the International

Standards Organisation (ISO) or wishes to influence the setting of standards. In India for example, a great deal of work has been done by the Indian software industry in providing an interchange mechanism for a number of the more widely used Indian scripts. by not being a member of ISO India risked that its interchange mechanism would not be compatible with the new international standard character set being set up through the ISO. By good fortune the Indian character set appears to be compatible with the new ISO set.

The third area of IT policy is concerned with the IT infrastructure needed to support the national development plans. In this case, IT infrastructure [21] comprises:

- communication channels ranging from conventional telephone lines and postal services, to electronic networks, communication satellites, mobile telephones and faxes.
- facilities such as telephone exchanges, repeater stations, value-added networks which enable other components of the infrastructure to function.
- education and training facilities to provide the level of competence, understanding and skill of the population at large, to ensure successful use of new technology.
- software tools including spreadsheets, Email systems, CASE tools, Data base management systems, and systems software.
- hardware systems including mainframes and PCs.

The fourth relates to the use of IT as a way of achieving goals which by conventional means are almost unachievable. For example, remote sensing provides a possibility to collect data on land use and resources which would be enormously more difficult to collect with conventional survey methods. It may create an additional link of dependency, but it seems there is no other option if the survey data is regarded as essential. IT based modelling and simulations provide the possibility of assessing the value of alternative development programmes in a way which would not be possible using non-computer methods.

In addition to these four areas, there are many other policy decisions to be made regarding IT, including:

- whether (and how) to support the development of an indigenous IT industry, or to import technology and concentrate on effective utilization practices;
- what effective use of IT in the government sector can be made;
- how effective IT use for the benefit of the country's economy and society can be promoted.

Appropriate IT at the level of the policy maker means that the IT provides the means for or supports activities which in national terms are seen as desirable. Technology can never be an end in itself. It is appropriate only to the extent that it has a chance of furthering some national objective.

However, it must be noted that the record of implementing IT policies which have been promulgated is littered with failures. The failures are of three types:

1. Failure to make the policy effective - that is a policy may define certain actions, but those actions do not take place or are subverted in some fashion. The case study by Madon[31], described below, is a good example of policy being subverted by the action of certain stakeholders in the system.

2. The policy is successfully translated into action, but the consequences of the actions have effects other than those expected when the policy was promulgated. The Indian Government policy to exclude foreign owned IT contractors was intended to strengthen India's own IT industry and at the same time reduce spending in foreign currency. The effect of the policy was to deny to India some technological developments taking place outside India without achieving the main objective of building a strong Indian IT industry. Later India was forced to reverse the original policy.

3. The policy becomes irrelevant because the circumstances which gave rise to the policy in the first case have changed significantly. An example, which illustrates the problem is the changes which have taken place in Eastern Europe. The defence policies of the Western Alliance based on the notion of a Soviet threat have been made redundant by the collapse of the Soviet Union. An example of a very different policy area comes over from the field of medical informatics. The apparently successful expert system devised by Shapira [42] for the management of patients subject to Deep-Vein Thrombosis was made completely redundant by the development of a drug which prevents the condition occurring.

The consequences of failures in policy making and planning are particularly severe in developing countries. Not only scarce resources will have been misapplied and yield little if any value, also failure may lead to the regressive concept that the technology itself is the cause of failure and encourages anti-technology ideologies.

The frequency of failure suggests that planning and policy making for IT needs to be accompanied by actions that:

1. Ensure that necessary pre-conditions are met. An example described by Madon [31] illustrates the problem. The Indian Government programme for providing resources to enable the poorest of the poor in rural communities to upgrade their opportunity for raising standards of living relied on the banks to disburse the financial grants and the village authorities to assist in choosing suitable recipients. A pre-condition for successfully implementing Government policy was that the local bankers and the village authorities understood and shared the objectives of the policy. In practice many bankers were more concerned with making safe investments than in providing assistance to what they regarded as the high risk poorest of the poor intended recipients. The village authorities frequently chose as recipients those who were already powerful and could further the career of the authority. As a result the policy, in itself well conceived, largely failed to achieve fits objectives. The effectiveness of the computerisation efforts which were intended to support the rural development programme were inextricably linked to the success of the development programme itself.

Policy makers need to systematically examine each policy option, and to consider what conditions would have to be met if the policy is to be successfully implemented. Techniques such as Constraints Analysis [25] or Management of Change guidelines [21] can assist in such an examination.

2. Evaluate the risk of each policy option. In particular to evaluate the consequence of a policy failing or the consequences of a policy not meeting its target or having a counter productive impact. Techniques such as scenario planning or the robust planning technique recommended by Rosenhead [37,38] can assist policy makers in these evaluations.

3. Ensure that the policy option chosen is not at variance with another policy by one Government ministry may be frustrated by the policies enacted by another ministry. One of the commonest failings is the incompatibility of policies between different policy making groups. Han [14] provides examples from Malaysia where different planning authorities placed emphasis on objectives which were in some ways irreconcilable.

4. Assess the extent to which it is possible to predict the future at the time policies are being made. Political instability is one of the prime sources of rapid and unexpected changes, and a part of the developing world has been prone to such problems. It is necessary to identify the forecasting horizon, and ensure that any policies and plans fall within the forecasting horizon [19]. Planning has not only to map a path into the future, but also to identify what aspects of the plan have to be flexible. Planning on the basis of multiple conceivable scenarios [37, 38] increases the possibility of plans not being outdated by unforseen realities.

5. Ensure that the implementation of the policy is properly managed and monitored. This implies that the policy must have clearly stated objectives which are translated into project milestones and benchmarks. As far as possible the measurement of progress needs to be assessed independently from those responsible for project management. It is important that a project does not generate so much inertia that it cannot be stopped even if it no longer meets its original objectives or the original objectives have become irrelevant.

5. DEVELOPING APPROPRIATE INFORMATION SYSTEMS

The question what IT applications are appropriate to develop in an organization can be best dealt from the perspective of information systems. The concept of 'information system', broadly meaning information handling activities within an organization, provides a powerful vehicle to study and develop IT applications in an organization's context. The literature of information systems suggests that throughout the systems development process, from planning what new information handling arrangements are needed to support the organization's functions, to carrying out particular information systems development projects, technical options should be examined in relation to the conditions of the organization, such as its structure, management, skills, culture. Technical systems, such as a software application or a computer network, should be designed in parallel with preparing changes of structure, job procedures, management functions. In effect, the development of an information system is a process of socio-technical change.

In theory, this perspective drives an analyst to consider the socio-economic appropriateness of technical options during several critical tasks of the systems development process: the planning of future major information systems changes, requirements analysis, feasibility study, and implementation.

Information systems planning considers the possibilities of improving the performance of the organization (either business performance, or public services) by designing new information systems. This may include the acquisition and implementation of new technology, re-organisation of data resources, or re-design of information handling procedures. A variety of methods are available to assist managers in understanding the significance of investing in new information systems projects, to align them with the more general plans for their organizations, and to assess their organization's capacity to carry out the change [11].

Requirements analysis is the task of finding out in more detail what information needs a proposed information system project should cover. Therefore, it considers the activities performed in an organization, how they are organized, how information is communicated from one group of employees to another, how decisions are made, how their legitimacy is monitored.

The feasibility study examines whether a proposed information systems change is viable and what benefits or risks it entails. Analysts have to consider carefully several different aspects of the proposed new system, such as: whether it is technically possible (for example whether the necessary skills to develop and use it are available); whether it fits the current organizational structure and culture, and if organizational changes are envisaged, whether they are possible to implement; whether the people in the organization and the customers of the organization will accept and co-operate effectively within the proposed system; whether the proposed system makes sense economically; whether the proposed system is legally possible. The feasibility study should lead to specific decisions on what technical option should be developed, what physical space arrangements should be prepared, what job changes should be undertaken, what training and other preparation is needed, what managerial tasks should be introduced, what organizational reforms will be made, and what data infrastructure should be prepared.

The implementation of a new system comprises both technical and socio-organizational changes. Training of people for their new information handling tasks is recognised as one of the most crucial factors for the success of the new system. People must feel confident about the new system and satisfied with their changed work environment.

In practice, however, few of these studies of appropriateness that the information systems literature suggests take place, either in industrialised or in developing countries. Most methodologies which guide the practices of systems analysts are predominantly dealing with the effort to design the software subsystem [2] and little methodical effort is made to match technical and socio-organizational change. It is not surprising that the number of systems that fail to contribute to any improvement in the organization in which they are embedded is very high. In developing countries in particular, even efforts starting with the best intention to support development objectives often end up as under-utilized and marginalised applications [26,31].

Nevertheless, there has been some research drawing attention to the nature of the pre-conditions that should be met for effective implementation of IT. Taking such findings into account does not guarantee the development of appropriate applications, but it can help to avoid the waste and frustration of attempting to develop technical systems where they cannot be used effectively.

1. Strassmann's [43] findings from a major study of USA companies suggest that a critical success factor for the successful use of new technologies is management competence as measured by an index of his devising, ROM - the value added by management. His research shows it is not possible to overcome poor management practices and understanding by the deployment of new technology. Land, taking a socio-technical view suggests [20] that managerial competence embraces both social and techno/economic understanding.

   The issue of managerial competence and managerial understanding is one of critical importance in many developing countries, which have had few opportunities to develop a cadre of highly trained managers, either in the private or public sectors, in particular at senior levels. Appropriateness of an application, then, is related to management competence, and the question to be asked: have we reached a sufficient level and if not how can this be achieved?

2. Other research points to the importance of shared values as a critical pre-condition for managing change [22,23,24]. Shared values implies that the work force at all levels share certain concepts: there is broad agreement on the mission of the organisation, on how that mission is carried out, on the appropriateness of the existing authority structure. An indication of shared values is often that differences in viewpoint are tolerated or even welcomed. Shared values may be achieved by a policy of consensus building as demonstrated by many Japanese enterprises, or by a system which ensures that all who are not like-minded are excluded (achieving shared values by attrition).

   Again, developing countries may face special difficulties in the direction of shared values. The use of ex-patriates at senior levels can create situations in which it is difficult for indigenous staff to share values. On the other hand traditional forms of hierarchical structures are sometimes deeply embedded and accepted. If the hierarchical structure is threatened by the introduction of new technology implementation difficulties occur.

3. The last point is underlined by the notion of 'organisational invalidity' [34]. The notion suggests that many information systems have failed to be implemented successfully, despite apparent agreement on their desirability, because the change runs across deeply ingrained organisational norms and structures. Hence the feasibility process must probe the extent to which existing norms and structures might be offended and how robust such norms and structures are.

   In many traditional societies such norms and structures are indeed robust. Major organisational changes such as those made possible by the use of Information Technology cannot be brought about without first breaking down the existing culture [1].

4. Research has shown that unless all those affected by the change have a clear idea of what is expected of them, what benefits or payoffs may accrue to them and what support is available to them in case problems arise, how the process of change is going to be managed and who has responsibility for the project, they may not co-operate or may even subvert the introduction of a new system [16]. The phenomenon sometimes described as 'resistance to change' challenges the introduction of change. Hence a pre-condition (necessary but not sufficient) for the successful transfer of technology is a work force which has adequate channels of communication of those in authority, and has an informed knowledge of what change is planned [21]. One of the most important obstacle to the successful implementation of even well conceived systems is uncertainty on the part of those affected by the system.

5. Evidence is accumulating that the possibility of introducing technology effectively is significantly enhanced if the work force - at all levels - has a high level of education and training. A well educated work force has a better chance of understanding the nature of the changes called for, and of adjusting their skills to new demands. Those countries which place a high value on education and already have the resources to provide a high level of education - Japan, Germany, Singapore are examples - are also countries where technology transfer and diffusion takes place most readily. At the micro level the organisation which invests in an educated work force and ensures that education and training is continuous has advantages in terms of adapting to change over the organisation which sees technology as an opportunity for employing a work force with reduced skills.

Research evidence suggests that whilst education is positively associated with adoption of new technology [18] user satisfaction shows a negative effect - in other words, a well educated user may have higher (partially unfulfilled) expectations of what the technology should deliver [27,28,29].

Many developing countries are at a significant disadvantage in this respect. They have not got the resources to enable them to provide the requisite level of education to a large part of their population. The question arises: what is the appropriate or minimum level of national education required to ensure that advantage can be taken of new technologies and tools?

6. CONCLUSIONS

In this paper we explored the concept of appropriate technology and found that one meaning of 'appropriateness' is particularly useful to consider in order to make effective use of IT in developing countries.

Effective utilization of IT requires careful consideration of social and organizational aspects at a national and organizational level. If such aspects are not considered in projects involving the transfer of IT, systems fail to pay off and meet initial objectives. Indeed, IT projects which do not result in expected benefits is a common outcome rather than an exception, in industrialized as well as in developing countries. Yet, by a process of costly trial and error, most organizations in industrialised countries have the capacity to adapt gradually to their new technology based information systems. Information technology, which is invented and

develops within the context they function, is 'appropriate' enough to drive retrospectively the necessary, even if expensive and painful, organizational changes.

In developing countries the problem is much more serious. Not only is the proportion of information systems projects which fail to deliver benefits to the organization higher, also our understanding of what social and organizational changes are necessary and feasible is still very poor. Methods for socio-technical design, such as Checkland's soft systems methodology [6], or Mumford's ETHICS [33], were devised to fit the organizational behaviour norms prevailing in specific industrialised countries. There is little evidence, for example, that the idea of deciding on feasible information systems changes through an effort to reach consensus can be effective in many developing countries. Even 'user participation', one of the most fundamental features of socio-technical design is doubtful whether it is applicable and effective in rigid bureaucracies traditionally run by the authority of superiors rather than the initiative of employees.

There are significant aspects of information systems in developing countries which are poorly understood and cannot be systematically considered by analysts, even if they do intend to try to develop appropriate information systems. These include: the capacity for and the process of organizational reform of institutions such as government bureaucracies, or small size enterprises; the prevailing rationality in decision making processes; the cultural aspects which affect the use and value of information, the communication and decision making processes and the work procedures. Still, research in such areas is almost non-existent. Although international donors and development centres accept the necessity of choosing and developing technologies that fit the socio-economic conditions of a community at present, they promote the diffusion of new IT without any serious effort to monitor fits effects. It is time to organize and fund research to improve our understanding of the process of information systems development in contexts which differ form that of the industrialised countries, where most information systems research has been taking place so far.

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IMPLEMENTATION OF INFORMATION TECHNOLOGY: SOCIO-CULTURAL ISSUES

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ABSTRACT

In the history of development cooperation, technology has been given a major role in trying to narrow the gap with the industrialised countries. Cultural aspects have not been appropriately dealt with. Today, information technology plays an important role in development projects. When introducing and using a new technology, a preliminary investigation of socio-cultural aspects is effected, through a specific case-study.

1. INTRODUCTION

The implementation and use of (information) technology in developing countries has to be regarded in the broader perspective of development cooperation. Today, no policy of development can be outlined without reference to information technologies as important tools [4,9]. Vital questions which need to be asked, are the following: what is understood by development and how is this reflected in the implementation of information technology? But even if goals and strategies of development are well outlined, the transfer of new information technologies only is no guarantee for success. It is the reception and acceptance by the public (micro-level) that determines the final degree of success [21]. In this article, we will look in particular at this micro-level and investigate how the socio-cultural reality of developing countries (in this case Africa) affects this acceptance and usage problem of new information technologies [see also 24].

2. DEVELOPMENT AND TECHNOLOGY IN PAST AND PRESENT

Technology has been the primary input for development since the beginning of development cooperation. But the specific kind of input always reveals ideological positions. In this sense, the dominant development theories as reflected in development policy and the view on technology and technology policy for particular moments in time, have to be reviewed. An inherent element in the debate on development and technology is how to cope with the issue of culture.

2.1 Development and Technology in the Past

Both the paradigm of modernisation (1950-60) and the dependency-paradigm (1960-70),

focused on the 'engineering' aspect of economy. Quantification of development in terms of GNP or the relation between GNP and population growth [12] constituted at that time the formulation of both goals and means of development. In the modernisation theory, the conditions, responsible for Western development had to be imitated in order to initiate the take-off. Western technology was believed to be neutral and an accelerating instrument in the development process. Culture was considered a surmountable and irrelevant obstacle in development; culture was supposed to adapt itself to the economic process as well as to technology.

For the dependency theorists, the take-off could only come about by tearing themselves away from centre countries and by creating large import-substituting technology programmes. This point of view reflects a first vision on appropriate technology: a strategy for breaking dependence and reaching economic growth from within [2]. Culture did not have a clear role within this paradigm: cultural dependency existed only as a reflection of economic dependency.

Both paradigms have clearly one idea in common: starting up the economic machinery, in which the dynamic rationale of both would simply be assured by searching for maximum profit [19]. Underdevelopment could hence only be defined de facto in terms of a time-lag.

Poor results of the development process and the idea that high material standards were no guarantee for happiness or harmony, have led to a rather culture-relativistic view on development and technology. Development was no longer defined as economic growth but had to focus on the fulfilment of basic needs (this approach was launched by the International Labour Office in 1974). The ultimate goal of the new strategy was the self-reliance of local communities. Technology could be of great help, if appropriate. In this context, appropriate technology was defined as small, simple, capital-saving and labour-intensive. This constitutes the second - alternative - view on appropriate technology [2]. Building proper technologies became the newest strategy for breaking the dependency relation with northern countries (in this way, the paradigm of dependency is joined). This view on technology was again contradicted by Arghiri Emmanuel [14] who put every appropriate technology on a par with underdeveloped technology.

2.2 Development and Technology in the Present

For the last decade, international organisations have been inducing strategies of export-oriented growth within the framework of structural adjustment programmes. In development policy, information technology is considered to provide the new potential to leapfrog into the information society. Cultural aspects are not taken into consideration. Hence, modernisation is again setting the tone.

But all efforts have not succeeded in narrowing the gap between poor and rich countries. According to the year report (1992) of the United Nation's Development Programme (UNDP), the gap has doubled in 30 years time. A closer look at the present policy does not seem to indicate much of a change. Development is still based on the economic imperative whereas the problematic link technology-culture is not seriously taken into consideration. However, recent studies reveal new lines of thought on the level of development theory and in the western

world, doubt has arisen about the viability of its proper development model.

3. DEVELOPMENT, TECHNOLOGY AND CULTURE

The western model has never been put so much in question as today by the ecologist movement. Their political thinking is based upon three premises:

- the existence of a cultural preliminary, e.g. the necessity of a planetary, global and long term approach to deal with the present-day problems;
- the rejection of the dominant economic postulate according to which unlimited growth of production and consumption would eventually allow for the satisfaction of the social needs of all and,
- the claim for democracy or the establishment of the participation of citizens on all subjects [11].

Interesting to note is that these premises can also be found in different normative schools of thought [26,29,12,27], going further than the 'basic needs-approach'. Sen conceives development as "a process of expanding capabilities of people" [10]. Servaes argues that "Another development" should be based on a number of principles, such as the satisfaction of basic needs, endogenous solutions that are ecologically sound, self-reliance, participatory democracy, and the search for a structural transformation [27,29]. According to Sen's definition, it is our opinion that capabilities should expand in order to improve the freedom and the opportunity to make autonomous, qualitative choices. Following these principles and lines of thought implies that the road to development cannot be considered universal. Every principle in "Another development" implies cultural aspects. Also, the ecologist approach confirms a cultural preliminary and a participatory development process.

In this context, it is not possible to consider technology as neutral. It incorporates the technical and social viewpoint of its designers and producers [15,25,1]. But the consequence is not that endogenous technologies can only work optimally within the corresponding culture or that its uses are predetermined or unalterable [29]. This would imply a rather static view of culture. The question at stake is not whether technology determines culture or culture determines technology but whether and to which extent a degree of mutual adaptation is possible and how eventually change can be monitored. In this perspective, the failure of many technology implementations can be partly ascribed to conflicting values, habits and organisations. Managerial methods will then vary according their cultural setting [5]. To this effect, we have tried (1) to identify the importance of culture within one particular IT-implementation project and (2) to investigate how to cope with particular cultural aspects. The following case is a scientific information capacity-building project on a regional level through the use of information technology.

4. SOCIO-CULTURAL CONDITIONS FOR SUCCESSFUL IMPLEMENTATION AND USE OF INFORMATION TECHNOLOGIES: THE CASE OF RECOSCIX-WIO

Primary objective of RECOSCIX-WIO (Regional Cooperation in Scientific Information Exchange-West Indian Ocean) is the improvement of the marine sciences information flow to,

within and from the West-Indian Ocean Region. The Regional Dispatch Centre (RDC), the key element in the flow of information, is situated in the Kenya Marine Fisheries Research Institute (KMFRI) in Mombasa. The design of RECOSCIX-WIO contains three phased elements: the information *to* RDC is collected by cooperating libraries from outside the region. Those libraries are suppliers of information. The demand for information arises from the cooperating institutes within the region through RDC. Those institutes have to cooperate in order to reach the second element, the flow of information *within* the region. In the final phase, information *from* the cooperating institutes should be available to scientists outside the region. The means to achieve these goals are

- (to) the availability of international databases on CD-ROM;
- (within) the construction of three regional databases:
  (1) a database of the available literature in the region, also incorporating grey literature, (2) a database listing the scientists from the region with their expertise, and (3) a database with abstracts of all publications of local scientists;
- (from) the incorporation of RECOSCIX-WIO in the PADIS- network to exchange information with marine scientists from outside the region.

Which are the identified problem areas concerning the implementation and use of the new technology?

4.1 The Organisational Structure/Social Setting

Various elements constitute this structure, such as

4.1.1 The Hierarchical Constellation

In Western countries, the particular (formal or informal) hierarchical structure does not always appear adaptive to implementation nor to the use of new information technology. Moreover, it does not seem to coincide with its intrinsic elements [6]. Proposals to remove such problems vary: the "modulation" of the organisation through management of technological change or the adaptation of technological design to organisational conditions [1], the taking into account of different social and organisational factors at the moment of the introduction of new information technology [25] or, the incorporation of expected problems in the conception of the technology itself [18]. The probability of participation in design -even in the Western world- is very low. Participation in the choice of technology seems more realistic. Still better is the anticipation of possible problems at the stage of introduction. Adaptation of the structure to technology or adapting technology to organisational conditions can eventually be used in a second phase.

Concerning the hierarchical structure in RECOSCIX-WIO and its adaptive capacity for information technology, the KMFRI seems characterised by a strict pyramidal structure. Little contestation is allowed and solidarity seems organised around the ethnic group. Such constellation makes strong social control possible. Because of the social control, the informal structure is a reinforcement of the formal, pyramidal structure (see for the importance of informality also [22,24]). This has its impact on RDC because the staff -except for the associate

expert- is connected to the institute in the first place and has to follow its (unwritten) rules.

The point is of course if this hierarchical structure has conflicted with the implementation and use of technology. An example can be given through RDC's choice of technology for achieving the information it requires. The pyramidal structure of the KMFRI implies that only persons on a high hierarchical level are allowed to use the telephones. In case the information capacity-building project was based upon on-line services through modems - the most obvious choice from a technology driven oriented point of view -, it would have conflicted immediately. This was anticipated by the associate expert - who had decision-power on the choice of technology - who opted for the use of CD-ROM. Information is directly sought for by means of computer and CD-ROM and consequently asked for in writing to the cooperating libraries. No telephones have to be used and hence, no immediate conflict with the hierarchy has occurred. This incorporation of expected socio-cultural problems through choice of technology has led to (1) successful use of the new technology and (2) relative autonomy for RDC whereby future use of on-line services remains an open question.

4.1.2 Autonomy of Work

The autonomy of work is closely related to the hierarchical structure. A large part of development project studies pleads for local control in order to guarantee this autonomy [30]. In this context, we consider the locality of supervision an inappropriate question. It is more to know if a certain work-autonomy exists. The supervision of the RECOSCIX-WIO project is foreign (donor-organisation) but the staff depends on the institute. Even if the director has to justify everything that makes out the "outside" of the institute (recruitment or dismissal of personnel) before the board of the answerable Ministry, he can take decisions at random "within" the institute. Personnel can hence be transferred to other departments or institutes of the KMFRI. Consequently, control at local level combined with a strong hierarchical structure would clear the way for taking arbitrary decisions and open the possibility to the prevailing of personal interests over project interests. In the case of the RECOSCIX-WIO project, we believe that foreign supervision of the project itself is suitable because it guarantees relative autonomy - albeit limited - for the working of the project. Within the limits of the project and the organisation, exploration of a strategy is required in order to gain that necessary autonomy.

4.1.3 Social Integration

Social integration is the integration of demand and supply in the structure of the functioning of social groups [7]. For the RECOSCIX-project we distinguished three levels of social integration. The first level concerns the RDC itself, which coordinates demand and supply of information. A second level in the project refers to the institute as a whole, in which scientists easily reach the demand for information. Finally, on a regional level, scientists reach the demand for information through the responsible coordinator of the institute. The RDC as the key element is at the same time the strong and the weak link of the project. It is a strong link because the RDC functions as a filter for queries from other institutes and because its centralised operations reduce costs for document delivery. It is a weak link because the construction is vulnerable; if RDC cannot function as it should (cfr. hierarchy, social control

etc.), the whole project collapses.

4.2 "Acquisition Substitution"

The consumer seems to consider replacing a new technology only when it substitutes an older one with a better quality and/or at lower cost [6,31]. Conceived from our western point of view these elements are motivational aspects. But what elements constitute this motivation in African context or foresee the reasons for participation in a project [8]? Through this domain, some preliminary ideas can be put forward.

We have often heard that Kenyans "have no work-responsibility", "lack sense of initiative" and that they "need guidance". A disturbing element for this - mainly Western - point of view is the fact that Kenyans seem to have sufficient initiatives and organisational capacities when it comes to "their own business". Many have an occupation in the informal sector. This difference in "work enthusiasm" is then explained as a result of personal advantage. However, could this difference between "not working" in the formal sector and "working" in the informal sector not be explained as a strong control of uncertainty? In most African countries, no social security system exists in case of a job-loss. Hence, uncertainty may be reduced by getting employment in the informal sector. In western countries, the control of uncertainty tends to be coped with in two ways: on a macro-level unemployment benefits are provided for and, on a micro-level, internal rules, planning etc. within the organisation prevent abrupt dismissal. Is it not possible that those mechanisms are absent in Kenyan organisations because the uncertainty is not controlled within the organisation? The passive and non-critical attitude can be seen as part of the same control of uncertainty.

Can other motivational mechanisms, used in western organisations be of any use to African organisations? Mechanisms as upward mobility seem to lose their motivating power because of, among other things, the monetary obligations to the "extended family". Earning more money means looking after more members of the family or the tribe. Hence, a particular social security system. Connecting this to the strong control of uncertainty, the employee may consider wage-increase less interesting than employment in the informal sector because the official wage can be easily controlled by the family. In this way, he is able to partly escape his social obligations.

It is clear that more elements have to be scrutinised when talking about motivating people in projects, which will be, no doubt, culture- or value-related. One possible motivation is the formulation of objectives in terms of existing needs [23]. In RECOSCIX, the scientists' need for adequate information is obvious. The group of scientists gains collective profit. But next to the scientists, the administrative personnel working with the new technology, should be taken into consideration. In a general way, it may be more relevant to look at the social or economic surplus-value that each participant can realise separately (individual gain) or different groups of participants (collective gain) can realise in the project [6]. In the project's administration for example, a programme was developed to calculate the employees' wages. The idea of using computers was adopted from that moment on. In this way, elements from the demand side (needs) can be complemented by a kind of internal marketing from the supply side [20]. Next motivating aspect contains the involvement of every participant in the final

objective of the project. Finally, continuity and flexibility (to learn and change [23]; no blue-print approach [13]; a "learning by doing" [17]) will have positive effects. A long lag of time between training and adaption of the equipment cannot be expected to be favourable for a project. On the other hand, flexibility during the execution of the project, is required.

4.3 Working Habits

Western work ethos is based on working a fixed number of hours. Official labour is the key to participate in overall society. In many developing countries, the aforementioned informal sector plays an important part. The fertility of this sector is said to be directly linked with cultural resistance against a development conceived as foreign [32]. Many people from the institute have, next to their official job, an activity in the informal sector. However, interference between work in the project and work in the informal sector should be prevented unless the elements, responsible for the attraction of this sector could be incorporated in the project itself which seems hardly possible on local level.

4.4 Education

Working with technology requires skills and good training [24,13,3,28]. But next to the acquisition of skills, the need for a heuristical art is urgent [16]. Education should give more space to develop a critical tradition, to stimulate debates and discussions about all kinds of subjects. On a project-level, training should be more interactive in order to find harmony between the needs or objectives of the trainee and the needs or objectives of the trainer. Understanding and cooperation can only improve.

5. CONCLUSION

Because of the intrinsic qualities of information technology, the presence of information technology is relevant for a country's development. Import of new information technologies should therefore not be rejected. On the other hand, information technologies are not to be considered as magic devices that generate development. Simultaneous efforts are required in other areas. But because of its potential, it is important that information technology is consciously implemented. From a sociological point of view, some required conditions for successful implementation and use are the following: anticipation of possible conflicts with the hierarchical structure, sufficient work autonomy for the employees, integration of involved social groups, motivation of all personnel working on the project and sufficient education (on a overall level) and training (on a project level). If incorporation of difficulties proves impossible at the moment of introduction, flexibility is required.

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ASSESSING COMMUNICATION TECHNOLOGIES FOR DEVELOPING COUNTRIES

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ABSTRACT

Information technologies and telecommunications are key factors in the development of society. Since most developing countries still have a long way to go on this road, past failures in technology policy due to technocratic, technology driven and top-down approaches should not be repeated in this area. This article points out why good assessments in this area are problematic and puts forward the need for policy related insights in the societal user dynamics of new telecommunication and information services.

1. INTRODUCTION

In Western technology policy, the input of social sciences in the technology assessment approach, as opposed to more technology driven approaches, becomes more and more accepted as essential instruments in developing efficient technology innovation and implementation strategies [7]. This is especially true in the field of information technology (IT) and telecommunications (TC). The OECD for example observed that 80 up to 90% of all innovations in this sector are never implemented [47]. But IT and TC are not only very cost intensive, they reveal to be technology-imperative too: once a certain route has been chosen, it is extremely difficult and costly to change the technological trajectory which follows from that choice. With regard to developing countries (DC) similar concerns are expressed [29,12,24,46]. Yet, in terms of social science assessments a lot of work has to be done. In fact, only recently development related scholarly work is pointing in this direction [5,8].

From a more traditional macro-economic assessment point of view, the demand for TC services can be written, at a certain point of time (t), as $Ct = Ct(Pt,Yt,Zt)$; whereby P = the unit price of the services, Y = the economic level of activity or income and Z = the vector of other explanatory variables such as population, indices of reliability, computing speed etc. [38]. In this article attention will be drawn to some obstacles when applying this formula to assess possible developments in terms of minimizing failures and costs and maximizing successful applications.

Our point is that the present state of research does not allow to calculate this, because there is a lot of confusion on what C stands for, there is great uncertainty about what the precise relationship is with Y and one is poorly informed on what Z should contain.

2. THE NEED FOR GOOD ASSESSMENTS ON THE DYNAMICS OF THE INFORMATION SOCIETY IN DEVELOPING COUNTRIES

There can be little discussion that the poor state of IT and TC in developing countries is a vital problem for these countries when catching up with the developed world.

However, since most of the DC still have a long way to go, this enables them to leap-frog some of the development stages of these new technologies. But it is hardly imaginable that DC can invest, as the EC did up till now, approximately 5 billion $ in finding out what the most appropriate new IT and TC applications for Europe could be.

A lot of choices have to be made, since many scenario's are technologically possible. However the financial situation of most DC is so critical that, in contrast to the Western countries, not too many mistakes can be made in their policy towards IT and TC.

In other words, even more than the developed countries do the DC face the challenge of innovation and implementation of these technologies. Several examples illustrate this. In the seventies many DC invested heavily in satellite technology, often advised in this by Western experts, whereas they are facing a situation now where they lack the resources to establish it further on. Hence, the much criticised underusage of existing TC facilities in these countries. The problem with TC however is, since it is such a capital intensive sector, that once a path has been chosen it is extremely difficult and costly to choose another one. Once the decision made to invest in a nationwide wire telephone network it is almost impossible to turn back the clock. Or to give a real example related to the investments in satellite one decade ago: once Nigeria decided to give up its totally unrealistic AEROSTAT balloon plan (lost money: 200 million US $) to provide satellite service by a, technically, much more realistic, earth satellite system DOMSAT, the money is lacking to consider other scenario's. Though, from a public utility point of view these other policy options might be necessary given the fact that DOMSAT is mainly used for national broadcasting transmission and that only a limited proportion of the population, the well-to-do urban dwellers, can afford it [43].

A more recent example that illustrates the difficulties of innovation in TC, is the introduction of ISDN in Thailand. It was found that instead of utilizing TC investments to build up long term national capabilities in digital IT, the Thai TC authorities focused mainly on short-run returns on investment thus relying heavily on foreign import of hard and software as well as management [23]. Which shows that if the TC investment is done according to the market game - in order to "solve" the financing problem - knowledge dependency on foreign import is created and may then in turn result in long term problems [19]. Especially since TC and IT are characterized as very much knowledge-based technologies and industries. And, one could add to this, since 2/3 of all Thai telephone connections are taken up by business and government users, the high public investments on ISDN favour once more these users only.

Not only does the present financial debt crisis of the third world restrict their possibility to try-out different scenario's in the development of TC. Evidence suggests that investments in basic TC infrastructure is becoming more and more problematic too [4]. This seems to be so

for the poorest DC, especially the Africans [28], as well as for the so called more developed DC [49]. Which explains why the World Bank insists on privatising the whole TC sector in the DC. A recent report of the World Bank proposes to deregulate "... cellular, paging, data communications and Value Added Services; along with long distance services" [1: 22]. These are the booming or business oriented services as well as the big money makers in TC. The idea of the World bank is than that since TC are operated inefficient in DC and since economies of scale are no longer necessary to justify a monopoly, these services can as well be organised on a private basis. Though there is certainly something to say on the inefficiency of TC in third world countries, privatizing the booming sectors as well as the money makers in TC, inhibits very important social consequences. Namely that even fewer money will be available to build up a universal service in telephony. Because if these public services are privatized, where will then the money come from to make the necessary huge investments to provide universal service in TC.

Precisely at this point the analogy - what is good for developed countries (deregulation) is also good for others - stops. Deregulation started in most Western countries only after universal service was realized and not before. There is even no parallel possible with the, in the West often quoted, newly industrial countries. They too, as the Korean experience shows [52], started to think on deregulation, only when their basic network was established and not, which would follow from the World Bank advice, when building it up.

And if universal service would not be realised this brings, at least for DC, the whole idea of upheaval of their overall standards of living, via better telecommunications in danger. More than 2/3 of the developing world is indeed rural and a privatised TS has no incentives at all to go to that "market". And because a well functioning telephone system is essential for all further TC services development, this would imply that at least 2/3 of the DC would be left out of the supposed benefits of the information society. This would then come on top of the already made observation on the Thai case of ISDN, that TC developments in DC up till now are mainly in the benefit of the urban, business and governmental elites. Thus a closer assessment of the specific pattern with which TC might develop, reveals that the proposed cure (privatisation) may be worse than the disease (inefficiency, under utilisation, low coverage). Which then leads to the conclusion that the real challenge for DC is not so much to deregulate or not, but how to make their public services more efficient in view of realizing universal service. Or, more precisely, that the real choice, in terms of allocation of resources, for DC to be made is the one between upgrading existing networks to Western standards in order to meet the "demands" of the information society or providing universal service. And that is a fundamental political and social choice.

3. THE INFORMATION SOCIETY: WHAT IS IT ALL ABOUT?

The question to answer then is if research has enough knowledge and/or the right kind of knowledge to policy IT, TC and so forth in the directions mentioned. Here the literature suggests that a very superficial, conflicting and non-empirical knowledge of what is going on. Two examples will demonstrate that there more talking than sound research on what is supposed to be a fact.

First, one will quite often find the importance of the TC sector described in billion dollars, in order to illustrate the coming information society (or its dangers). The world market of TC is then estimated on 100 billion dollars pro annum and that of information processing on 100 billion dollars as well. In fact those figures are useless when used to "prove" the importance of the information society and to legitimate the necessary TC and IT investments in order to establish that society. The turn over of the tourism sector for example is, already since the seventies, more than double, 448 billion $ [36]. Up till now this has not led someone to speak about a tourism society where travelling is the new raw material. In fact the major part of the TC traffic does not consist of datatraffic or whatever futuristic application one may think of. At the end of the eighties more than 80% of all this traffic consists of interpersonal talking via the plain old telephone [25]. And research into the degree with which different communication techniques/mechanisms are being deployed by, mostly fully electronically equipped, research and information centres in Latin America revealed that the main communication technique used, was the writing of a letter. Followed by telex, fax (which are in fact substitutes for a letter), telephones, personal meetings and finally E-Mail. The latter being used nine times less than letters [41].

Secondly, if one speaks about an information society, it is essential that one can demonstrate that, at least, the economy of Western societies is moving towards an information or information related economy. In this respect, Porat's [40] analysis of the American information economy is considered a reference. Not only is this already an old study, partially based on data collected during the sixties, but his data collection is very questionable too: he considers the education system part of the information society too.

In general, most of the economic oriented studies [39,51] on the information society are, for different reasons, not very convincing. A recent international survey of this type research demonstrated that at least 8 different and not comparable, even not compatible methods are used to indicate the existence of an information economy [20]. Consequential comparative international research has to conclude that most countries who proclaim themselves "en route" to an information economy, use different parameters to prove that [26]. Whereas economic oriented critics of the information society on the other hand go as far as to deny the realistic possibility of such an economy [10]. They demonstrate that up till now our economy still is at large based on the production of manufactured goods and the success of knowledge based industries or information goods is largely dependable on the success of the simple industrial economic system. This is a serious point of critique. Most government workers or bureaucrats who receive the status of information workers in the economic oriented studies, can in fact only exist on the surplus generated by the primary, agrarian and secondary, industrial economic sectors.

Thus on a general level convincing figures are lacking. The same can be observed for developing countries [22]. If already the existing lack of basic reliable statistics would make it possible to conduct these studies [13]. Nevertheless a few attempts have been made to indicate the relationship between TC, expressed via the availability of telephones, and economic activity, mainly expressed as GNP, of a DC. The question, and the problem, is if this correlation is an exclusive and causal one or not. According to Göransson, whom discussed this for Tanzania, it is impossible to give a plausible answer to this quite essential question: "All

we know is that the richer a country is the more likely it is to have a high proportion of telephones - which is perfectly natural and true for all other goods with a positive income elasticity." [18: 1].

Probably the most reasonable thing to say then, at this stage of research, is that the relationship between TC and development is a chicken and egg problem: TC contributes to (economic) development and vice versa.

The relationship of TC with the factor Y, from the assessment formula quoted is thus, according to existing evidence, a very indistinct one.

4. HOW NEW ARE THE NEW MEDIA?

In order to make clear analysis on the development patterns of new communication services a second point needs further investigation too. More specifically the fact that there are too many communication services defined as being one consistent group of factors C from the assessment formula. A closer look at the new communication services that TC make possible reveals that a clear distinction must be made between new media and new IT and that they can not at all be regarded as part of one interchangeable group of new communication services. Quite often such a distinction is not made and thus one can find cable television, video, satellite broadcasting but also trans border data flow (TDF), computer networks, and so on being considered for analysis as one consistent group of "new media" or new communication services".

From the point of view of the communication process they make possible, two very distinctive groups of new technologies are to be distinguished. At the one end there is distribution technologies (e.g. cable TV) which is predominantly cultural in its content, represents passive use and is a mass medium. At the other end is information technology (e.g. e-mail) which are informational in content, interactive in use and represent point-to point contact. Information technoloies cover processing/distribution/retrieval/telecommunication.

It follows from this that, when discussing the contribution of communication technologies to the development process, it is misleading, as some prominent policy makers or analysts tend to do, to analyze all the communication technologies as one group and thus facing the same problems or offering the same opportunities for a DC [3,37].

Important however, is the fact that it becomes more and more difficult to make a clear distinction between these groups only on basis of their transport/infrastructure system. Indeed due to technological advance in digitization, the same transport system can carry different new communication services that belong to different groups: it is the same cable, or frequency when speaking in terms of radio transmission, that transports television as well as telephony as well as other data. On the long run a problem of allocation of transmission infrastructure - what kind of service will be allocated to the available channels - might occur. Especially when, as it is the case for DC, transmission channels are scarce. To put it (not too) hypothetically: given the fact that in DC satellite channels are already scarce and that a broadcasting channel, initially allocated for educational use on that satellite, may, via digital technique, as well be

used for data transmission, the social and political dilemma to be solved then is which communication need has to be served first. This will raise a problem of setting the agenda of development priorities in TC: public or private applications of the new services. Especially when one considers the fact that up till now in most DC satellite TC services are the domain of the public PTT's and that it is stated that precisely these PTT's should be privatised. Which, in the scenario of complete convergence and deregulation, would mean that there is no public service control at all possible on TC as well as on mass media.

5. BLIND SPOT: THE PUBLIC

Finally very seldom research on the impact of or need for the new communication technologies, is designed from the point of view of the user. Why, how and under which conditions does the user or the public maximize personal profits from a new communication service; and if not what then must be done in order to do that. Very little is known on how the user reacts to new communication services, how he deals with it, why he accepts services X and not Y, and so on [33].

This essential question is also raised in computer system development where it is admitted that designing from a user point of view is now the major constraint in the overall progress of computer systems [15]. However 'to take into account the needs of the user' means more than ergonomics because unlike "normal" technologies or industries, the IT and TC area has a double character. They are not only hardware, requiring skills to master them, but also software, requiring knowledge to manage them. Half of the problem for DC to benefit from remote sensing for example is the management of the data itself and not the access to it [36]. In other words the IT and TC sector is, in contrast to more conventional industries, also a knowledge based industry which has its own logic and requirements in terms of user skills and user needs. For DC comes on top of that the argument that IT is modelled and system designed according to the socio-cultural habitus of the Western users [27]. Which means that unforeseen social consequences might occur when applying a system engineered from a Western logic into a non-Western context. Conversely, when one wants for example to implement an Artificial Intelligence system in a DC context, it follows that the expert system should take into account how this socio-cultural habitus affects users dealing with knowledge [17]. Research in the US clearly demonstrated that the information-seeking and handling behaviour of different ethnic groups varied substantially precisely because of their different cultural standards [34].

From the point of view of how public needs could be incorporated in the design and policy of new TC services this lack of research means that vital information is missing. Information which is not provided by the diffusion and innovation theories either [30,42], because these (useful) theories only describe the process of acceptance and don't explain it (see [2] for an application with regard to the DC).

And if there is already research available from a public point of view, one can often see that this is done on a non comparable basis. This means that the success, acceptation and so on of a new IT in the professional sphere cannot be extrapolated to the private public sphere [9]. How to explain, for example, that the overall sale of personal computers - leaving aside the

replacement of old PC's with new lap top's which is indeed a booming business - is stabilising whereas the hardware becomes cheaper and cheaper and the software more and more user friendly. Why don't more people use these potentially very interesting instruments?

Whatever may be the answer, the profits a personal computer or a new IT can make for a professional user are not the same as the profits that a private or residential user can make out of it. These are simply fundamental different social settings reacting to a new IT. And the private or home user seems to have reached a saturation point of the computer games which were one of the main reason's why personal computer were bought for in the private sphere (to be seen as a way to maximize "play" profit).

Linked with this, one must also look at the social or economic surplus value and/or relevance which can be realised by that new technology in terms of what the user defines to be his or her surplus value [11]. And there is also something as an "acquisition substitution" [7]: the user considers replacing a new technology only when it substitutes an older one with a better quality and/or at a lower price. This might explain why the mentioned E-mail systems in Latin America are underused: the high "cost" of it in terms of time it takes to establish the connection due to poor telephone transmission.

In short one can say that in the professional sphere a new communication technology is successful when it lowers the costs of the communication process (for example CD Rom searching, mailboxes) or when it improves the quality of the communication process (TDF). Ideal is of course when both meet each other: a fax is cost reducing as well as quality improving. Thus its huge success. Apart from that it goes without saying that in this field, every new technology that helps maximizing (individual or collective) profits is very likely to be successful too. Which is then in turn dependable on how these new communication technologies fit into the set of general variables that explain why an innovation in a work environment is a success [14]. Worth considering is that the rational, cost minimizing etc. application model is not the only one which explains why an organisation adopts an IT successfully or not. On the contrary, research into the use of IT in all kind of organisations has shown that many obstacles, hidden agenda's and so on have to be taken and that social dynamics in the first place determine the success of the innovation in the organisation [16].

This explains why introducing an IT in an organisation does not mean per se introducing more efficiency. The computerization of public service bureaucracies tends to reinforce the bureaucratic character instead of diminishing it. This deserves special attention since it is precisely the public service sector which is the biggest computer user in the third world [27].

On all these points, there are varying differences between developing and developed countries [50]. Which means that, as suggested by the theory that the use of technologies is most of all determined socially, the reason's for success in the developed world may not at all be transposed to DC. To give an example, academic computer mediated communication systems (CMC) are mostly used in developed countries to maximize organisational efficiency and speed up interpersonal communications. For third world scholars however, CMC has the special surplus value to enable them to be in touch and keep up with scientific developments. Something that is becoming more and more difficult given the financial problems affecting the

already poorly equipped library and information services in the third world [6]. On the long run this is a serious challenge to DC, since it poses them a serious problem in terms of brain drain. Hence, investing in CMC, too often regarded now in DC as a luxury or as not essential in global development goals, may be much more interesting than it appears [45].

Thus, a precise investigation, of the as large as possible set of parameters that explains the acceptance and success for existing technologies as well as the failure of others, is essential to make good assessments.

The challenge for development related research is then to find out what this means for DC, how the above outlined parameters may apply or not to them and in what degree. Organisational culture may be an overall important parameter, but organisational culture differs between countries and even between continents. Hence, specific or appropriate implications for the innovation process in DC [48].

Just as, and this may be of extreme interest for DC, the parameter "are the users part of a rural setting or not" needs special specification. Which then in turn can be refined if they are women or not, educated or not, etc. The importance of these dynamics can be illustrated by a study on how a rural setting, due to its specific character, affects the successful use of TS, in this case the telephone in rural Senegal. It was found that the rural development policy of the telephone in the region investigated did not take into account at all the specific dynamics of a rural user (no telephone books provided, no telephone use possible than during the expensive day tariffs, no adapted tariff policy, etc). Hence, with regard to the deregulation debate discussed above, an extremely important conclusion that "current rural telephony is not a viable investment because it has inherited urban telephony technical and organisational problems" can be drawn [32]. In other words, a better insight in the dynamics of 2/3 of the users of the DC can be an important element to make TC development efficient.

6. CONCLUSION

This contribution pointed out a few problems which, from a social science point of view, obscure the analysis of the dynamics of IT and TC development. These problems are of a theoretical as well as a conceptual nature and can be resumed as not enough sophistication in the analysis and too much unrealistic speculation on future needs.

As a result, to work out the calculus of services assessment ($Ct = Ct(Pt,Yt,Zt)$), it should be clearly defined what C exactly stands for and at least two of the three parameters to work out the macro-economic assessment should be substantially refined: the relationship between TC and economic development (the Y factor) is unclear whereas very little is known on the socio-political and user dynamics (the Z factor).

It should be clear however that the whole field of TC and development can only be tackled from an interdisciplinary point of view.

With that respect a major theoretical input could come from the work dealing with the transformation of present societies from a fordist and localist nature into a post fordist and

neo-globalistic one. It is essential that the degree with which this is also valid or not for DC should be investigated. As most DC and large parts of the most developed countries, are still working in a pre-fordist industrial production system. One can question if it makes sense at all to speak about a possible information economy for DC, since that is the last and logic stage of development from the agrarian society onwards. Or to put is the other way round: if an information economy builds on the surpluses generated in the post-industrial society, which in turn is only possible if there are surpluses generated in the industrial sector, itself only successful when the agrarian sector is healthy enough, how can this then be applied to countries where even the beginning of the chain is missing? The leap-frog to be taken in TC is thus not only a question of bringing up the level of TC investments in DC to that of the developed countries.

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THE CULTURAL AND SOCIAL IMPACT OF NEW INFORMATION TECHNOLOGIES IN AFRICA

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ABSTRACT

This paper is a reflection on the introduction of New Information Technologies (NITs) in Africa and its interaction with African societies and local cultures. The paper will thus emphasize the relationship between the technical and the social. Hence, beyond the diffusion of the technical tool, one is more preoccupied by its appropriation and its various uses. An attempt is going to be made to examine the utilization of NITs in Africa in enhancing the development process. Before we discuss this, we will first of all, list the specificities of NITs. This will enable us to better evaluate their impact on the social fabrics of diverse African societies and their interaction with cultures. Finally, we will touch upon the problematic of NITs transfer to Africa.

1. THE MAIN CHARACTERISTICS OF NITs

The evolution in computers is a unique phenomenon in history. In five generations, highly performing machines have been produced, carrying out increasingly diversified operations from scientific research to professional and private use. Today the impact of NITs is felt everywhere. Thanks to this, we are experiencing a real explosion of communication in modern societies. Some theorists like Daniel BELL have gone on to suggest that the explosion of communication accelerates development of post-industrial societies. This is characterized by the fact that information and knowledge are the motor of society unlike the indus- trial society, where development was characterized mainly by capital and labour [2]. While vapour, electricity and petrol have been vital elements of the industrial society, the computer, micro-chips and optic fibre represent the foundations of Information Society. The slogan which calls information "the petrol of the 80's" illustrates amply this perspective.

The NITs don't have the same characteristics as other traditional technologies. From a strictly technical point of view, new technologies are continuously getting more integrated, especially through the links existing between the three major technical families, namely: audiovisuals, telecommunications and computer [4]. A second characteristic of NITs is the possibility of creating a wide network throughout the world. This could be regarded as one concrete manifestation of the world as a global village as promulgated by the Canadian sociologist Mc-LUHAN. From this integration of technologies which were initially disjointed, have sprung new activities in areas such as software, artificial intelligence, robotics, electronics, optics, laser and videos and so on commonly called New Information Technologies.

The changes resulting from NITs have been so revolutionary that many theorists have gone on to suggest that the explosion of communication accelerates developments of post-industrial society (cfr Daniel Bell's and other theorists copious literature on post-modernity). These theorists believe that we are at present witnessing a mutation as important as that of the invention of writing. Indeed, contrary to the wheel, to the printing press or to the steam-powered machine, NITs are not simple machines made to assist man in his work.

These new technologies influence our views through the "mediatization" of relations in the

society and through the "mediatization" of individual reactions to different events.
What is in fact fundamental about NITs is precisely their capacity to serve as vectors for new social norms, for organization of our societies, for the restructuring of our enterprises and institutions, that affirms their "paradigmatic character" much more than their technical performance [6]. Thus, new technologies constitute absolute systems working as set-ups linked with each other. For instance, professional users of computers often need to be connected to a central computer or to a data bank. Here we would like to stress the notion of system and the approach of communication as a communication system privileged in a particular society (This is a point of view from communication studies and media researches).

Historically, we can identify four privileged systems of communication with particular social structures and cultures at each time.

- Speech : in the societies where people used essentially to speak to communicate between them, those people lived more in groups, in community.
- With the writing emerged individualism, and the institution of state with dictatorship and democracy.
- The printing developed anonymous communication for people living in modern towns.
- Now with the computerized society, the goal is to be connected to other terminal devices, data banks, etc..

So new technologies, based on interaction and the creation of networks, are preparing anthropological changes of major proportions. They are not simple machines made to assist man in his work. For instance, with traditional media or mass media, men used to transmit messages. The word here is to communicate with others. On the contrary, NITs belong to our environment. They are a part of our organism. We communicate in them to establish contact between machines, between men and machines and from man to man

The changes which are underway incite diverse reactions, fear for some and hope for others. Pessimists see it as an enslavement of mankind to a machine. They consider it as an end, the end of man, the end of history. On the other hand, optimists consider the information society as a chance for the liberation of man. Man would be freed from the pains of the productive system. It would be the end of routine. Work and labour would give way to simple regulation of machines. Man would then perform only the function of controller and supervisor.

2. LIVING DIFFERENTLY

We do not want to side with either of the groups mentioned above. But we can affirm that the appearance of NITs has greatly changed society. One takes off from the fact that the emergence of NITs (with networks, satellites, terminals, new services...) disrupts previous balances in society and affects social relationships. We can thus note that no part of our life escapes these new technological developments. Consequently, new technologies intervene in the limitation of our horizon. Everything seems possible and imaginable. This scenario affects

even the very domain of our existence. For example, thanks to these new technologies, sterile couples can conceive. This is a manifestation of the importance of new technologies. It loses all artificiality and becomes real.

Furthermore, the NITs affect our representation of the reality and impose on us new ways of appreciating both space and time. Time is no longer visual or manual. There is no time for reflection. With computers, operations are carried out immediately. The same goes for space. Space becomes immediate and simultaneous. Communications are established freely without the intervention of political power, thanks to satellite networks. The whole world has become the village of Mc-LUHAN.

As against an immediate, non-mediatised social relationship based on blood and race, emerges a new superimposed social relationship. It has become another way for people to get together and to organize their individual and collective relationships. Many hypotheses and scenarios try to imagine this cabled society of tomorrow. Some people believe that the introduction of NITs as mediator in the communicative process between people helps to reduce antagonism. Jean BAUDRILLARD cites two examples where this was the case [1]. At first in a football game between Real Madrid and Naples in Madrid, the match was played in the absence of spectators. This interdiction was decided by the International Football Federation on the basis of the uncontrollable conduct of the fans. The supporters crowded around the stadium and were unable to watch the game which was entirely retransmitted on television. This ghostly game, to use the expression of BAUDRILLARD, could be linked to the famous game in Heysel, Brussels (1986) where English fans went wild, caused a memorable and deadly scene.

It is important that such contact is avoided and we deal only with the television in order to control this emergence of chaos, where sport stops being a friendly event and becomes an uncontrollable event, and the public itself changes roles from spectators to murders or victims [1]. This is more and more the case about some games football especially. It is an anticipation of future events, an illustration of the hyper-realism of our world, one in which real events would take place in the absence of the public, forced to watch from a distance, through the television screen. The same illustration could be made about western politics. Political affairs also take place in empty stadia, in the absence of a public, sent off because of the possibility of the eruption of passions. In this way, politics remains no more than a televised event in the shape of opinion polls.

However, Bernard Henri LEVY warns that the cabled society would not, nonetheless, be a perfect one. It would have limitations and would experience ruptures, misunderstandings and differences. It would be faced with, he warns, a conflict of unpredictable consequences, where the key would be the power to control world memory, the appropriation of knowledge and technological know-how [9]. With the problem of appropriation, we touch an important point in the discussion of the social and cultural implications of NIT's for developing countries, more precisely for African countries.

3. SOCIAL AND CULTURAL IMPACT OF NITs IN AFRICA

The African continent cannot escape from this new wave of technological development which

is very quickly becoming the mode of communication in the world. More precisely, it is thanks to the presence of computers on the market that Africa has been able to get on board the band wagon of Information Technology. At this stage, it may be interesting to point out that we cannot divide the world into a developed North and a developing South from a technological point of view. The development of Information Technology is indiscriminately advanced in diverse parts of the world. Countries like Brazil or the NIC's (Korea, Hong-Kong, Singapore, Taïwan) are all members of the group of countries with highly advanced Information Technology. In the same light, there is no precise path to this technology. Technological progress is not a linear phenomenon with well established steps that each country has to go through. However, we can observe that the rate of adoption of these new technologies across countries is different. This difference comes principally from the way different people use this technology.

The use of these technologies is directly linked to the technical experience of the employers. Different societies have different technological histories due to their degree of development and sometimes simply by accident. Thus, the use and adaptation of Information Technology in various societies is not homogeneous. Gilbert SIMONDON emphasizes this point by saying that NITs are being developed following a need which is purely western [12].

The root of the problem is to find out how these NITs could be better transferred and adapted from one society to another. It would be one thing to import these technologies simply for simple consumption purposes; however, it is another thing to be able to master and to reproduce them. This means that the transfer of technology is not simply a question of installation and adaptation of the technology. The stumbling block lies in the capacity to transfer knowledge and know-how [5].

As stated by LEROI-GOUHAN, a technical know-how can't be isolated from other spheres; not from a purely technical context, an economical context and especially from the cultural context. In this respect, one can pose the two questions raised by A. LEROI-GOURHAN; "what is to be done?" and "how is it to be done?". The former relates to the needs a society chooses to satisfy; while the latter deals with the means used to satisfy these needs. For instance, in the not so distant past, the degree of development was measured by the number of radios, TV's and newspapers available in developing countries.
It became clear that the massive importation of these techniques of mass diffusion did not ensure the supply of a transportation network which was very often poor or non-existent in different regions of the world.

The fundamental question posed is therefore not the aptitude of the receiving populations who benefit from such a transfer. What is important is their attitude towards this new technology. These attitudes and behaviours correspond to the social and cultural needs of the population. Their attitudes are in effect directly related to their perceptions of the world seen through their culture. Culture here is defined as *"what constitutes the personality and identity of a people and consequently makes them different from others"* [5]. Or if one uses the definition provided by Hugues de VARINE, culture is *"a set of original solutions that a group of people invent to adapt themselves to the natural and social environment"* [7]. Thus, to successfully transfer technology, it is necessary, first of all, to find a point of reference in the receiving

population from where the technology provided could be selected, rejected or copied to fulfil the needs of the society. It is against this background that one poses the problematic of technology transfer to Africa. In relation to Africa, it is important to ask what NITs can offer.

Other questions posed are, the consequences of the introduction of these new technologies and their impact on individual relations in the society. What kind of society is aimed at with the adoption of these New information technologies? Does it mean that NITs are relevant or appropriate for the development of African countries? Theoretically, the appropriateness depends on the activities in which NITs are involved.

Otherwise the speeches of African politicians and intellectuals represent also favourable indicators of the desire to construct and orient society in a particular direction. Many leaders have expressed their fear of seeing africa once again left on the side-lines and have thus wished to see Africa close the gap with the West. For President HOUPHOUET-BOIGNY of Ivory-Coast,*"after having missed the industrial revolution, africa should not once more miss the computer revolution"*. He continues: "Countries that neglect this domain in their development process are increasingly widening the gap between themselves and the developed countries, who will find in this a new reason to exercise more monopoly over power"[8].

This idea is not shared uniquely amongst African leaders. It is also held by UNESCO and IBI (Intergovernmental Bureau of Informatics). The Director General of IBI expressed the same concerns in the following terms: *"For developing countries, computer technology is an opportunity to grab. The less developed countries of tomorrow will maybe be those that today are showing an observable reluctance to get on the plane of computer technology"*. It goes without saying, he concludes, that: *"at this moment when communication networks have reduced the size of the world to that of an "agora", African countries as well as others should employ this new "short-cut" provided by computer technology if they don't want to be left on the periphery of the new world"* [10].

Is it already possible to analyze today the social effects of the introduction of NITs in Africa? We do not have sufficient information to help us answer this question. What we can more or less affirm, however, is that it occupies only a marginal position globally in African societies. Even in Western Europe, this evaluation is still partial because the new technological developments have not penetrated yet the entire society. On the other hand, what we would like to stress is that these NITs can open the way to the future - a much desired future of individual and collective choices. Hence, the necessity of elaborating strategic and efficient actions.

In this light, a reflection on the possible contribution of NITs has to be oriented towards the solution of the problems facing Africa today such as transportation, education, health, agriculture, etc... Whatever the possible options that could be undertaken, African states have first of all to develop a program of action based on two points: formation and cooperation in the field of New Information Technologies.

In the area of formation, it should be organized to allow the transmission of knowledge and know-how in order to permit the domination of one's environment (African countries might

avoid to import NITs for consumption purposes merely). In the area of cooperation, African countries have to become conscious of the necessity of south-south cooperation at sub-regional and regional levels. From a regional perspective, not only can they have a better chance of negotiating with western multinationals, but more especially, they can coordinate their resources in order to develop materials like software, that are adapted to their local conditions.

Secondly, it is necessary to promote international cooperation. However, one should emphasize again that the support of the international community can only be beneficial if it stimulates internal development of computer technology adapted to local realities.

4. CONCLUSION

Beyond the observation that NITs are invading virtually all fields of activities, one should further note that they are becoming in fact standards for the restructuring of new social orders, as well as for the organization of enterprises and institutions. In the field of interpersonal or mass communication, these changes are becoming increasingly obvious as a result of the growing mediatization of the relationships among people and between people and the environment. In view of this evolution, African countries would like to close the gap between themselves and the developed countries by "catching up" with the train of the computer revolution. Nevertheless, the task is to find the best way by which NITs can be put in place successfully in Africa. In other words, it amounts to asking how best African cultures can re-interpret and adapt this transfer in order to make it operational.

Finally, what is more important is the preliminary organization of the receiving environment rather than the technical transfer. And the organization needed is the product of each particular culture.

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STRATEGY FOR INDIGENISATION OF INFORMATION TECHNOLOGY IN AFRICA

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ABSTRACT

There is a general consensus today that Information Technology (IT) can play an important role in the economic and social development of the Developing Countries (DCs), including those of Africa. This has led to calls for African countries to develop national IT strategies/plans in alignment with their national economic development policies. In order for IT to be of benefit towards the development of African countries, it needs to be adequately assimilated, diffused, mastered, utilised and, where possible, effectively transferred. For African countries to benefit from this new technology they need to develop a "culture of IT"; ie., a culture that is aware of the technology and its different functionalities/uses and that utilises it in different governmental, industrial and services sectors. A state of "successful IT-use" is that which engenders changes that ensure a healthy assimilation, adaption and development of the technology to suit not only existing needs, but also present economic and manpower capabilities of the country.

1. INTRODUCTION

The age of information technology - IT as we call it here - has arrived. I know of no other technological advantage which has brought together so many areas of rapid and exciting development. Computers and telecommunications are converging very rapidly, huge investments are being made, and the impact of information technology will be felt at every level in our society; in industry, in commerce, in our offices and in our homes [1].

As the above quotation made by the then education minister of Britain indicates, IT is ushering in rapid and exciting new products and areas of economic development. In fact, some believe that the world is witnessing a new industrial/technological revolution; one that is based on IT [2,3]. IT, as Baker points out, refers to all the new technologies that are based on computers and telecommunications. It refers to computer systems, fax systems, telex systems and other information-based systems that offer people a means for storing, retrieving and communicating vast amounts of data and information quickly and cheaply. It also enables society to integrate previously separate ways of using information, ie., text production with the use of typewriters, data processing using large mainframe computers, printing machines,

communications with the telephone and radio and television. These separate technologies have today been integrated into a single technology - IT. IT assumes an increasingly high profile in organisations around the whole world as both its impact on government administration and national resources management, business performance and its level of usage and cost increases. In parallel, the technology continues to evolve at a remarkable speed. As a result of the importance of this technology, it is fast becoming a key concern for various countries in terms of how to acquire, efficiently utilise and sustain the technology.

This paper attempts to explain how African countries planning on embarking on the road to the acquisition of this technology can do so. It first describes the nature of the potential benefits of the technology to Africa; its social implications (that need to be carefully observed and considered in any IT planning and development projects in the area); strategies for acquiring the technology; and the manpower requirements for the use and development of the technology. It suggests three strategies which African countries can use to pursue this technology based on their size, Gross National Product (GNP), GNP per capita, educational infrastructure/level of sophistication, industrial capability/sophistication, etc.

2. IMPORTANCE TO AFRICA

What are the possible implications of IT systems to African countries? Can they be used to enhance organisational management, effectiveness and competitiveness in both the private and public sectors? Can they engender increased standards of living and economic growth? Can African countries cope with this technology? These are some of the questions that will be answered in this section of the paper. According to Ernst [4], Africa and other developing nations are capable of coping with, and benefiting from this technology with adequate planning and utilisation of their resources. Also, according Gupta [5], "It is now an accepted fact that there are various areas in a developing country where the pace of development can be speeded up significantly by the use of computers".

2.1 Decision Making

The issues facing all African countries differ from one country to another as they are all facing somewhat different political, economic, social and cultural imperatives. However, similar themes are evident in any study of the diffusion of the technology in the whole of the continent. For example, most African countries are presently facing a period of harsh economic realities and are operating some programmes for structural economic readjustment. Also, it is widely believed that one of the reasons for the poor economic performance of many African countries is to do with the failure of both their private and public organisations, in terms of good administration, effective management and efficiency [6]. At the public sector level, this has led to acute inefficiency and mismanagement of public utilities/institutions, and so, to poor and inefficient provision of public services like electricity, transportation, telecommunications, government administration, etc.

The availability today of powerful, cheap and easily transportable systems which can be used to improve the administration and management of private and public sector organisations, has meant that IT has potential positive implications for organisations in Africa. It means that

African countries can utilise this technology to improve the management and productivity of both their private and public sector institutions. It can enhance the decision making, administration and management of organisations in Africa. It in fact, has become increasingly indispensable in the management of government administration, organisations and projects all over the world, as they help in the improvement of organisational information flows.

2.2 Productivity

Just like most other technologies introduced in industries and other organisations, IT systems are capital intensive, labour saving and cost effective - if introduced appropriately [7,8]. They could therefore be used to enhance productivity. Automation via IT has the potential to increase productivity and save costs, by enabling fewer workers to use it to achieve the same productivity level many will achieve without it. It has the ability to facilitate operator control, provide comprehensive records, co-ordinate operations, and provide comprehensive analysis of production performance, tools which management could use to efficiently rationalise the labour process. For example, a computer can be introduced to mechanise decision processes - in engineering design, or for control of stock, or cash inventories - resulting in some form of increased productivity in the organisation's operation.

This potential for increasing productivity and efficiency has positive implications for Africa. It means that African countries can use it to make their government and civil service more efficient and to increase their manufacturing productivity. In fact, it can, with adequate planning, hasten the industrialisation of the countries that embrace the technology.

Despite all the above evinced benefits of IT to African countries, if the wrong steps are taken today by countries in the continent, it could have a negative impact on government efficiency, instead of helping in the improvement of government and organisational efficiency, standard of living and economic growth of the countries. If it is used to automate the wrong functions; if it introduces new/alien practices/culture/procedures that recipient organisations in Africa are not willing to go along with; if it cannot be properly used, supported or maintained; then the outcome of the introduction could be more harmful than beneficial to the organisation, and, the IT systems could get all the blames for the low task performances, inefficiencies and bad management of the user organisations. Thus the IT systems introduced could become counter-productive instead of positively enabling to the user organisations.

3. STATE OF DEVELOPMENT AND DIFFUSION IN AFRICA

3.1 The Observed Shortcomings of Projects in Africa

There is a low penetration of IT systems in Africa. Most of the systems in existence are designed by consultants from abroad, or through off-the-shelf systems which are bought from vendors, or that are pirated. There is a lot of ill-utilisation and under-utilisation of systems. Most of the systems often break down and are unable to be repaired by the staff of the user companies. Developers of systems in Africa make use of planning and development models from the West. The African business environment is characterised by poor telecommunication infrastructure, unpredictable electricity, and lack of financial and material resources. As a

result of all the above problems, most of the potential benefits that can accrue from the use of this technology have not started manifesting themselves in most African organisations.

In fact, Africa is not experiencing technological *transfer* but only the mere physical dumping of technological goods made elsewhere. Real technology transfer occurs when a particular technology is capable of being developed, repaired, managed and operated domestically - when the country has acquired not only the operational knowledge but also the deep technical know-how and tacit knowledge of the given technology. All this leads to the suggestion that African countries should endeavour to initiate and control the process of IT skills and know-how acquisition through an internally generated development and policy/strategy, instead of relying on the Multinational Corporations (MNCs) or the multilateral organisations like UNESCO.

At the level of actual implementation of systems, many organisations in Africa attempted to introduce systems with varying degrees of success. A look at some of the literature on African IT systems use and introduction suggests that some of the attempts have been disastrous failures: (1) Some systems planned to be introduced never materialise into actual operational systems; (2) some projects are abandoned half way; (3) some machines and software introduced are automating the wrong functions in the organisation; (4) some systems are introduced without adequate training of those to upgrade, support and use them; and (5) it is often the case that some of the systems engender more inefficiency than they eradicate [Eg., 9,10,11].

3.2 The Underlying Problems which cause the Shortcomings

The problem of IT systems use and acquisition in Africa (like in many other DCs) can be characterised or grouped into three main types, namely; operational problems, contextual problems, strategic problems [12]. Operational problems are to do with, for example:

- technical constraints;
- lack of skilled staff;
- inability to effectively utilise the technology;
- under-utilisation of the technology;
- inability to maintain the systems when they break down.

Contextual problems arise when, for example, there is a:

- weak fit between models of the technology which is Western and the recipient African organisational and socio-cultural environment;
- semantic differences between how phenomena is understood and how things are worded;
- difference in value systems;
- differences in what constitutes reasonableness, rationality and what is acceptable.

Finally, strategic problems refer to:

- the diffusion of IT and, how scarce resources, competing with other crucial demands in DCs, are to be best utilised;
- the selection of appropriate applications with particular emphasis on developing problems

such as basic needs, as well as the formulation of national IT policies and strategies.

Most IT projects in Africa turn out to be disasters as a result of the myopic concentration of emphasis on the procurement of hardware, lack of vital infrastructure, poor project planning, lack of a maintenance culture, lack of knowledge in the use of metrics and quality assurance (QA) practices, lack of effective cost estimation skills, inadequate feasibility studies and too much concentration on the technical aspects of the system to the detriment of socio-organisational and business factors [13].

Moreover, most vendors/suppliers of IT systems in Africa still possess a "dump the goods and run" business mind-set. They get organisations (who do not know better) to sign agreements that bind them to supply only a given machine/software and nothing else, which they then carry out and go on to look for another contract. They do this without properly training the users/support staff and without guiding the organisation to ensure that they are automating the right function/problem and that the system will satisfy their organisational and business needs. They ensure that the system passes the user acceptance test - which they help to construct themselves, and so receive their payments. The user organisation is therefore left with a system, a fairly simple basic training, and sometimes, some user/systems manuals.

There is an acute lack of IT awareness in the whole of the society and on the part of business managers and government officials. Hence, there is need for general IT awareness education for management in both the private and public sectors and for the general public.

Also, there is the problem of the unavailability of the necessary telecommunication and electricity infrastructure which are required for any meaningful use of IT [14]. It is believed that: Technical as well as socio-economic constraints found in developing countries reduce the potential benefits of computers in on-line operation: poor functioning telephone lines result in unreliable data transmission and insufficient infrastructure development turns out to be a serious obstacle when adopting a formal and systematic approach such as that of an advanced computer-based solution. The computer can not be integrated, as in a developed country with an advanced infrastructure, with other external functions and thus increase the overall performance, simply because the functional interfaces between the computer and those external functions have not been appropriately specified [12].

3.2.1 The Problem of Culture

A lot of systems fail in Africa as a result of the cultural mismatch between the systems (as they bring Western culture with them) and the recipient African culture. Lind (12] explains this problem thus: Many enthusiastic computer projects in developing countries have been launched where computer solutions, successfully implemented somewhere else, have failed to perform, often because the actual reality was never fully understood (values, authority patterns, rationality, time concepts, etc.). Starting from reality, in an attempt to understand the application area of the actual company, will therefore enable us to identify major parameters influencing the production system of the company and, hence, also the conditions for the computer.

IT systems, like most other technologies [15], are not culturally neutral; they come with an in-built cultural and organisational bias: It is generally admitted that information is not culturally neutral. By considering programming languages, it can be seen that they are largely based on the English language. Above all, current information is a reflection of a certain way of thinking and of a certain economic and social organisation: it is the product of a rationalist and Western culture. Is this cultural dependence inevitable and must developed countries resign themselves to it? [16].

If systems are introduced without adapting them to African cultural realities, it would bring about more break down of African culture - because "Western techniques" bring "Western values" and cultures with it. The resulting clash of cultures could further warp Africans and cause cultural disorientation. Planners should understand the cultural bias of the systems they are introducing, adjust them to fit with the domestic culture if need be or if it is possible. If it is not possible to adjust or develop the technology to be acceptable to the local environment, the pros and cons of having each system, in terms of the cultural damage or enhancement it might engender, should be carefully appraised before deciding whether to go ahead with the introduction or not.

3.3 How to Overcome the Problems

In order to introduce IT correctly so that it would be effective and functional, organisations should endeavour to make sure that their business and information systems strategy are first determined and that the systems to be introduced are well aligned with their business objectives and information systems strategy [17].

Organisations should first determine the feasibility of the system and identify, quantify and prioritise the organisations's requirements. It is after a good feasibility study that other stages of the systems development life-cycle should begin, namely; systems specification, design, implementation, validation verification, introduction, change management and maintenance. The following factors should also be considered throughout the whole life-cycle of IT systems design and development:

- business objectives;
- organisational requirements;
- user requirements;
- time and budget constraints of the organisation;
- the flexibility, efficiency and level of applications integration required;
- the security of the system;
- its maintainability, reliability and robustness.

The desired level of simplicity and user-friendliness, should all be taken into consideration. Also, organisations should ensure that hardware selection should not precede the determination of all the above factors. See, for example, Eason [18], Woherem [19] and Bell [20] for a fuller discussion of the various stages and factors to be considered when designing or introducing new IT systems.

4. STRATEGIES FOR ACQUISITION OF IT IN AFRICA

The starting point for bringing about a sustainable acquisition/utilisation of IT in an African country is for that country to define the acquisition strategy from a national perspective, ie., in alignment to their national economic and technological development objectives. There must be a formalised (easily adaptable/adjustable) strategy document for every section of the IT policy/strategy, including:

- national development needs
- communication needs
- training needs - five years (or beyond)
- organisations needs and how to satisfy them
- general public's needs
- needs for software/hardware and development methodology standards
- IT staff pay policy
- the regulation of the industry
- needs for national data banks and communication networks
- the country's technological and infrastructural position and the implications of that to the type/level of IT strategy to pursue.

Countries should realise that the primary measure of their success in acquiring this technology is how able they eventually are in: (a) effectively using it (b) developing their own hardware and/or software industry and (c) the ability of organisations in the country to operate and enhance the systems they have introduced even when the developers or providers have departed.

Information technology acquisition/development in Africa should not be driven solely by the actions of vendors, consultants, developers and the users alone. It should be driven by the national, economic, business, socio-cultural and other environmental factors/needs. African countries require an explicit national IT systems policy/strategy that will clearly analyze and map out the needs of the countries, what they are capable of achieving, what resources they have, what could be achieved with the help of IT, etc.

However, it has to be realised that this technology alone can not catapult all African countries to "Mount Development". For an African country to climb "Mount Development", it needs to have some basic requirements, eg., some vital human and natural resources, skills, technological base, a rational national IT strategy, national will, etc.

It is pointed out that leap frogging of technological development is predicated on the "current levels of domestic technological capability in general and the capacity to absorb high technology in particular" [21]. A country has to have the organisational capacity for innovation and the ability to make new products. It also means that it should have an indigenous technological base, that will help it assimilate, utilise and upgrade the new technology. To Bhalla, not all the developing countries have the capacity for absorbing and developing new technologies. To him, "export oriented" NICs that are already competing in international market are much better placed than the LDCs (less developed countries, author) or the MICs

(middle income countries, author); and even within the NICs (newly industrialising countries, author), he feels, that India lags behind [6].

Elsewhere [6], some African countries were grouped into three possible categories of IT use/acquisition strategy, as a result of their size, level of educational facilities/sophistication, level of industrialisation, Gross National Income, per capita income, population, etc. This was because, it was perceived that the above factors can determine the ability of each of those countries to develop their own IT industry or to be able to buy and make use of the technology appropriately, and therefore determines the type of IT strategy they should pursue. It was argued and suggested that countries should develop an IT strategy/policy that is in keeping with the recommended strategy stipulated for the countries in the category they feel they belong to.

Countries in category one (eg., Mali, Togo, Uganda, Chad and Niger) are those that:

- have an acute shortage of skilled staff;
- have a very low per-capita income
- have a very low level of literacy
- have very poor infrastructure like roads, transport and telephones
- have few higher education and training establishments
- have very few personnel able to man their IT systems and the training of new personnel.

Countries in category two (eg., Kenya, Libya, Zimbabwe, Cote D,Ivoire and Cameroon):

- have a fairly good educational and training institutions
- have small populations
- do not have enough financial and human resources to establish their own fibre optics, electronics and computer hardware industries
- can afford to establish a viable software industry.

Countries in category three (eg., Nigeria, Egypt and Algeria) are those which have:

- huge populations
- large human and natural resources
- good educational and skill training establishments
- large markets
- enough financial and human resources to establish viable fibre optics, electronics and computer hardware industries

It should be noted that governments always have a central role to play in the industrial process of their respective countries. For example, they have to provide the infrastructure and stability necessary for the private sector to operate properly. The government's visible hand has to provide the rules of the economic and industrial game that will help the IT industry to mature.

As technology (IT in particular) is vital for the economic growth of African countries today, and

as these technologies bear the cultural imprint of the West, and as they also have potential negative impacts, I leave the reader with this important advice: If, indeed, we accept that we want development and feel that technology plays an important role in this process, then the philosophical and ideological questions become vitally important. Are we prepared for the social upheavals that may result, and are we willing to pay the social price for such development? And at what stage are we able or prepared to impose control on the effects of the technological revolution? In fact, can we control it at all?

If development is indeed our goal, we have no option but to use technology. But to succeed in our objective, there has to be a strong ideological base and the single-minded, ruthless implementation that comes with it. Perhaps what is required is the sacrifice of the individual for the larger social good over at least one generation, and very clear-cut attempts to maintain cultural identity and national cohesion in the face of universal homogenisation not consonant with the concepts of sovereignty, self-reliance and independence. we must master the technology, not become its slaves [22].

5. CONCLUSION

This paper pointed out the importance of IT to Africa, the social implications of the technology, and suggested what African countries should do towards the successful and sustainable acquisition and use of the technology. It pointed out that the potential for IT to increase productivity and efficiency has positive implications for Africa. It means that African countries can use it to make their governments and civil service more efficient and to increase their manufacturing productivity.

It was pointed out that with adequate policy and planning, IT can enhance productivity, reduce costs and increase efficiency in most African countries. Also, as there is no magic wand with which an African country can use IT to catapult itself to "Mount Development", and as African countries are different from one another, it was suggested that they should all develop a well articulated IT strategy that is suitable to their own national objectives.

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THE INTERNATIONAL CRISIS IN TRANSNATIONAL COMPUTING

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ABSTRACT

Multinational Corporations (MNC) can use information technology on a global basis to improve coordination from headquarters to subsidiaries; collect and process corporate intelligence; internalize economic transactions; and to gain competitive advantages in overseas markets. A survey of 25 MNCs examined location of data centers, employees, data storage devices and computer processing power. The data shows that developing countries are *not* getting a balanced transfer of information technology. Research indicates that MNCs transfer information technology to developing countries only within the context of their overall business strategy and the foreign direct investment (FDI) decision. Developing countries can encourage meaningful technology transfer by adopting a variety of incentives for the MNC, primarily by improving infrastructure, particularly telecommunications.

1. MULTINATIONAL CORPORATIONS AND TRANSNATIONAL COMPUTING

It is generally recognized that the managerial control and operation of transnational corporations have come to be widely supported by information technology (IT). Computer systems, such as mainframes, minicomputers, microcomputers, and workstations are linked together through a complex web of local area networks, campus networks, wide-area networks, and international networks. By the end of the 1980s in the United States, some estimations indicated that approximately 49% of all capital investment [84] was being put into IT, but with little apparent benefit [107], in spite of rapid growth [22]. It was clear, however, that understanding how transnational corporations use information technology can help to unlock deeper questions regarding how decisions are made and what type of social and economic effects the MNC is likely to have in the host countries where it operates. The role of transnational IT is not well-understood, in spite of early efforts [78,53]. Data on key aspects of IT infrastructure of the MNC [91] is lacking i.e. how IT is used to coordinate global manufacturing operations [47]; its use to perform environmental scanning; its use to improve overall economic efficiency to gain true competitive advantage.

1.1 Centralized Coordination Means Developing Countries Lose Autonomy

The balance of power between the headquarters of the MNC and its various subsidiary offices

has long been studied to determine where effective decisions are made, as this indicates the degree of autonomy exercised in developing countries. We know now that rapid advances in technology, the substantial increase in the capacities of global data networks and the growing sophistication of software,[1] network control techniques and massive efforts towards global standardization of data elements[2] have all combined to create new possibilities for management and *direct* operational control of subsidiaries, regardless of their geographical distance from headquarters. Many critical functional applications can yield significant advantages for the MNC when they become *centralized* [16]. One important example is centralized *financial control and reporting*, which enables the MNC to more rapidly keep track of its financial position on a daily or even hourly basis. MNCs which use global inventory control have captured significant economies in management of turn, estimation of safety stocking levels[3] and ability to meet customer needs faster than the competition [72,93]. In centralized applications such as this, we would not expect to find a great amount of development of information technology in developing countries since the MNC must concentrate all its resources at a central point, typically in its home domicile.

Although some applications tend to be decentralized [51], this does not imply an automatic transfer of technology to subsidiaries in developing countries. The balance between centralization and decentralization suggests fundamental changes in organizational relationships [97]. The functions of information technology in the MNC imply different flows of information according to function: Coordination between headquarters and subsidiaries implies a two-way flow of information, but intelligence gathering is a one-way process in which information is reported to the center. In contrast, the projecting out into foreign markets proprietary ways of using information technology implies one-way flow from the center to the periphery of the MNCs world system of computerization and information. If information technology is used to decrease the autonomy of subsidiary organizations and host country nationals, then this is a grave development for the developing country.

1.2 Market Monitoring and Corporate Spy Systems

Information technology systems are also used to help the MNC perform *environmental scanning* of its surroundings including political risk assessment to help guard against unexpected changes in policy (i.e., nationalization) on the part of host governments [70,52,68]. Although

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The use of this technology allows a TNC to keep copies of the same database in several geographic locations at the same time, with automatic up-dating of information and file-locking of records to control changes in records.

The standardization of data elements is a major task many TNCs are having to undertake as they move towards more integrated global information systems. They are finding that the separate data centers located in each country where they do business have, over the years, created different data definitions and standards for similar information.

Calculation of the minimum amount of inventory to hold in each product to ensure a guaranteed level of availability.

the formal intelligence functions being carried out within MNCs have long been the subject of much speculation (and occasional exposé), the role of information technology in supporting these activities has not been widely studied. Teleconferencing, facsimile, voice mail, and globally addressable electronic mail systems combined with artificial intelligence algorithms which automatically perform routing functions for messages based on content analysis have all tended to radically compress the reaction time to unexpected events for the MNC [37]. Generally, it is recognized that monitoring developments in markets is an acceptable form of corporate intelligence. However, monitoring of political events, personal details regarding key political leaders, or serving the overseas security interests of the headquarters country may be considered a violation of host country sovereignty.

1.3 Economic Efficiency at any Cost

The role of information technology in making more efficient the internalized economic transactions [20,41,43,112,2] handled through the MNC is not well understood, especially at the level of individual transactions, yet it is clear we are seeing the emergence of a strong trend. The concept of world-wide sourcing for manufacturing components can only be carried out through sophisticated information technology systems which handle not only inventory control and logistics, but electronic distribution of design releases and engineering specifications through networked CAD/CAM systems[86,31]. The rise and fall of many financial services firms depends heavily upon their ability to capture market transactions away from their competitors [99,24]. From the point of view of developing countries, the use of information technology for increasing internalization of financial and market transactions within the MNC may raise issues of transfer pricing abuse and potential disruption of national enterprises. As greater volumes of economic transactions are internalized into the value-added chain of the MNC, a possibility may exist in some markets for the multinational corporation to obtain higher levels of vertical integration, thus further deteriorating the bargaining power of the developing country.

1.4 Firm Specific Advantages or Unfair Advantages?

Another threatening dimension involves the use of information technology for competitive advantage in overseas markets. FDI theory holds that MNCs tend to make investments only where they have specific advantages which they can exploit to gain a dominant foothold in the host country market. The question is whether in some cases, the role of IT can be so strong as to take precedence over all other forms of advantage for the MNC. It is generally assumed that IT does *not* play such a role, but there is much research suggesting that within *domestic* markets, IT *can* play such a role [44,19]; so we can expect to soon see similar phenomena at the international level. Some research has pointed to this possibility [3], and there has been concern expressed at the international level regarding the negative social and economic effects of global MNC-controlled computerization. MNCs are leading edge users and account for the bulk of the world consumption of IT. Four dimensions provide an organizing framework for examination of the role of IT in MNCs. How does understanding these functions gives clues as to which MNCs engage in meaningful technology transfer. Apart from very limited cases, promoting technology transfer to developing countries is *not* the chief goal of the MNC. Unless specifically "encouraged" by the host country where it is conducting business, the MNC is

likely to transfer only that amount of technology which is key to operating the business [38,40].

2. GROWING CONCERNS WITHIN DEVELOPING COUNTRIES

The emergence of global information technology systems operated by MNCs has raised questions for developing countries. At a general level, the fears expressed by many states regarding their potential loss of economic sovereignty as a result of the technological, financial and organizational power of the MNC, led to development of a strong current of careful regulation. The rise of information technology as a new social and economic force in the world's economy, and in the internal operations of the MNC, has led to further concerns regarding the *informational sovereignty* of the nation state, particularly host countries. This concern has centered around two issues: protection of data on individuals and transfer of information technology to the host country. Hoffman and Hobday argued, for example, that "valuable information can be transferred by multinational subsidiaries located within a developing country to the parent company at another location." [61]

2.1 National "Informational" Sovereignty and Protection of Data

Should multinational corporations should be allowed to process data through international computer communications networks without regard to national legislation [62,33]? If not, then what types of control are appropriate? The world's community has come to recognize that protection of information held in computer data banks concerning individual citizens deserves a unique type of protection, and that in order to secure this protection, nation states are justified in imposing restrictions on international data processing [118,57,17,85,10]. There is a clear conflict between forces promoting nation-state based computing and information processing, and those forces, both economic and technical, driving the MNC towards creation of more fully integrated global information technology systems [79,100,101]. Sachs has asked: "Will turning information into a infinitely exploitable resource lead to an erosion of cultural capabilities, namely the capacity to autonomously create meaning?" [45] Resolution of these issues is clouded by contradictory developments in information technology. End-user technologies such as personal computers, multi-user systems based on virtual memory, file servers and local area networks, greatly strengthened the ability of the MNC to *decentralize* its data processing on the one hand; whereas rapid developments in large scale computing such as super-computers, vector processing, massively parallel processing, and multiple-virtual machine architecture, combined with very rapidly decreasing telecommunications costs,[4] have tended to greatly raise the attractiveness of a *centralized* solution. The centralized information technology architecture within the transnational corporation which have gradually become more popular imply a lessening of technology transfer and a threatened loss of "informational" sovereignty in developing countries. Transborder data flow regulations alone are not be enough to force the MNC to decentralize its data processing operations, since privacy is a concern with less than 3 per cent of the data being moved across international borders.

From 1980 to 1990 in the United States, the cost of semiconductor memory has declined by approximately 30 per cent per year, whereas the costs for data transmission has declined by 38 per cent per year.

2.2 Encouraging Technology Transfer to Developing Countries

For years it has been the policy of many nations to encourage the real transfer of technology to the host country [108,71],as a condition for the MNC being given access to the national market [42], although Teece's research concluded that regulation of the multinationals in this regard is not very effective [112]. Countries involved in strengthening their capabilities in management wished for MNCs to ensure that data processing took place within their national borders [27,103,30,104,25,82,54,116], thus insuring that local personnel would receive training. Information technologies can be used in traditional economic activities [11], and training of nationals by multinational corporations is one of the key elements in bringing about effective technology transfer [56]. Encouragement of host country-based data processing should result in the MNC building more and larger data centers in its subsidiaries, thereby benefiting the general infrastructure of host countries in the developing world [98,15]. Controls over data processing and telecommunication are one of many levers of industrial policy which might be applied in pursuit of national goals. Odedra has distinguished four different channels of technology transfer including (1) direct acquisition of information technology, (2) technical assistance, (3) education and training, and (4) Foreign Direct Investment (FDI) in the information technology sector [80]. She and others [105] have argued that technology transfer is still failing, and that host governments should take more vigorous actions to improve the telecommunications infrastructure in their countries. Developments in information technology are increasing the pressure towards decentralization [94] and we would expect to see more transfer of technology to developing countries, should MNCs wish to take advantage of these new possibilities.

3. DISTRIBUTION OF INFORMATION TECHNOLOGY IN MNCS

The table below presents data on level of decentralisation base on a sample of 25 US based corporations.

Table 1 *Average Level ofInternationalization*

Variable	Percent of Internationalization
Data Processing Power (MIPS)	36%
Data Storage Capacity (DASD)	28%
Employees in Data Processing	41%
Location of Data Processing Centers	60%

The degree of decentralization of information technology[5] can be measured by examining four

For other measures, see [115].

infrastructure components — (1) location of data centers, (2) how much data is stored in different locations (measured in gigabytes), (3) how much processing power is available in each location (measured in MIPS — millions of instructions per second), and (4) how many employees working in each location. For each of these measures, an internationalization index can be ascertained by calculating how much the MNC's IT resources are located outside of its mother country. Of course there are many variations in the scope, size, and structure of MNCs, but based on a sample of 25 U.S. based corporations the following conclusions can be drawn.

3.1 Distribution of Processing Power Does Not Favor Developing Countries

Most data centers are located within either North America or the EEC. MNCs have data centers in other parts of the world, including Asia outside of Japan, Africa, the Middle East, but the general level is significantly lower than in the core developed areas of the world. Examination of the distribution of MIPS, which is a better indicator of where real data processing is taking place, shows an even stronger tendency to concentrate resources in North America and the EEC. Developing countries are left out of the picture.

3.2 MNCs Resist Internationalization of Information Technology Infrastructure

The level of internationalization for MIPS and DASD appears significantly lower than that for Employees and Data Centers. The lowest average is for DASD, which represents the "corporate memory" of the transnational corporation. This implies that the MNCs are keeping the bulk of financial and other records in their home country. The same balance is seen in MIPS. These two variables, DASD and MIPS combined together give a strong indication of the relative geographical balance of the information technology infrastructure in the MNCs sampled, and it is a picture which is not of any advantage to developing countries. Although MNCs have many data processing centers located outside of their home country, usually a minimum of one in each of their subsidiaries, these centers control considerably less infrastructure, and this implies a lack of participation in decision making.

If "information is power" then the power is being held at the corporate center of the MNC, at least this is indicated by measurements of the IT infrastructure [67]. Regardless of the great variety of industrial and national policies regarding computerization [55], the distribution of information technology infrastructure does not favor developing countries. Utilization of information technology in the developing world is "10-20 years behind" developed countries [110]. The very low density of telecommunications and data processing in developing countries raises the need to give "high priority to telecommunications and data processing industries" in these parts of the world [1]. In spite of the great number of subsidiaries operating in the developing world, there is not a corresponding balance with real distribution of information technology infrastructure. The data centers which are located in these countries are "branch" centers, with a function usually of performing limited data processing for local needs, and consolidating information, especially financial reports, for transmission to headquarters [102], but it is clear that the bulk of control is being exercised by the center. One is forced to conclude that the very unequal distribution of computer equipment suggests that *MNCs have not been a powerful force in transferring information technology to the*

developing world [96], or in giving control over information resources to decision takers there.

4. POLICY IMPLICATIONS FOR DEVELOPING COUNTRIES

It is true that a developing country could take policy measures which would force the multinational corporation to transfer technology, and many have done so. However, from the point of view of the MNC, such policy actions only tend to make the host country unattractive from the point of view of further investment. Doz has discussed in detail the bargaining relationship between host countries and MNCs and found that particularly during the early stages of negotiations, when the MNC has yet to commit substantial investments, the bargaining power of the developing country is weakest [38,40,39]. Others have raised questions about the success of forced technology transfer [75,9]. Some developing countries are recognizing that it is in their benefit to loosen up restrictive practices in data processing and to provide critical infrastructure [73]. Information technology is only a reflection of the grand *business* strategy of the multinational corporation. The foreign direct investment (FDI) decision is based on many factors, one of the least significant of which is the availability of computing resources in the host country [41]. Attempting to coerce the multinational corporation to transfer information technology is rarely a viable option. If taken too far, it will drive away further FDI. The fundamental nature of the FDI decision is made on strategic grounds, but once the MNC has set up operations, *then* the developing country can begin to take actions which will encourage the transfer of information technology. The best way to do this is to set up a sufficient infrastructure and incentive scheme which will make it both easy and economical for the MNC to invest in data processing operations in the host country.

4.1 Creating Incentives in Developing Countries

What types of incentives might be provided by developing countries to induce the MNC to transfer more information technology? The analysis of the *determinants* of FDI has grouped host-country policies such as incentives as only one of three determinants, the other two being firm-specific and location factors [114]. "The size of the host country market and the strengths of linkages with the international networks of transnational corporations can provide location advantages in some situations" [18]. Unfortunately developing countries many times have 1/1,000 telephones per person while developed countries have as many as 1,500/1,000 telephones per person [18]. "With 70 per cent of the world's population and 17 per cent of its income, developing countries account for only 7 per cent of the world's telephones" [63]. In addition, it is clear that if a developing country has a poor telecommunications infrastructure, it is unable to take advantage of many of the deeper social and cultural aspects of telephone technology in society [49]. "The quality of telephone services will determine the ability for computer users to benefit from high speed, reliable data transmission facilities, both locally and long distance" [76]. This would indicate that developing countries which have a modern and transparent telecommunications system available at competitive prices for the MNC might stand a better chance of attracting investments in local IT infrastructure [113,26,5,4,77]. Some developing countries have made rapid progress in developing a software industry [106,66,14,51] which can also be used to lay the groundwork for technology transfer. National responses towards development of information technology can be classified into three dimensions: controls over supply, control over applications range, and controls over geographic

reach [14]. Helping in developing of the telecommunications infrastructure encourages development of more reach to the information systems [92,35,34]. Some studies have directly addressed the competition between cities and have concluded that by adopting investment policies which make available in the infrastructure state-of-the-art telecommunications facilities, such as fiber optic networks, some geographic locations have been able to gain a competitive advantage over other locations in attracting high technology investment [46,69,28].

4.2 Global Networks and National Incentives for Data Processing

In the 1990s, telecommunications systems in developed countries will become more digital and it is certain that MNCs will become the world's largest users of the Integrated Services Digital Network (ISDN) standard as well as broad band ISDN (B-ISDN) in most advanced economies. A result of this trend will be the emergence of a new nexus of applications called *Computer-Integrated Telecommunications Systems* (CITS) which will rely on high speed circuits which are used, and tariffed, according to demand and which integrate voice, data, video, telemetry, and other information together in the same circuits. This type of interconnection is more complex than simple physical interconnection and calls for a level of co-operation between the MNC and the public data authorities which has not been seen in the past in most instances. Some developing countries may exhibit a skew towards public as opposed to private investment, potentially making assimilation of new technologies more difficult [58,6,60]. As CITS capabilities will become critical for business operations, so too should developing countries consider what steps they might take to facilitate their adoption, even though they may not have a clear use at first. In this light, measures to accomplish this objective as well as the broader objective of attracting more technology transfer might include several tactics. The development of a national telecommunications grid should be considered a top priority infrastructure investment [13]. Developing countries might consider identification of selected backbone circuits which might be upgraded to SONET[6] standards, they might attempt to use competitive tariffing of services, and work hard at simplification of interconnection procedures for computer systems from MNCs. Depending on resources available, a developing country might wish to provide financial incentives to MNCs which engage in training host country nationals in information technology.

There are also many problems with up-grading the ability to use IT in developing countries [33]. In some cases, however, creative public policy implementation on the part of host countries can go far in encouraging meaningful transfer of IT by vendors, who have been heavily criticized [119,88,89,90,48,32], but this is entirely different from inducements to have *users* of information technology, such as MNCs. Writers such as Meyer-Stamer have questioned the efficiency of these policies [74]. The key to influencing technology choice on the part of users involves making available a world-class infrastructure which includes electricity, air conditioning, adequate human resources (programmers, analysts), transparent equipment

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High speed leased lines are typically 1.544 mbps in the U.S. and 2.048 mbps in Europe, or multiples thereof. The SONET standards are considerably faster: OC-1 is 51.84 mbps, OC-3 is 155.52 mbps, and so on up to OC-48 which is 2,488.32 mbps. These higher speeds are enough for multiple television signals over the same circuits along with other data.

importation procedures and the like. Without these, the installed base will remain low [29].

These types of policy adjustments will not be done over-night, as the case of India shows [36,81]. If developing countries fail to adopt the newer technologies such as fiber optics and digital switching systems, their public telecommunications systems will be incapable of supporting the new wave of applications routinely used by MNCs. Conflicting economic, social and political problems can either accelerate or degrade adoption of new technologies [22]. The danger is that advances in telecommunications and information technology are making it "cheaper for institutions and firms in developing countries to have their problems solved for them elsewhere than to develop local research facilities, [83]" and the crisis is that little effective transfer is taking place [64]. Many different writers have warned that information technology has the potential to erode the terms of trade for developing countries, others have emphasized that information technology also opens up possibilities for underdeveloped societies "to modify their educational systems, their forms of production and ... the institutions, in order to make the most of information, which has become the new vital raw material [109,117]". Given the record of the past, only the most optimistic would expect a sudden change for the better in the near future.

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II

SOCIO-CULTURAL AND ORGANISATIONAL ISSUES IN IT APPLICATIONS IN NIGERIA

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ABSTRACT

The process of Information Technology (IT) applications in Nigeria is fraught with socio-cultural and organisational issues that often influence the outcome of IT application projects in the country. These issues pose great pedagogical and professional challenges to trainers and practitioners of IT respectively. This paper examines some of these issues and discusses their implications. Also, the paper makes some recommendations which include advocating for appropriate curricular orientation in the country's IT manpower development programmes, such as would assist in the production of a calibre of IT professionals with appropriate indigenous expertise, i.e. those who can adapt IT to the socio-cultural and organisational context of the country. In concluding, the paper suggests that the issues and challenges raised may not be peculiar to Nigeria, it therefore stresses the need for a carefully designed IT programme that is appropriately adapted to the respective socio-cultural and organisational contexts of developing countries in general.

1. INTRODUCTION

Socio-economic changes in Nigeria over the years have resulted in the existence of large and complex socio-economic structures requiring large scale information systems that could integrate the use of their data for planning and decision-making. The application of Information Technology (IT) has become a matter of priority in many public and private organisations throughout the country. In recent years, the Nigerian society has been experiencing a rapid IT revolution because of its growing awareness of the indispensability of information management system to efficient decision-making.

However, while a lot of investments have been made on several computer installations in the country, the enormous potentials that IT offers as a basis for providing powerful information systems for efficient decision-making has hardly been realized. Most of the IT applications in these installations are limited to routine clerical activities. It is evident that IT applications in the country have not been making the necessary impact on the country's decision-making process. Decision makers in both the private and public sectors of the economy are therefore, demanding improved Information Systems with broader IT applications in order to meet the need for increased organisational productivity.

My experience as a consultant on some IT application projects, reveals that there are some socio-cultural and organisational issues which influence the outcome of IT applications in the country. The complexity of the socio-cultural and organisational context within which IT applications take place in the country, requires IT experts with appropriate knowledge and skills to deal with that context. It requires the availability of a better trained cadre of indigenous IT professionals who have a clear understanding of the social, economic, organisational and cultural conditions of the country. These conditions are crucial factors in determining IT application requirements and potential utility [9]. Furthermore, the requirement for this kind of IT professionals calls for improved IT manpower development programmes. This will help in the production of IT professionals with indigenous expertise in the knowledge and management of the socio-cultural and organisational issues involved in the process of IT applications in the country. However, the various kind of IT training programmes being offered in the country's institutions at the moment, fall short of this ideal [14].

It is the aim of this paper to examine some socio-cultural and organisational issues in IT applications in Nigeria, discuss their implications, and make appropriate recommendations towards effective and productive IT applications in the country in particular, and in developing countries that share similar IT application context in general.

2. SOCIAL DIMENSION IN IT APPLICATIONS

Technological determinism suggests that technical development follows certain inner laws of its own, while social development in turn, is controlled by what happens in the field of technology [11 p.9]. This thinking seems to govern prevailing beliefs in IT applications. The traditional way of applying IT has been to start with the available technology and then design job and work systems around it for the users. That is, users are squeezed in to fit the technology [16 p.78]. This approach takes a purely technical perspective which does not give due recognition to the human factors necessitating a social dimension in IT application in general.

The reality of the social dimension in IT applications in developing countries is an undeniable fact. There has been an awareness among IT researchers [e.g. 2,3,8,9,11,14] of the need to relate IT more closely to the socio-cultural and organisational environment of the users so as to minimize as much as possible, the conflicts that might arise from the users' view of the world and that of IT. These researchers stress the need for a "technology with human face". That is, one which recognises the importance of "human factors" along with "technical factors". A disregard of the social dimension in IT applications often results in failure of IT application projects [11 p.40]. Therefore, in addressing this crucial issue, the suggestion has been to take into consideration a socio-technical perspective of IT applications.

Socio-technical perspective is a response to the problem created by the purely technical perspective. The central question is, "What is the place of humans in relation to the system?" In the purely technical perspective, human beings are placed outside or at best placed subordinately to the IT application system. Thus, the crucial issue of human factors are relegated to the background. The basic idea of socio-technical perspective is that an organisation is considered as consisting of two separate systems: a social system and a

technical one. A social system belongs to the world of human beings, which lies beyond the reach of formal system theory that underpins the technical perspective. However, the two systems are equally important and neither is subordinate to the other. Bjorn-Anderson reiterates that social and technical needs as well as goals should be considered as equally important, and that effort should be made to create a whole which takes both systems into account [11 pp.72-73].

Leavitt construes an organisation as a system consisting of a number of mutually interdependent variables, the most important being tasks, structure, technology and people [11 p.74]. This provides a basis for the thinking in socio-technical perspective. The relevance of the theory of the technical perspective is limited to the technological factor [11 p.75]. The structure, tasks and people aspects constitute prominent areas of human factors in relation to IT applications and the changes they impart on organisations. The reality of Leavitt's concept of an organisation shows clearly the need to expand the frame of reference so as to take into account the social dimension in IT applications.

Human factors constitute the predominant issue in social dimension to IT applications. In this regard, three human actors are recognisable: the application developers, the users and the decision makers. The perception of the purpose and goals of an IT application project held by each of these actors often goes a long way in determining the success or failure of such a project. We shall consider the social dimension in IT applications in terms of these three actors.

User involvement is a major issue that brings a social dimension into IT application. The effectiveness of any IT application is influenced by the way in which the user is involved. Lundeberg reiterates this point in his observation that it is not enough for an information system to be a technically impeccable, high-quality product if it is not accepted by the users. The anticipated gains will inevitably fail to materialise [11 p.75]. User involvement is concerned with the role of the user in the IT application process and the ways in which he can be encouraged or assisted to contribute towards its success. It is generally believed that user involvement at each phase of IT application development process forms a continuum which shapes his attitudes and responses to the product.

The reasons for user involvement are not far to seek. From the application developer's perspective, users (a) have valuable specialist knowledge and (b) wish to avoid resistance to change. From the users' perspective, there is a need to (a) check and perhaps, challenge the political and organisational ramifications of the IT application and (b) develop a feeling that it is right that users should be involved in planning their futures. The problem is that there needs to be the will on the part of the IT application developer to involve users, and more importantly, develop effective methods by which users can participate successfully [4]. However, user involvement produces problems where self- or vested-interest predominates and organisational interests are of secondary importance. Vested interest can lead to disagreement, delay and sometimes, complete failure of an IT application development process [7]. Vested interests encourage parochialism which in turn, inhibits integration across the various levels of an organisation, especially where there is an obvious need for organisational change. It is not uncommon to find well orchestrated but subtle efforts designed by some actors, to resist

and in fact, sabotage an IT application project that do not fulfil their needs or support that which enhances their personal gains. Vested interests are issues of social dimension and they constitute a real factor that undermines IT application system development in developing countries [13].

User attitude can be a major issue of social dimension in IT applications [5]. Such an attitude constitutes "the sum total of a man's inclinations and feelings, prejudices, bias, ideas, fears, threats or convictions about any specific topic" [15]. Attitudes are expressed by actions or opinions. People say what they believe, and those beliefs can, if there is no pressure to the contrary, be reasonably expected to indicate real attitudes [15].

An individual to be affected by an IT application may not acknowledge its benefits if he fears that it may not serve his personal interest. He could express his hostility by making efforts to exhort validational evidence in favour of a type of social prediction which has already been recognised as a failure. This reaction may manifest itself, for example, in his refusal to concede that IT application may bring some benefits, or that the disadvantages will prevail.

Vested interest is not only limited to the user actors. IT application developers and decision makers can cause failure of an IT application project through vested interests too. In a situation where there exists no code of conduct for professional practice, an IT application consultant who pays a bribe to get the job could easily mortgage his conscience by failing to do that which is professionally right. So also is a decision maker who receives bribe would have no choice but to turn deaf ears or blind eyes to whatever is going on in respect of an IT application project, even when it is obvious that such is not in the best interest of the organisation. Further still, a decision maker who is a political appointee, would as of necessity, dance to the tune of his masters even when such will not be helpful to the success of the project. In such a situation, an IT applications process could follow the direction dictated by those who are in the position to influence it for personal gains. Furthermore, where an organisation is a federation of groups with overlapping and sometimes conflicting interests, the direction of an IT application development could be the outcome of a political process. If coalitions in the organisation differ on the directions they prefer, the actual direction of an IT application project will be a by-product of conflict, domination, sabotage, or compromise [6, 7]. The issues involved here are obviously non-technical. Rather, they are purely of social dimension which has to be recognized and appropriate methods developed to manage them.

Communications gap among the three identified actors - user, decision maker, and IT application developer is another issue of social dimension. In the debate over IT and its use, the battlefront, so to speak, has been drawn between the users and the developers. The management of an organisation which bears financial responsibilities for the systems, watches from the sidelines, sometimes with considerable bewilderment what is going on between the two. The three actors at times give the impression that they are talking at cross-purposes without any understanding of what the others are saying i.e., they are talking different languages [11 p.11]. Such a communication gap occurs in a situation where the training background of an IT application developer is such that he can communicate only in a technical language. The user only understands business language and/or he does not really know his needs. The decision makers only understand the political language, and worse still, both users

and decision makers may be IT illiterates. Given this kind of setting, adequate understanding of human relations and interpersonal skills for communicating effectively with other actors in IT applications becomes a necessity for an IT practitioner

People's institutionalised work culture vis a vis the ability of the IT applications developer to effect the necessary change through IT is another issue of social dimension. The capabilities of the computer have developed at such a high speed that the thought process of human society has not been able to keep pace with it. This speed-lag is one serious psychological factor which matches well with human nature of accepting any change without a certain degree of scepticism. Further to this is the fact that IT application imposes strict work discipline on their users which could require them to do away with their traditional work culture and to imbibe the new IT culture.

The socio-technical concept of organisation described by Leavitt [11 p.74] alluded to earlier, raises the social system to the same level as the technical system. Technology-oriented design has proved inadequate in this regard. This is so because the implementation of an IT application system is not a purely technical problem alone. Rather, social and organisational changes have to be linked to changes made in the system [11 p.107]. The diagnosis and evaluation of the failures and the problems of IT application systems suggest the need for a review and reframing of current approaches which takes adequate care of the social dimension of IT applications [3].

3. ISSUES AND CHALLENGES IN IT APPLICATIONS IN NIGERIA

The following are some of the socio-cultural and organisational issues and challenges in IT applications in Nigeria.

3.1 Culture of Self-motivated Commitment to Public Services

During the colonial era, an average Nigerian worker had the notion that he is working for the "whiteman", rather than working for his nation. Consequently, people usually separated personal from organisational interests and were more concerned about the former. There is a carry-over of this attitude into the post-colonial era, most especially in the public services. An average Nigerian public servant often refers to public services as "government work". This general attitude is summed up in what one commonly hears: "government work does not require sweating". The result of this type of attitude is inefficiency in the running of public services including IT application projects. It could be a great problem devising effective method to carry along people who may be more committed to personal gains than to the organisational purpose and goals of an IT application project. For instance, on one of the IT application projects in which this writer was involved in collaboration with four social scientists, he had no alternative but to strike a balance between his technical stance and the humanistic perspective adopted by the four social scientists, before some measure of success was achieved.

3.2 Culture of Preference for Informality

Most Nigerians seem to prefer doing business informally rather than following a formalised

procedure. The consequence is that a simple procedure for doing a thing is deliberately made complicated. This is so because personal and subjective parameters - e.g. tribalism, nepotism, bribery, etc. are easily introduced into decision-making processes. For example, as part of implementation of an IT application project in one of the government ministries in which the writer was involved, a point-award system for decision-making had to be designed. This was to make the decision-making process more rational and straight-forward. However, this did not go well with the decision makers involved simply because it was too straight forward to accommodate this culture of informality and the expected personal gains. The reality of the matter is that, traditionally, people generally abhor system-thinking and automation that do not imbibe this culture of informality, for the obvious reason of vested interest. It could be a difficult, if not an impossible task to reflect this culture of informality in an IT based information system without ending up with a compromise system that would not be able to achieve the desired goal.

3.3 Culture of Over-politicised Decision-Making

Decision-making process in most Nigerian organisations, especially in the public sector, seems to be over-politicised. There would always be multi-dimensional interests to consider in decision-making. More often than not, rational judgement has to be sacrificed on the altar of political expediency. As it is well known, the political view often stresses the actors' private interests and strategies to achieve such interests. It is a common experience to see the direction of an IT application development following the direction of a political process or evolving as a by-product of conflict, sabotage, and compromise. A politically motivated decision-making often results in poor project planning and control, poor selection of leadership and technical personnel, poor selection of applications, hasty computer system selection and installation, etc. An obvious implication is that an IT practitioner to some extent must be a shrewd politician and ready to make compromises, if he is to make a success of an IT application project. There is also a challenge for building an IT-based information system that is flexible enough to cope with the amorphous and unpredictable nature of such decision-making procedure.

3.4 Culture of Secrecy

A scientific world view is based on an "open predicament" and hence science is a public property. On the other hand, the traditional African world view is based on a "close predicament", and so African cosmology is shrouded in great secrecy [12]. An average traditional Nigerian, true to his African cultural identity, has the culture of keeping secret, any information in his custody. That one has a knowledge which others do not have, is often considered a thing of pride. Also, people generally abhor others having knowledge of any information about them that may be unfavourable. This is the truth both at the individual and the organisational levels. For instance, organisations do withhold and sometimes falsify information where doing otherwise will not help their image. This issue is one of the limiting factors responsible for people's response to such IT idea of integrated information system. The fear is that an integrated information system, with a centralised database, poses a great threat to privacy, raises the possibility of misuse of information, as well as leads to a shift of "information power base". Hence, determining an acceptable level and degree of information

systems integration and centralisation is a challenge.

3.5 Culture of Bureaucratic Complexity

Bureaucracy could be an effective management control mechanism when it is so well channelled. In Nigeria, we have seen how decision-making on an IT application project had been delayed, until the project was abandoned all in the name of bureaucracy. Experience has also shown that people could create artificial bureaucratic bottle-neck to stall any project that they feel would not serve those personal interests they would want the project to serve. The bureaucratic structure is the kind that smothers individual initiative and does prolong decision-making. In the Nigerian setting, an IT practitioner must of necessity possess some bureaucratic skills if he is to deal successfully with the bureaucrats. Otherwise, he would experience resistance and ultimately, frustration sufficient to attenuate his energy and weaken his motivation.

3.6 Inadequate Research Support Culture

Research generally is grossly underfunded and IT research is not an exception. The society seems to prefer a trial and error approach, using ready-made tools, to solve problems. Unfortunately, such ready-made tools like turn-key packages imported from developed countries are often ineffectively used. The government does make some provision for research in our institutions, but the funding is grossly inadequate. Research funding from the industrial sector is a rare occurrence simply because an average Nigerian businessman does not seem to believe in any venture that would not yield immediate dividend. Hence, IT researchers are grossly handicapped to carry out an in-depth research that could facilitate effective and productive IT applications in our kind of socio-cultural and organisational setting. Consequently, IT practitioners are very limited to the rather inadequate system-theoretical approach to IT applications.

3.7 Self-motivated Research Culture

Like an average Nigerian researcher, an IT researcher seems to take delight in self-motivated, solo-effort research activities. Cooperative research activities is therefore a rare occurrence. This unhealthy situation is encouraged more by the "publish or perish" syndrome prevalent in our institutions. The number of papers published rather than their practical application has become the rule. The implication of this situation on IT applications is that the present IT research activities in the country are rather limited in scope. They lack practical orientation and therefore, do not provide adequate knowledge-base for practitioners in the field or consumers of IT products.

3.8 Inadequate Policy Culture

Policy makers are more concerned with rhetoric rather than concrete formulation and adherence to such policies. There is yet to be a clearly formulated and well articulated IT policy in Nigeria. The only IT-related documented policy made public so far is the National Policy on Computer Education [10], which is only limited to a statement of how the

government plans to carry out the programme of introducing computer studies into the secondary school curriculum. The result of this situation is that at present, just anything goes in the country; anybody who has the money to do any IT-related business does so without any guiding policy. The supposed-to-be IT professional association, the Computer Association of Nigeria, which should have appropriately guided the government on this issue is still struggling to find its right footing. Thus, it is right to say that IT applications in the country is currently taking place in a free-for-all jungle. And yet, a lack of clear-cut IT policy is a sure cog in the wheel of effective and productive IT applications in the country.

3.9 Culture of Inadequate Curricular Flexibility

The various IT-related sub-degree, bachelors degree, postgraduate diploma and postgraduate degree programmes currently being offered in Nigerian institutions of learning are inadequate with regards to producing the right calibre of IT professionals that can meet the challenges of effective and productive IT application in the country. Some reasons for this were adduced in an earlier paper [14]. There is an apparent unwillingness on the part of the IT educators who are in the leadership position to accept an IT perspective that takes them beyond their background in Mathematical and Basic sciences.

3.10 Culture of Exploitative IT Vendoring:

Besides the common profit-making objective, a businessman should also be concerned about his client's productive utilisation of the acquired product, especially when a sizeable investment is involved. The writer's experience in dealing with Nigerian IT vendors shows that most of them are more concerned about what they are getting out of a business deal than their clients' productive utilisation of acquired computing systems. The fact is that IT vendoring business is dominated by businessmen who only have the money to start the business but lack the professional know-how to give necessary user services support to their clients. Vendors would exploit ignorance of clients to sell to them computer systems that may not meet the information system required by such clients. Every problem the clients have with the system provides an opportunity for the vendor to exploit them further. They would make elaborate publicity of services that they could not competently offer. Their greatest weapon is the aggressive marketing drive, which easily works in a predominantly IT illiterate society as Nigeria is.

3.11 Culture of Infrastructural Inadequacy

Infrastructural facilities such as regular power-supply and reliable telecommunications network which are very essential for effective and productive IT application are still lacking. These facilities fall within public utilities being provided by government agencies. As earlier pointed out, anything government is not being run efficiently. Recent measure taken by the Federal government to commercialise these two public utilities to ensure their efficient running, has not yielded the desired result. Therefore, any organisation that decides to invest on IT application, must always be ready to provide alternatives for these support facilities. In fact, most vendors make the acquisition of power-supply support facilities a condition for giving warranty and signing any maintenance agreement on computer hardware sold. The cost

of these facilities could be as much as between 20% and 25% of the total investment on the computer system. The inadequacy in infrastructural facilities, which necessitates the need for extra expenses imposes a great constraint on many organisations that would have invested on IT applications.

4. RECOMMENDATIONS

To address the issues and challenges raised in the preceding section, the following recommendations are made:

a) Curricula re-orientation in the country's various IT manpower development programmes. Such a re-orientation should appropriately address the pedagogical challenge of producing the right calibre of IT practitioners. It should embrace not only technical knowledge but also the knowledge of the socio-cultural and organisational setting of the country. This undoubtedly requires a pedagogical approach that involves interdisciplinary teaching cooperation. In this regard, there is a need to demystify the prevailing rigid belief that IT training programmes should always be in the environments of Mathematics , Science and Engineering. There is a need to re-orient IT curricular to take adequate care of the social dimension of IT applications.

b) Cooperative, interdisciplinary and well-coordinated research activities among IT researchers on the one hand, and their social scientist counterparts on the other. The research activities should basically address IT application problems of practical nature. Further, industrial/academic research cooperation, should be encouraged. While the industrial sector provides funding for research, the researchers should undertake research activities that address practical IT application problem in the industries. A National Institute for IT Research and Applications should be established to facilitate an effective coordination of these research activities as well as the administration and utilisation of the limited research facilities. Such a national institute should be adequately equipped to accommodate IT researchers on study leave for research work.

c) Formulation of appropriate and well-articulated IT policy for the country. The earlier proposed National Institute for IT Research and Applications could serve as a think-tank for the government in formulating appropriate IT policy for the country. There should be policies on such issues as: computer systems requirements for the country, IT manpower development, importation of computer hardware and software, IT training standards especially for private institutions, requirements for the establishment of IT-related business ventures, professional practice ethics and so on.

d) A sustained programme for IT literacy. This should involve:

- Seminars/workshop for employees of public and private organisations, including policy makers;
- Computer education of the populace using the mass media;
- Adequate exposure of students in tertiary and higher institutions to computer education, to make them potential supporters of IT applications in their future work places;
- Further efforts on the current programme of computer education in secondary schools

backed up by better planning that will make it more functional.

5. CONCLUSION

The issues and challenges raised in the Nigerian context of IT application may not necessarily be peculiar to Nigeria. Rather, it may be a phenomenon of developing countries in general. While there is no universal "culture of developing countries" [8], local IT practitioners in developing countries need to devise appropriate ways of coping with the features of the local culture. It needs be realised that IT, like any other science and technology-based discipline, is largely a product of the developed countries, i.e. in a culture of mechanistic world view based on things. This is quite different from, say, the African traditional world view, which is informal and based on people rather than things. The conflict that might arise from using IT products from the former is not likely to be permanent, considering the adaptive features prevalent in any human society [12]. What is needed is a carefully designed IT programme that is appropriately adapted to the respective socio-cultural and organisational contexts of developing countries.

This paper might have raised more questions than answers. However, it is hoped that necessary stimulus for further debate has been provided.

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STRATEGIES FOR INDIGENISING IT PRODUCTION IN DEVELOPING COUNTRIES

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ABSTRACT

Policy-makers in developing countries are concerned about questions of information technology (IT) indigenisation. Should they emulate the high levels of IT production found in Western nations; or should they ignore production and focus on IT diffusion and use? This paper argues that IT policy must include the development of local production capabilities, and case studies are described to illustrate this point. The cases are chosen from India because its government has assisted a dramatic indigenisation of IT production over the past twenty years. The case studies indicate there is a key choice - to build local capabilities through the assistance of multinational corporations (MNCs), or to rely more on local organisations. Each choice brings with it a series of costs and benefits but, from the experience of India, it seems that the 'home-grown' approach of using local organisations - often seen as a second-best option - can actually have much to offer.

1. INDIGENISATION AS A STRATEGY

Quantitative measures of indigenous IT industry development are inadequate because the critical resource in these industries - the skills and experience of individual workers - can only be assessed qualitatively [15, 18]. A representative measure is'technological capability', seen as a crucial determinant of indigenous industrialisation [16, 17].

A scale can be drawn up for this measure (see Table 1). One may define technological capability as the general ability to undertake the broad range of tasks outlined in the table, and technological development as growth in the capability as defined by movement up the categories and regardless of whether or not the final stage is attained.

Developing countries need to indigenise IT capabilities for several reasons. At the most basic level, if a country has no local capabilities, it will not even be able to use the technologies that it imports and it will be reliant on the whims of foreign suppliers and operators. To avoid this dependency, countries must have skills that allow understanding and control over technology introduction and management.

There is also a need for technological capabilities which allow adaptation of technology to local conditions. Hardware must be adapted to local power and environmental conditions;

to local keyboard layouts; to locally-available supplies. Software must be adapted to local languages and scripts; to local financial laws; to local organisational procedures; to specific local needs. With their far deeper understanding of local laws, conditions, customs and needs, it is local staff who will be better equipped than foreigners to undertake this adaptation successfully.

Table 1 *Scale of Producer Technological Capability*

1	Choice and Use	• Choosing the technology • Setting the environment for use of the technology • Using the technology
2	Adaptation without Production	• Product modification to meet local needs • Minor product innovation to meet local needs
3	Basic Production	• Copying technology • Assembling technology • Full production using existing products and processes
4	Inward-looking skilled production	• Product or process modification to meet local needs • Product or process redesign to meet local needs • Product or process innovation to meet local needs
5	Outward-looking skilled production	• Product or process modification to meet regional/global needs • Product or process redesign to meet regional/global needs • Product or process innovation to meet regional/global needs
6	Global Production Competing Through Innovation	• Major product or process innovation to meet global needs • Transfer of technology to other users and producers

Thirdly, without local technological capabilities, there is no possibility of goods being produced in a developing country. If that country does not build up to the higher levels of technological capability, then local production will be low in skill- and technology-intensity; consisting of low-paid assembly work instead of high value-added production. Countries seeking to export

have often done so on the basis of low labour costs, but innovation is becoming an increasingly important part of competitiveness. Developing countries will have to innovate in order to export - they will therefore need relatively high levels of local technological capability.

Finally, the cost of *not* building up capabilities may be high. A country would be forced to rely on exporting primary products, which earn little compared to the cost of importing large items of technology. Foreign investment would also be reduced because investors prefer countries with skilled workers to those where training has to be provided, or where skilled operations cannot be undertaken.

Of course, there are financial and time costs in increasing local technological capabilities and, as local people become increasingly skilled, they are more likely to join the 'brain drain'. There is also a problem of deciding what kind of capabilities are developed, and in whose interests those capabilities should be developed.

Despite these costs, there is agreement on the need to develop local technological capability [6], which can be done in two main ways. Firstly, by getting foreign multinationals to supply training and contracts for on-the-job learning. Secondly, by getting local organisations to develop their own skills. The Indian case studies presented below draw out costs and benefits of these two choices. Data were drawn from a survey and interviews conducted in India in 1989, and greater detail can be found in [10].

2. INDIGENISING SOFTWARE PRODUCTION

2.1 Multinational Case Study: Unisys and Tata Unisys Ltd (TUL)

Tata Unisys Ltd is one of the largest Indian software companies. It was formed in 1976 as a joint venture between the Indian conglomerate Tata Sons Ltd and the US computer firm Burroughs (renamed Unisys in 1986). The TUL link has enabled Unisys to sell several million dollars-worth of Unisys computers to various Indian customers. Unisys has also used Indian software skills to offer low cost information system development to potential customers overseas, so helping it to sell more computers. Both Unisys and TUL are happy about this, though the Indian government has been worried that Indian skills are being put to work to develop software for organisations in the US and Europe, rather than at home.

Unisys has transferred skills to Indian staff by running training programmes for them in India and the US; but also, and more importantly, by subcontracting software work and so offering Indian workers real 'on-the-job' experience.

Unisys has transferred technology-related skills to Indian workers about particular Unisys hardware, Unisys systems software, and preferred Unisys applications software. It has also transferred skills relating to standards of work - inter-project communication, scheduling and delivery, documentation - and about new software development methods such as Structured Systems Analysis and Design Methodology. Finally, Unisys has transferred understanding to Indian staff about Unisys corporate strategy and corporate culture, so that these staff can

use their skills most effectively to help Unisys grow.

Despite this transfer of skills, Unisys has been a little unsure about using India as a source for highly-skilled work. As a result, many of the contracts given to TUL have been for rather low-skilled conversion work - in other words, just for programmers rather than designers or analysts. TUL can do little about this because the final decision on contracts rests with the US company, which has always been concerned that the transfer of skills should help it to sell more computers and to increase its own profits, and which has always seen software as a secondary concern to the problem of selling more of its computers.

Because of this and other dissatisfactions, there has been a very high rate of staff turnover in the Indian company - up to 25% per year. Many of these are workers who leave projects they are working on in the US or Australia and take up residence there, thus depriving India of their skills. The Indian company would like to reduce this, but it has had little say in the type of contracts given by Unisys.

The Indian company was interested in the collaboration with a multinational for two main reasons. Firstly, through collaboration, TUL has been able to get round many of the export market barriers to firms from developing countries and get virtually guaranteed export work from Unisys. However, this is a two-edged sword because TUL is essentially a captive seller, whose fortunes are closely linked to those of its sole customer. Thus, according to an ex-TUL manager, "TUL's US marketing offices are basically there to take orders from Unisys. Life is easy but very dependent."

TUL has been particularly dependent on the financial health of Unisys, with the Indian firm's profits and revenues dipping sharply in 1985 and 1989 when the parent company was going through hard times. Other Indian software companies have dropped out of the software business when their foreign collaborators went bust or lost interest.

As a consequence, Tata management has tried to diversify operations away from Unisys, particularly because staff were worried that their Unisys skills might be of little value if Unisys went bust. However, the diversification has met with only limited success - by the start of the 1990s, 85% of TUL's work was still for Unisys or its customers.

Secondly, collaboration has provided TUL with investments - both direct ones in technology and indirect ones in skills. It has been given early access, often free or at greatly reduced cost, to various new technologies, and training in their use. For example, Tata staff have been working with fourth generation programming languages (4GLs) since at least 1982, many years ahead of most other Indian organisations.

2.2 Local Organisation Case Study: CMC (Computer Maintenance Corporation)

The Indian government has invested in millions of dollars-worth of software development, either through direct funding of software research and development (R&D) or through software purchases by public sector organisations. The government has been able to decide what capabilities it wants to build up and has focused on two main areas.

Firstly, skills in areas which would otherwise have been dominated by imports, such as word processing, database management systems, computer-aided design and artificial intelligence applications. Some of these have been criticised as inappropriate - why invest in artificial intelligence work, for example, when many villages do not have clean water.

Secondly, capabilities in applications which are specific to Indian requirements, which are often outside the normal business area, and which therefore might otherwise have been ignored. These include regional language word processing, water pollution and irrigation management, hospital management, rural development planning and so on.

A well-known example has been the work of the Indian company CMC to computerise the passenger reservation system of Indian Railways. CMC was chosen partly because it had already been experimenting with a simple computerised reservation system, as the by-product of a UNDP-funded programme intended to look at the development and use of new technology in developing countries. Foreign companies or systems were not considered because of the cost and because of their lack of match to the complex Indian situation.

Because CMC was relying on its own skills, system development took some time, and there were criticisms that it was based on rather old-fashioned technology: on number-crunching rather than on-line transaction processing. Nonetheless, the system went online in Delhi at the end of 1985 and has since been installed in most major cities. Maintenance is easy because the company is local, and the Railways feel secure in the knowledge that this application will continue to be supported - even in the very unlikely event that CMC went bankrupt, the skilled staff would still be around.

The UNDP-funded work provided a valuable base of work experience and skills, but a much greater gain came from the award of the Railways contract. This allowed a large saving in foreign exchange since no payments had to be made to foreign software firms, and CMC used the project to build a large team of skilled, experienced workers.

Several dozen programmers learned coding skills on this contract; software analysts and designers were able to put into practice things that had, until then, largely been classroom knowledge; and CMC software managers got their first experience of managing a very large software project - the largest in the country at the time. By the end, then, there were capabilities not just of basic production, but right up to product innovation to meet local needs. Of course, mistakes were made, but that was seen as the essence of learning and of building capabilities which could be applied more effectively in later circumstances.

The software developers enjoyed their work, which was more interesting and skilled than many small domestic projects, and this helped to persuade many of them to stay with CMC rather than seeking their fortunes overseas.

The contract therefore allowed a large base of skills to be built up which could then be applied to other contracts, and it provided a huge demonstration of CMC's abilities to potential customers. Subsequent contracts won with the help of the reservation contract include work

on the computerisation of the Nhava Seva port complex in Bombay; sizeable contracts with London Underground and Felixstowe port in the UK; and work helping to computerise rail reservations in China and Egypt [5]. It must be admitted, though, that this was a particularly positive outcome - in other cases where applications have been matched closely to Indian needs, there have not been many export opportunities.

2.3 Costs and Benefits of Each Route

Although specific case studies have been quoted here, they were chosen because they epitomise much more general findings about the role of multinationals and local organisations in the development of the Indian software industry.

Multinationals have provided skills - sometimes on a long-term basis - which upgrade technological capabilities within the local economy; skills often not available from any other sources, especially for a new industry or technology. This was seen, for example, in the provision by Unisys of 4GL-related skills. By contrast, local organisations, like CMC, have been in danger of building skills which are not applicable to the latest technologies.

Multinationals like Unisys often provide an early awareness about new technologies plus related skills (though the latter come only where the MNC has had a focus on production in the developing country rather than just consumption). By contrast, local organisations often take a long time to build up their knowledge and this entails a high cost compared to skills provision by multinationals, which generally pay for any training.

The Railways case was rare in providing a base for subsequent exports. In most cases, local organisations do not build skills which can be directly applied to exports whereas multinationals can do this if motivated. In such situations, the MNC will also provide a route through which these skills can be gainfully employed to produce export earnings.

However, as the Unisys experience indicates, such export earnings are often based on low-level, cheap-labour skills; are dependent on the multinational's health; and are isolated from the domestic economy. They may lead to a greater opportunity for a 'brain drain' of local talent in situations where local organisational development can help to reduce this.

Multinationals invest foreign capital - a source which cannot be tapped so easily by local organisations. However, this may not be a major benefit since, as illustrated by the Unisys case, relationships with multinationals generally involve a long-term net loss of capital because MNCs will always want to take out more than they give. The Railways software case is one of many in which local organisations have developed capability on the basis of a relatively low outflow of capital.

Of particular relevance to the focus of this paper - building technological capabilities - has been the failure of Unisys and similar companies to deliver as much as local organisations can. Multinationals tend to transfer relatively 'low-level' skills. The capabilities built tend to be oriented to the technologies and the sales needs of the multinational. Therefore there is a substantial opportunity cost because these capabilities are not particularly appropriate to

national development needs.

With local organisations, there is still a danger that the bureaucracy will make inappropriate choices about which skills should be developed. However, this is clearly not always the case. More often, capabilities and products can be matched to local needs and can be integrated with the development of the local economy rather than isolated in a multinational or export enclave. Most important of all, there is the opportunity to build capabilities up to the highest level of innovation.

At least where the public sector is paying for software development, there is a possibility for local choice and control over the capabilities that are built whereas, with the multinational, control of decisions about the skills and technologies transferred remains largely with the parent company. As a result, the local economy becomes dependent on external sources of supply and innovation; leaving that economy vulnerable to alternations in the financial health of the multinational and politically less self-directing.

3. INDIGENISING HARDWARE PRODUCTION

3.1 Local Organisation Case Study: Innovatory Indian Hardware Companies

Most innovatory Indian hardware companies (referred to below as 'design innovators') are long-established. In the late 1970s and early 1980s, the Indian companies which dominated the micro- and minicomputer markets were building up design innovation production skills. They designed the overall component layout for their computers' circuit boards and peripherals; bought in components (such as processors) from foreign or local sources; put them together to make the computer; then tested it. Locally-made operating systems, systems and applications software were added to create a complete system [9]. The computers produced were not as technologically up-to-date nor as cheap as those on the international market, but these factors and skills were slowly being improved.

The build-up of indigenous capabilities continued for a while but, in the mid-1980s, was halted by a government policy decision to turn towards multinational collaborations and imports. In the market for basic PCs, design innovators were unable to compete with companies assembling imported kits. They were forced to become kit assemblers themselves, often relying on foreign collaborations, as one General Manager described:

> "We didn't have the necessary lead time to develop our own machines. It was a case of collaborate, or lose our market share in this crucial sector. I swung the Tandy deal for the company, but I still feel very sad at its necessity. We had the brains and the infrastructure to design and develop an Indian computer" [19].

As well as the lack of development time, fierce competition in this market forced cost cutting. Production and research investments made in 1983-84 were largely lost, profits reduced, and R&D largely abandoned. Some capable firms lost their design capabilities. Those which kept them could only afford to invest in R&D in areas of lower competition.

R&D staff were therefore moved to work on more powerful computers. There were few Indian computer companies with foreign collaborations producing such PCs, and the continued and subsequently rising level of import protection ensured the design innovators of sufficient profitability to justify their heavy R&D investments. Technological capabilities were thus once again being built up locally.

Design innovators were assisted by a government committee decision which recommended use of the Unix, rather than MS-DOS, operating system (running on powerful PCs) for Indian bank automation. This decision paved the way for a large potential market for Unix-based hardware, further encouraged R&D investment, and so helped to form the base for hardware innovations in the late 1980s, many of which were Unix-based machines. Whether this decision was far-sighted or just lucky is debatable. A different decision might have proved to be a costly mistake.

By the early 1990s, some (but not all) design innovators had a 'strong manufacturing capability' producing powerful PCs 'conceived, designed and developed entirely by their R&D' [13]. Each firm had over a hundred R&D staff, and they each spent about US$10m annually on R&D, typically working simultaneously on ten or more new designs for main circuit boards, secondary boards and peripherals. They used a much higher proportion of local components than other firms; had produced machines before any other company in the world; and had started exporting such machines or their designs [4, 20].

Throughout the decade, then, a number of firms which built up indigenous technological capabilities during the early 1980s were able to maintain those skills during the 'dormant' period of the mid-1980s and then reassert them in the last years of the decade. By staying on the local organisational route and rejecting multinational interference, they became highly successful and even internationally competitive. As a result, they became (relatively) independent operators in the world market and, where they did choose to negotiate with multinationals, they were able to do so "more as equals than as shark and minnow" as one manager put it.

3.2 Multinational Case Study: Collaborating Indian Hardware Companies

These are Indian computer companies which import much of the technology for the computers they produce. They import it from a foreign hardware firm with which they are in collaboration. Collaborations can be import agency operations, or technical collaborations or joint equity ventures which manufacture computers in India.

Foreign suppliers have been pushing such collaborations as the hardware market in India has grown. They tie up with Indian firms and transfer skills through training and/or contracts to ensure that their products are well marketed and supported. They have a vested interest in high quality production and have invested significantly in capital and skills to boost their sales. Because of these investments and objectives, the multinationals have been concerned to maintain a strong degree of control over their collaborations.

Indian companies seek out such collaborations as an alternative to investing in R&D; as a way

to access the most recent technologies; and because of the preference Indian consumers have shown for imported rather than indigenous technology over and above considerations of cost or performance. As a result, the number of collaborations has risen sharply, from 15 in 1985 to 41 in 1988, with a further 15 being agreed by 1990 [5,12].

Given the background of many collaborating companies in trading or assembly, it is not surprising that their technological capabilities were generally lower than those of local innovatory companies.

Capabilities built up in agency operations are largely restricted to software services, while R&D in other types of collaboration seems more limited than that of local innovatory companies. There are fewer R&D workers in collaborating companies and these workers are oriented more towards local sourcing of components in order to fit in with the government's phased manufacturing programme, and towards the development of applications software and other adaptations to local conditions rather than towards design innovations. The work of one such company was described:

> "We are not involved in any basic developmental work in the strict sense of the word Rather we would like to look at a product and see what enhancements we can offer, by way of system software, operating systems, ruggedization, etc" [13].

These collaborating companies rely on innovatory capabilities and R&D carried out in developed countries and embodied in imported technology rather than on their own efforts. Because of the opportunity costs of this form of production within a technologically capable industry and the competition with more capable local firms, collaboration has therefore tended to reduce the extent of local design and research and development work [8, 21]. As a specific example, the Indian firm PSI lost its R&D capabilities when it was taken over by the French computer company Bull [14].

3.3 Costs and Benefits of Each Route

The costs and benefits are substantially similar to those which emerged from the software case studies. The multinationals can help upgrade the technological capabilities within local hardware companies, offering early access to skills which relate to the latest technologies and which may not be available from other sources. Local organisations, on the other hand, have sometimes (but not always) lagged behind technologically and certainly their initial efforts tend to be slow and high cost by comparison to foreign routes.

But the capabilities that multinationals provide are relatively low-level compared to those which local organisations can build, which can even reach up to redesign and innovation. Not only do multinationals and their related imports substitute for local technological capabilities, but their retention of technological 'know-how' makes local companies and the local economy dependent on them. This is strengthened by the control that multinationals retain over the skills that are to be transferred - skills which are often geared solely to increasing sales or profits for the multinational.

By contrast, the protection of local companies has allowed them not only to build skills but also to build confidence and markets. They are therefore less dependent on foreign skills, technologies and markets for their economic survival, and this has strengthened their bargaining position vis-a-vis the foreign firms.

Most of India's hardware industry is in the private sector, so the state has had limited control over the skills to be developed. In the example cited, the Unix/banking decision did have major and positive repercussions, but this is not always the outcome of state guidance.

Finally, as with software, there has tended to be less net outflow of capital where local organisations are involved though, conversely, they have not obtained the kind of initial foreign exchange inflows that multinational investors are able to command.

4. CONCLUSIONS

4.1 Building Technological Capability - Foreign and Local Routes

Technological capability is the general ability to undertake a range of tasks that involve consumption and production of any particular technology. It is embodied in the skills of workers either locally or overseas, and is gained mainly from hands-on experience rather than just from training programmes.

The indigenous development of this capability is necessary in order for any nation to exercise control over its 'technological destiny', and in order to adapt technologies to local conditions and local needs. The indigenous development of this capability is desirable in order to save foreign exchange and to encourage foreign investment. Without this capability there will be no local production, no local innovation and no exports of goods.

For countries lacking the most basic technological capabilities, multinationals can provide a first source of such capabilities - indeed, they can provide what may be virtually the <u>only</u> source of such capabilities.

Even for countries that have acquired a sound basic level of capabilities, multinationals can provide a source of minor production innovation capabilities - mainly by getting local staff to modify their products to local conditions, local components and local needs; and they can provide skills that will assist exports.

However, for a sustained build-up of technological capabilities, there is a need for some level of protection from imports and from multinationals. Without this, foreign capabilities will continue to dominate the local economy; tending to substitute for and therefore displace the skills that are already present within the local economy; skewing that economy to the consumption of possibly inappropriate foreign goods; and consigning the country merely to following far behind technological trends that are controlled elsewhere. In this case, while staff and capital are both lost from the country, it remains dependent on foreign skills and technology.

A catchphrase one often hears is "let us not re-invent the wheel", this being an argument that whenever it is quicker and cheaper, a country should rely on the import of goods produced by multinationals rather than try to develop them itself. This is far too narrow a viewpoint - the lesson of the experience of the Indian IT industry, of Japan, and many other examples is that developing countries *can* build a base of indigenous production and indigenous technological capabilities by initially reinventing a few wheels - for example, by producing microcomputers or software packages very similar to those produced by multinationals, and which are protected by import barriers. In these circumstances, high levels of capability - even up to regional or global innovation - can be achieved. At this point, but only at this point, some opening up to dealings with multinationals may be considered.

Development of capabilities via the 'local route' may take longer; with high initial costs; mistakes and inappropriate skill development; and with fewer exports than might otherwise be achieved. But against this must be balanced the fact that the information technology produced can be matched to local needs; the development of capabilities remains more under the control of local organisations and, to some extent, government decision-makers; and there is only a limited outflow of both capital and people.

The case studies of local companies are not sufficiently detailed nor sufficiently quantified to state that they offer a better alternative to building technological capabilities than collaboration with multinationals. Indeed, a clear message is that one cannot pre-judge the issue - in certain circumstances (for certain technologies and certain local skills) it may be better to work with multinationals, while in other circumstances it may be better to build via local firms. It is likely that in most sectors, including those connected with information technology, some combination of sourcing will need to be used.

But, while there may well be a place for multinationals in the indigenisation strategies of all countries, the relationships with them need to be critically appraised, monitored and managed to see what long-term gains are actually being achieved, rather than just focusing simply on variables such as immediate cost. It can also be seen that there *are* alternatives to dealing with the multinationals - decision-makers in developing countries should not feel that foreign companies are their only source for skills, because these skills can be built locally by local organisations if they are given the support of the government.

Finally, there is an underlying message that one should take great care when making decisions not to focus simply on what is easily quantifiable in the short-term. National development is a long-term, dynamic, qualitative as well as quantitative process, and decision making will only be valid if it shares this perspective.

4.2 Generalising the Indian Case

India is by no means a typical developing country, and its government has devoted many years to building an industrial and skills infrastructure, and has therefore been able to make choices that would not be open to other countries. This ability is reinforced by the size of the economy and population, and has allowed an Indian strategy which has resisted multinationals more

than many other nations could have done.

However, the lessons here are not unique to India. Firstly, there is similar evidence - that multinationals bring costs as well as benefits and that intervention and protection of local organisations are needed for a sustained build-up of skills - from IT industries of other countries including Brazil, China, Japan, South Korea, Taiwan, and the UK [1,2,3,7,11].

More importantly, while smaller nations may not be able to copy the Indian experience exactly, they can still aim for more modest goals. It seems clear that reliance on multinationals will not provide the strongest possible base for building technological capabilities. Governments in other countries can take a number of actions:

- Approach multinationals with caution, knowing that they bring costs as well as benefits;
- Negotiate with multinationals with the aim of exposing possible costs and minimising them through various concessions and controls;
- Monitor and evaluate the role of multinationals;
- Assist local companies which are negotiating with multinationals, by sharing experiences, by transferring negotiation skills, by providing a legislative framework for agreements with multinationals;
- Invest even limited amounts in local companies, local training, and local R&D;
- Encourage the growth of local IT companies through demand- or supply-side intervention. Actions include funding of training courses, tax concessions, purchase of locally-produced IT goods, provision of venture and similar finance, assistance with market research and marketing of products, and import protection where possible;
- Recognise the 'natural' protection offered to local customised software services, encourage the growth of this sector, and look for export opportunities;
- Recognise the need for a long-term view of technological and industrial growth, and the need to avoid the 'do not reinvent the wheel' short-term, quantitative view.

Such measures may not produce a vibrant local IT industry for every developing country but they can provide a base of local capabilities without which no long-term industrial development process will take place.

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INFORMATION TECHNOLOGY IN URUGUAY AND PARAGUAY: A STUDY IN CONTRASTS

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ABSTRACT

While there is little doubt that the developed world has ignored Uruguay and Paraguay, a recent research study identified several of the risks and opportunities the two countries have undertaken and continue to face as a new century nears. In this context, the authors analyze the possible effects of each country's historical, cultural, political, and socio-economic environments on the development and application of information technology. They also explore the future of informatics in each country -- the risks and opportunities of joining a proposed four-way common market with Argentina and Brazil, the success of which may depend on the countries' abilities to standardize their computing technologies and policies.

1. INTRODUCTION

Once thought of as the Switzerland of South America, Uruguay struggles now to remain a leader among developing countries. Neighbouring Paraguay, meanwhile, is trying to shed its reputation as the Albania of the continent as it recovers from a crippling 35-year dictatorship. They appear to have much in common: Both are small, share borders with powerful Brazil and Argentina, and have limited natural resources, relying on the same industry -- agriculture -- for their export earnings. It is remarkable, therefore, that the two countries have developed in such marked contrast. This is especially true in the field of information technology.

The purpose of this paper is to try to explain how seemingly similar countries have such dissimilar IT development. We first examine the choices for growth that are available to small countries, and then turn to the distinct approaches that Paraguay and Uruguay have followed in their treatment of IT. After offering possible general explanations for the glaring disparities, we close with a look to the future, specifically what can be expected from their current leadership and ties with the Mercado Comun del Sur, a new common market of which they are members.

This is a very tentative discussion based on preliminary research with limited data. Much of the information was collected during interviews in the two countries with local academics,

distributors of computer products, and government officials.

2. GROWTH IN SMALL COUNTRIES

Small countries, such as Uruguay and Paraguay, have limited options. In general, they cannot afford to develop major industries, and instead their economies tend to be more open to imports and dependent on large neighbouring countries [1].

Conversely, large countries, such as Brazil, have considerably more resources and are able to develop national industries. This distinction is borne out in Table 1, which compares Paraguay, Uruguay and Brazil in several areas. For example, Brazil's import-export total as a percentage of gross domestic product is 15 percent versus 39 percent in Uruguay, a reflection of Uruguay's greater economic openness.

While a strong import-export sector can result in higher levels of growth in industries in which a small country has a comparative advantage, it also may concentrate too much power in the hands of too few people -- the ones who control the export sector. Furthermore, over-reliance on a limited number of resources for export earnings may reduce the diversification of a country's resource base. [2]

These advantages and disadvantages appear to have influenced Uruguay and Paraguay differently and are obvious in several aspects of their economies. An important explanation for the differences appears to have been leadership, with its secondary effects on the development of local industries, education and infrastructure. The trickle down effect of these policies is especially evident in how the two countries developed and applied IT within their borders.

3. PARAGUAY: THE INFORMATION TECHNOLOGIES

The problems small countries face have beset Paraguay. With a government that fostered cronyism and opportunistic trade, Paraguay found a niche as an international smuggler of computers and luxury goods such as perfumes and whisky. Paraguay's fixed exchange rate also encouraged contraband trade with Argentina and Brazil at the expense of Paraguay's own official external trade. While the introduction of a free-floating exchange rate in 1989 may have reduced the incentive for contraband, illicit trade continues.

The market for many of the contraband computer products is Brazil, which by law since 1984 (and more informally since 1975) has prohibited the importation of minicomputers and microcomputers to protect its national computer industry. Consequently, many Brazilians turn to alternative supply channels rather than pay high prices for local products that are considered obsolete and less reliable.

Paraguay neither develops nor manufactures computer hardware. However, with only modest tariff levels -- an average of 16 percent, second only to Uruguay's 10 percent -- and a thriving contraband market, Paraguay imports and re-exports more computing and electronics goods per capita than any other country in Latin America [3]. Table 2 lists the tariffs imposed by

Paraguay, Uruguay and their larger neighbours.

Mainframe usage within Paraguay is low, and financial institutions and government are the primary users. There has been a modest increase in the number of low-level and midrange computers (e.g., IBM's AS/400s) among private businesses and government agencies and an even greater increase in the number of microcomputers of the PC-XT, PC-AT and PS/2 classes [4].

Paraguay also has no indigenous software industry, and software piracy is widespread. Illegal software can be obtained with contraband hardware and through dealers who include it with legally sold hardware as a buyer incentive; it also is simply copied (often on a large scale) and sold without supporting manuals or licensing agreements.

Although the state-owned telecommunications and telephone industry in Paraguay is considered poor by modern standards, it compares favourably with many other developing countries. There are approximately 250,000 phone lines (mostly of an electromechanical design) with plans to double the number of new lines in the next few years. Most phone coverage is available in and around the capital of Asuncion, with very little coverage in the interior (approximately one phone per 50 square kilometres in the Chaco region) [5]. Paraguay uses Uruguay's telecommunications network, URUPAC, and telecommunications utility, ANTEL, through a satellite interface in Argentina [6].

Faxes and cellular phones are becoming popular alternatives to Paraguay's poor phone service and unreliable postal system. While there are no official figures on the actual numbers of faxes and cellular phones in use, they are common at local businesses, especially in the Asuncion area.

Networking connections in Paraguay with the outside world are relatively underdeveloped and mainly used by large multinational firms and local financial institutions. The exception (though unofficial) is the use of microcomputers and telecommunications equipment for complex drug smuggling operations between Paraguay and Bolivia. It is claimed that computers and cellular phones are frequently used to specify transaction and drop off points among the hundreds of obscure airstrips in the interior.

4. URUGUAY: THE INFORMATION TECHNOLOGIES

Uruguay's approach has differed significantly, with the country attempting to define areas in which it has a competitive advantage. The capital, Montevideo, has become a banking centre in southern South America, receiving currency from Brazil and Argentina. Banking legislation in 1982, which authorized tax-free offshore banking, has made Uruguay a haven for jittery Argentine and Brazilian investors who want to safeguard funds from inflation in their countries.

Within this environment, many Uruguayan banking and financial institutions developed specialized software as a platform for applications programs that subsequently were exported to other countries. About $2 million of Uruguayan banking software has been sold to financial

institutions in Peru, Chile, Spain and Sweden [7].

Examples of Uruguayan software developments include the following:

GENEXUS. This software was developed jointly by a local software company (ARTECH Ltd.) and U.S.-based IBM. The technology and software were developed entirely in Uruguay with hardware and marketing support provided by IBM. GENEXUS is a Uruguayan CASE tool for applications design and development. The GENEXUS database generator has an interactive dialogue, adaptable database and various artificial intelligence features for use by systems analysts and systems designers.

URUCIB. A 4-year-old project of the United Nations and Uruguay's Office of Planning and Budget, Uruguay Cibernetico (URUCIB) is the only real-time database and executive support system of its kind in Latin America. It gathers information from dispersed government agencies and produces quantitative and qualitative summary reports, graphics and statistical time series projections for the president and his executive staff. URUCIB uses a private telex sub-network to transfer data from each agency on the URUCIB network. The specialized software for URUCIB was developed in Montevideo and is being considered for use by other state and government agencies [8].

Unlike software, hardware has received little attention in Uruguay. The business and government sectors' attitude toward hardware development and manufacturing is an interesting one: "Lo que es hardware es hardware." The "hardware is hardware" attitude reflects the country's position that Uruguay's competitive advantage lies neither in hardware development nor manufacturing but in software services and support. With a 10 percent tariff, computer technology is affordable (see Table 2 for comparisons) and readily available from the United States and the Far East. Several major international computer hardware companies have sales and support operations in Montevideo.

The largest user and purchaser of computer hardware is the government. More than 40 per cent of the salaries in Urugua are paid by government-owned industries and agencies. Between 20 and 25 of the country's 30 IBM 3090 mainframes are owned by state industries; however, hundreds of mid-range IBM AS/400s are used by small companies and industries. Microcomputers of the PC-XT AND PC-AT classes (together estimated at 12,000 in Uruguay) are used extensively by small business and the government, but no official figures were available.

Uruguay has one of the highest telephone coverage densities in Latin American with approximately 11.7 main lines for every 100 people. Main lines, also called direct exchange lines or exchange access lines, are the lines from the local switch to the terminal point on the subscribers' premises. As in Paraguay, penetration is greater in the capital city with 46.4 telephones per 100 homes in Montevideo versus 19.4 in rural areas. Although electromechanical and manual switching are still prevalent in the rural areas, Uruguay has recently sought to modernize its telephone and telecommunications systems by converting to digital exchanges. Bids to install digital exchanges with the capacity for 800,000 phone lines were recently submitted by companies from Spain (Telefonica de Espana), Germany (Siemens)

and Sweden (L.M. Ericsson).

Fax machines and cellular phones have become Uruguay's preferred mode for data and voice transmissions. Uruguayans find faxes easy to operate and more reliable than surface mail, which often is delivered sporadically. Recently, a EuroFax system was installed by Ericsson which allows Uruguayans to call Europe at affordable rates. Cellular phones are popular because of their low price and increasing availability. Businesses use cellular phones for long-distance calls, paying the state-owned telecommunications utility ANTEL only connect charges. Additionally, many businesses use AT&T's CALLUSA card for faxing or calling the United States because its long-distance rates are approximately one third ANTEL's rates. Approximately 80 percent of AT&T's network traffic in Uruguay is to the United States.[9] Uruguayan government officials hope the planned privatization of ANTEL will allow the utility to charge more competitive rates.

5. GOVERNMENT POLICY

Paraguay simply has no official IT policies. While businessmen say the government recognizes the importance of information technology to the country's economic well being, the pressing problems of foreign debt, inflation, and corruption have higher priorities.

The Paraguayan government has enacted intellectual property laws, but they are old, vague and do not include provisions for the registration and licensing of software. There has been some legal action taken in light of the blatant and large-scale copying of intellectual property, but little improvement is expected. Some people speculate that a local constituency who would benefit from software protection must first exist. A Paraguayan business executive predicts that "after nearly 35 years of smuggling contraband, things will not change in a few months." [10]

Such a constituency has appeared in Uruguay, but the country has yet to develop specific legislation regarding the registration and licensing of software (although intellectual property and copyright laws protect the author). However, the government and Uruguayan businesses have initiated a public information campaign to discourage illegal uses of intellectual property. Other evidence of change includes the recent formation of the government-supported Camara Uruguaya del Software (Software Chamber of Uruguay) and a presidential decree condemning software piracy.

Embracing U.S. President Bush's Enterprise for the Americas Initiative, Uruguay also is seeking to privatize and deregulate certain sectors of its economy, including ANTEL and URUPAC. The government also is involved in promoting Montevideo as a regional centre for scientific, technological and commercial activity. Two parallel projects under way are the Common Market of Knowledge and the Highway of Knowledge. The common market is an initiative that would make Montevideo a regional centre for scientific and technological research. The Highway of Knowledge development, stretching along the southern coast from the capital to Punta del Este, is to be a locus for research centres offering quality services, education and research.

6. WHY THE DIFFERENCES EXIST

Perhaps the best way to describe Uruguay's and Paraguay's relationship is as "distant neighbours. Although they are only about 200 miles apart, separated by a narrow strip of land that connects Argentina to Brazil, the two countries have little in common, including their ethnic makeup. An estimated 90 percent of Uruguayans are of Spanish or Italian heritage, while most Paraguayans are of mixed Spanish and Indian descent. The official language of both countries is Spanish, but the majority of Paraguayans also speak an Indian language, Guarani.

Uruguay's heritage has created strong ties to Europe that are reflected throughout society, including in its social welfare system. For example, the retirement system has supported more than 250,000 pensioners when fewer than 1 million Uruguayans were employed. The country now has more people who are over 60 than who are under 20 and a birthrate of 0.5 percent a year.

The population in Paraguay, in contrast, is predominantly under 20, and the country has an explosive birth rate of 3.2 percent annually. Moreover, its ties to Europe are tenuous perhaps because of its insularity. Paraguay is one of only two countries in South America that is landlocked (the other is Bolivia).

The other glaring difference between the two countries at a broad level has been in governance with its concomitant effect on establishing priorities. Stable democracies are the exception in Latin America. Even in the period following World War II, most Latin American countries have experienced several transitions between weak forms of democracy and military dictatorship.

In Paraguay, there are two pillars of power: the right-wing Colorado Party and the army, which historically has squelched any opposition. The possibility for change arose in 1989 when Paraguayans ousted Gen. Alfredo Stroessner, ending his 35-year-old police state. Often quoted as saying "corruption is the price of peace," Stroessner sanctioned contraband in order to retain control of a country where only a few presidents lasted for more than two years. Though the influx of imports kept inflation in Paraguay low by Latin American standards, the income that the illicit trade generated was neither passed on to the masses nor invested in local infrastructure.

During the 1970s and 1980s, Paraguay directed its attention toward grand projects such as Itaipu, the world's largest hydroelectric plant which it built jointly with Brazil. Rapid industrialization took place at the time, but when Itaipu was completed and capital inflows related to the plant tapered off, the economy plunged into a recession. [11]

Uruguay is one of only two Latin American countries in which democracy has prevailed (Costa Rica is the other). From the early 1900s until the mid-1960s, the country's economy and politics were relatively stable, earning Uruguay the nickname "The Switzerland of South America." Problems arose, however, as growth in agricultural exports -- the mainstay of the economy -- stagnated and as the country began restricting imports to spur local production.

Further threatening the economy were the expense of the retirement system and urban-based policies that directed limited resources away from rural areas.

In 1973, democracy tumbled when the army closed the Congress and established a military regime; it was not until 11 years later that a civilian was elected president. Barring this period of military rule, a two-party political system has operated in Uruguay for decades.

It was in 1966 that Uruguay began developing its local banking industry with the founding of the Banco Central de Uruguay. Diversification into financial software took place in the early 1980s, further reducing the country's traditional reliance on agricultural products for earnings. Working relationships that evolved between international customers and local software companies promoted further cultivation of the local IT industry. An example is the exportation by IBM of locally developed GENEXUS software. Drawing on its international marketing network, IBM has vigorously promoted the sale and implementation of GENEXUS software abroad. Since mid-1989, GENEXUS has been sold in Uruguay, Brazil and Chile through distributors, and IBM is marketing the software in Europe.

The effects of such polarized approaches -- a dictator's grandiose plans versus a democratic society's more practical diversification -- has had far-ranging repercussions: Paraguay has a division of labour where 47 percent of the people work the land while only 14 percent are in industry and a literacy rate of 81 percent. The roads are in disrepair and shantytowns co-exist with high-rise buildings.

In Uruguay, the agricultural/manufacturing division of labour is 17 percent/23 percent, but the roads, sewage systems, buildings and transportation are not much better than in Paraguay. However, literacy and education are considered very important [12], and Uruguay claims to possess one of the better educational systems in the region. [13] The country has a 95 percent literacy rate and regards itself as a well-read society. Businessmen believe education and literacy have contributed to the country's software industry and continuing economic prosperity [14].

Fortuitous chance factors that may have contributed to Uruguay's greater prosperity cannot be ignored. These include its relatively stable history and strategic location on the Atlantic Coast. Paraguay, in contrast, lost more than 75 percent of its population during the devastating War of the Triple Alliance with Argentina, Brazil and Uruguay (1865-70) and is landlocked. We have not conducted a factor analysis in order to weight these potential explanations of the two countries' dissimilar development, including in IT. However, it appears that the form of governance, ties to the Western world, literacy rate, population growth and industrial development have contributed to the differences.

7. MERCOSUR: THE FUTURE

How much these two distant neighbours will move together or further apart may depend on the success of the Mercado Comun del Sur. [16]

In March 1991, Uruguay and Paraguay signed a treaty with Argentina and Brazil to form the

Common Market of the South, known as MercoSur, with the explicit goal of stimulating internal trade. Under the terms of the agreement, existing import tariffs between the four countries are to disappear by Dec. 31, 1994, excluding products on each country's list of exceptions. With their small economies, Paraguay and Uruguay have the most excluded products, 439 and 960, respectively; tariffs on the excluded products are to be eliminated completely by Dec. 31, 1995. If the common market becomes a reality, Paraguay will have easier access to a market about 46 times the size of its population and Uruguay, 60 times.

The agreement also calls for a common external tariff among the member nations, wherein lies the major potential upset to IT. Uruguay, Paraguay and Argentina worry that their weighty neighbour, Brazil, will insist upon a high external tariff to prevent its $8 billion computer industry from turning into scrap metal overnight. Without a strict protectionist policy or creative alternatives, one could expect many of Brazil's 300 computer companies to fail. But with a high external tariff the member countries could become captive markets for Brazilian products. That's because high tariffs could reduce demand for imports, thus limiting the supply to goods produced within MercoSur, which for hardware means made in Brazil.

Uruguay's MercoSur negotiator already has said his country will oppose higher tariffs and that Brazilians must lower theirs [17]. But in Paraguay higher tariffs would ensure the survival of the thriving smuggling operations.

Unless it is forced to accept high tariffs, Uruguay can only benefit from MercoSur. The country faces the slight threat, however, that foreign companies already doing business within its borders will move to Buenos Aires as Argentina becomes more open. Uruguay's aim is to regain its old stature but this time a la Brussels. The government, headed by President Ernesto Lacalle, is trying to further diversify exports to lessen the country's economic dependence on a small number of commodities and to become a regional centre for banking and product distribution (free zones have been established). Montevideo also was chosen as the site of the Secretariat for MercoSur.5

Even with possible constraints, MercoSur can only be an improvement for Paraguay. In fact, the country could become a small market for Brazilian computer products in exchange for the benefits of a common market. Other positive developments may appear due to changes in leadership alone. Although the current president, Andres Rodriguez, was an ally of Stroessner's, he appears more tolerant politically and is encouraging economic development and foreign investment. Furthermore, some Paraguayans would like to "take back the country from the mafias" and see the smugglers put out of business [18]. MercoSur may be the catalyst for such changes, providing the means to bring Uruguay and Paraguay together and to narrow their technological gap with the developed world.

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Table 1 *Country Comparisons*

Measures	Brazil	Paraguay	Uruguay
Population (millions)	150.0	4.0	3.1
Area (million sq.km)	8.511	0.407	0.176
GDP (billions)	$323.6	$6.0	$6.7
Foreign debt (billions)	$112.0	$2.0	$6.3
Imports (billions)	$14.6	$0.5*	$1.2
Exports (billions)	$33.8	$0.5*	$1.4

* Because of widespread smuggling, these numbers do not accurately reflect Paraguay's imports and exports.

Sources: Mercado Comun Argentina-Brasil, June 19, 1991, Buenos Aires. Inter-American Development Bank, July-August 1991. The Americas Review, 1990. U.S. Department of State, Bureau of Pubic Affairs, Background Notes.

Table 2 *Existing Tariffs on Computer Products*

Product	Argentina	Brazil	Uruguay
Mainframes	10%	50-65%	10%
Minicomputers	13%	Market Reserve 10%	
PCs	24%	Market Reserve 10%	
Printers	N.A.	100%	10%
Software	24%	100%	Vague*

In Paraguay, the average tax on computers and software for domestic consumption is 16 per cent, according to a December 1989 report by the U.S. Embassy in Paraguay.

* Uruguay's laws only address hardware. It is doubtful if much as actually paid on software.

Sources: Political frame: Argentina; Brazil: Country Marketing Plan Fiscal Year 1992; Department of Planning and Budget, Montevideo, Uruguay.

IT FOR NATIONAL DEVELOPMENT: THE SRI LANKAN EXPERIENCE

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ABSTRACT

The move towards liberalisation of economies and of industrialisation, in the wake of the success of the newly industrialised economies of the Far East, has further necessitated the strategic use of IT in the developing world.

Sri Lanka is a small island with a population of 16 million having a high quality of life index. It has produced professionals of high calibre who have served in many other developed and developing countries. The paper provides an overview of the Sri Lankan experience in the use of IT for national development, from the eyes of a key actor in the process.

IT use in Sri Lanka like in many other developing countries, accelerated after the advent of the microcomputer. Over the last decade, it has had a steady growth in computerisation and has attempted to provide the necessities for IT related economic development. In trade and commerce, extensive use of IT is being promoted with several banks already providing ATMs. A trade network using EDI is in the planning stage. A much needed Data Communication network using packet switching is expected in a few months. With the political decision to devolve power to the provinces, IT has become a necessity for effective decentralised administration. The poverty alleviation programme of the government is also relying on IT for an effecting MIS.

CINTEC, the apex agency set up by the state has, in addition to providing literacy programmes and supporting Human Resource Development efforts, particularly at the university and professional levels, has looked into the use of IT in the two national languages by setting up standards for Information Interchange. A draft law for the admissibility of computer related evidence has also been finalised.

The story of computerisation in Sri Lanka is not all a success story. Many shortcomings exist, mainly due to the lack of coordination and cooperation, a malady in most developing countries. Another important issue is that of Brain Drain. These problems are analyzed and possible solutions presented.

1. INTRODUCTION

The recent advances in computers and communications, resulting in the lowering of the cost of hardware together with the availability of human resources has made it possible for developing countries to exploit Information Technology for national development. The

availability of powerful PCs, more advanced in power and capacity than the Mini Computers of the late seventies for less than a thousand dollars together with the possibilities that now exist for networks has resulted in computer use in many a government department or business enterprise. The user friendly nature of todays computer software has also contributed towards this. Application software for Data Base Management, Spread Sheets and Word Processing as well as facilities for Desk Top Publishing, CAD/CAM, GIS and Computer Aided Teaching/Learning has helped in attracting large numbers of users.

Developing countries have had the opportunity to leapfrog in the use of technology without going through the historical development process that took place in the developed world. They are now making extensive use of the micro computer by-passing the age of the centralised mainframe. The advent of networks, work stations and the lowering of costs both capital and recurrent has also helped in enhancing this trend. Governments are now able to use IT for the very important and necessary aspects of development-planning, implementation and monitoring.

This paper provides an overview of the Sri Lanka experiences in the use of IT for national development.

2. COUNTRY PROFILE

Sri Lanka is an island with a population of 16.8 m and a total area of 65,609.8 sq. km, located strategically in the trade routes between the East and the West. Sri Lanka has a human development profile [1] which stands out among other countries in South Asia. Traditionally dependent on agriculture (Tea, Rubber and Coconut), it is moving towards developing non-traditional exports such as garments, precious stones, manufactured goods and services.

The greatest comparative advantage of Sri Lanka is the rich and talented human resources with a literacy ratio of 87%. This high literacy ratio of Sri Lanka is the result of the nation's comprehensive education system.

3. GROWTH OF COMPUTER USE

Computer utilisation in Sri Lanka dates back to 1967. The slow initial growth of computer use received a boost in 1977 with the provision of Lump Sum Depreciation for computer purchase by the new government. Since then, computer imports to the country has had a steady growth.

In the early eighties, several important developments took place in Sri Lanka. The early microcomputers and mini computers appeared in the market making available computing facilities to several institutions, including my own University, which were not in a position to purchase mainframe systems.

4. NATIONAL COMPUTER POLICY

The government also showed an interest in evolving a national computing policy. An ILO

study was followed by the appointment by the Government of a committee, that submitted the National Computer Policy (COMPOL) report [2] in 1983.

Established in 1984 [3], in accordance with the policy recommendations made in this report, the Computer and Information Technology Council of Sri Lanka (CINTEC) commenced operations in 1985. CINTEC had been functioning directly under the Presidential Secretariat until it was attached to the Ministry of Science & Technology of the Ministry of Higher Education, Science & Technology in 1989. Later, the Ministry of Science & Technology was attached to the Ministry of Industries, Science & Technology.

The major role of the CINTEC is to assist the Government in formulating, coordinating and implementing computer policy and also in setting up a framework within which the Sri Lankan public and private sector institutions could co-operate and collaborate in their efforts to develop IT in Sri Lanka and to utilise scarce resources optimally, by eliminating the duplication of efforts and also averting the probable conflicts in policy and strategy.

Naturally, the major emphasis has been on promotion, encouragement and coordination rather than on control and regulation that can stifle the initiative in this rapidly progressing field. Accordingly, areas such as promotion of awareness, human resource development and the introduction of IT into several important sectors of the economy received greater attention.

5. IT POLICY GUIDELINES

Information is a major input to the development process. Information Technology has been recognised as strategic and vital to ensure the economic growth and the social well-being of the people. Its importance is even more pronounced as Sri Lanka undergoes economic restructuring through mammoth development strategies such as poverty alleviation program, devolution and decentralisation of public administration, industrial development and the modernisation of trade and commerce. As an export oriented industry IT could be recognised as a potential growth area which is not only an export earner but also as a sector that provides important support to the economy.

If Sri Lanka is to ensure competitiveness of her economy in the forthcoming information age, there should be a concrete plan in the usage and development of IT and in co-ordinating the roles of the public and the private sector organisations.

It is only through co-ordination and collaboration among these organisations that Sri Lanka could utilise her resources effectively for national development. There is also a need for a coordinated program to communicate the facets of the national IT plan to the various organisations involved in the development process. Therefore the major role of CINTEC is to promote, facilitate and co-ordinate the use of IT for the successful implementation of the national development programs.

The objectives identified in the CINTEC Act [3] encompass a wide range of activities. The following areas have been identified to be of vital importance that need highlighting.

- to advise the minister on the formulation and implementation of a national IT policy.
- to co-ordinate the use of IT in strategic areas such as;
  (i) development related activities such as poverty alleviation
  (ii) the Government sector
  (iii) human resource development
- to monitor the development of IT and its use
- to set and maintain standards in the use of IT
- to promote the effective use of IT and the development of the IT industry, through a catalytic role

In the pursuit of these objectives CINTEC should;

- be the apex agency that would undertake policy planning and implementation in the area of utilising Information Technology for national development
- co-ordinate all professional, technological and educational activities in the information technology field, so as to ensure the success of the national policy
- promote the IT applications in industry, trade and commerce, agriculture and Government activities
- encourage the collaboration between institutions and organisations engaged in the IT field, both local and global, in furthering computer education and IT development
- promote the IT industry including the export of IT based products and services
- create an awareness among the general public that information is a vital resource for bringing about the betterment of the quality of their life
- collect and disseminate information, publish reports, periodicals and papers relating to Information Technology
- obtain and disburse adequate resources including funding for IT related education, research and development and provide for the use of IT.

As of now, CINTEC cannot claim to have achieved 100% of the above objectives. However much work has been done on this direction as is illustrated in this paper. The ground work has been laid and consolidation has yet to be undertaken.

6. IT IN TRADE AND COMMERCE

The trade unions in the Banking Sector in Sri Lanka did not hinder the introduction of IT in the banks. This is probably due to the higher educational attainment of their membership (large numbers of non-staff grade employees are graduates) and their awareness of the need for modernisation. Banks began using computers as soon as they found the non-availability of electro-mechanical devices used for banking. The influence of the foreign banks was also important. In 1988, the Central Bank, after careful study and planning introduced an automated clearing house. ATMs began operation in 1986, and now 6 banks share a total of 50 ATMs in the city and suburbs. Inter-bank Electronic Funds Transfer (EFT) both local and international (using the SWIFT network) are planned for the near future.

Developing Countries depend much on exports - traditional and non-traditional. This in turn means that cargo handling facilities need to be efficient and competitive. With the switch

towards automation, in particular containerization and electronic documentation, there is a necessity to use information technology. Failure to do so would result in the payment of penalties and delay, as some ports (such as Singapore) would demand documentation in electronic media. Sri Lanka is fortunate in having its computerised container port at Colombo which has proved to be a great success. The government has also accepted in principle the need to establish a Trade Data Network. The use of international standards for trade documentation is also being promoted on the premise that the use of Electronic Data Interchange(EDI) in trade and commerce is not a luxury but a necessity in the context of international trade.

7. DATA COMMUNICATIONS

A major prerequisite for the use of EDI is a reliable data communication system. Transfer of data using the national telecommunications network is possible but unsatisfactory due to poor line quality, frequent break-downs and high costs. The obvious alternative is using data communication facilities. However, unlike in the developed world, where even the telecom system is reliable and cheap, developing countries do not have the advantage of a data communication network. In this situation, multi-nationals like IBM would pay large annual rentals to have their own dedicated links to their international networks. Airlines have their own network SITA and Banks, SWIFT for international data interchange. Others, like banks have resorted to micro-wave point to point links for local linkage while still others have used dial up lines due to the absence of an alternative.

At the inception of CINTEC, the necessity for data communication was identified. However, the Telecom Authorities were pre- occupied with the eternal problem of providing voice communication to the population at large. This being a social obligation and a politically sensitive issue, they had no time or interest in data communication. Their answer was that they would provide a data communication service when the demand justifies such a service. CINTEC, on the other hand insisted that the demand will grow only when the service is available. Almost five years ago, CINTEC supported the linking of Research & Educational Institutions through a private network. This did not materialize. However, an experimental network now exists between several Research & Educational Institutions with a gateway to international networks through the Netherlands [4].

The recent liberalization and industrialisation [5] policies of the government has given us the opportunity to obtain data communication services. Having found that there is a demand, a private sector organization lobbied for and obtained a license to offer data communication services in the country with a gateway to international networks. Datanet is offered by Lanka Communication Services which has 70% of its shares owned by Singapore Telecom and the balance by a government of Sri Lanka subsidiary. More recently, another private group Electrotech with 100% local ownership has also obtained the rights from the Sri Lanka Telecom Authority to provide data communication services.

Telecommunication in Sri Lanka is no longer a government monopoly. Deregulation brought about the disbanding of the Department of Telecommunications and the formation of a Telecommunications Authority (regulatory body) and Sri Lanka Telecoms, a state owned

business, looking after the supply and maintenance of the telecommunications service. Telecoms many diversify its ownership with a share issue sometime later.

In addition to the above, cellular phones and pagers are available in the city and suburbs. These developments are certainly bound to result on the establishment of EDI networks in the very near future while at the same time encouraging the efficient interchange of information.

The use of IT is closely tied to the development of infrastructure such as communications discussed above. Another important aspect is the necessity to change the currently applicable legal infrastructure.

8. THE LEGAL SYSTEM

The Law of Evidence in Sri Lanka is principally governed by the Evidence Ordinance enacted in 1895, which has since then, in substance, remained un-amended. The Ordinance is therefore inadequate to cope with issues and transactions which are either assisted by or totally dependent on information technology. In January 1988, the CINTEC Working Committee on Law and Computers undertook a study on the admissibility of information produced by computers and computer related devices. The study was to be a prelude to the preparation of a draft law on evidence relating to computers and information technology. The Committee met on several occasions and at the outset agreed that the present law does not provide for the admissibility of information provided by computer, electronic and mechanical recordings as substantive evidence. A seminar was held in April 1989 to ascertain the responses of a large gathering on this issue. Arising out of these discussions the Committee drafted a set of proposals. A second seminar was held in September 1990 to introduce the draft provision act. The objective was to explain the provisions to the participants and invite their observations. In general the participants agreed on the basic concepts proposed in the draft [6]. Amendments were suggested in relation to specific sections. These proposals for law reforms have been approved in principal by the Cabinet, and have subsequently been forwarded to the Legal Draftsman.

9. HUMAN RESOURCE DEVELOPMENT

Sri Lanka has consistently maintained a high standard of education. The high value placed on education by all sectors of the population has resulted in severe competition for higher education. Of around 100,000 who sit for the GCE (Advanced Level) Examination at the end of 13 years of schooling, 30,000 obtain the minimum requirement to enter university. However, only around 6000 are admitted owning to the shortage of university places. This situation is currently being remedied by the establishment of affiliated university colleges that are expected to offer job-oriented courses.

Asians in general and Sri Lankans in particular consider education as a very valuable asset. Many are the instances when education has resulted in breaking away from the barriers of poverty. This has been the case over the last few generations but today we note that this scenario has changed drastically. Todays youth, can no longer feel that they are assured of employment (as was the case forty years ago) by completing the GCE (O/L) Examination.

While expansion of the education system has resulted in much large numbers qualifying at national examinations at various levels, the socio-economic development of the country has not kept pace to provide adequate openings to all of them, thus creating an excess of educated youth. At the same time, there is a need for certain types of skills, not provided adequately by the system, thus creating a mismatch between educational output and the man-power needs of the country.

Modern technologies have often made certain employment avenues redundant while creating many others, directly or indirectly. Information technology, dealing with computers and communications, is no exception. It is extremely important to consider skills development and employment as forming part of an integrated national development plan. Manpower needs and availability of infrastructure, availability of appropriate technology and training facilities are all inter connected.

Information technology is considered as an important discipline in the technologically dominated world of today. Much emphasis is laid on the usefulness of acquiring skills in IT. This has led to the mushrooming of private institutes catering to a variety of training courses, eagerly accepted by a public that values education. Large number of applications for mid level employment opportunities, received from those who have completed short term training in IT related courses, illustrate that these courses do not guarantee employment. On the other hand, suitable candidates are not found in adequate numbers at higher levels such as computer professionals.

The absence of job titles and specifications has often confused the student. In order disciplines like engineering there is a clear distinction between the craftsman, the technician, the engineer and the researcher. In medicine, there is no doubt about the roles played by the hospital attendant, the nurse, the lab technologist, the radiologist, the physiotherapist, the general practitioner, the surgeon, the consultant etc. The respective academic paths to achieve these distinct positions are also known. This is not so in IT.

The expansion of the IT industry, particularly software exports will require qualified, competent professionals. The introduction of computing into Trade and Commerce would need large numbers of operators, who can be trained from among the existing work-force.

Those who want to use computers, would benefit from courses on computer applications, such as Data Bases and Spreadsheets. Secretaries would benefit from a course on Word-Processing. There are a considerable number of institutions providing such courses capitalising on the ever increasing demand.

A Course on computer awareness would be useful for those who wish to know about the computer and its many capabilities. The CINTEC mobile computer unit provides such a service to the general public while also exposing school children to the use of computers for teaching and learning. The Ministry of Education has launched a program of introducing computers to all schools having GCE (A/L) science classes as has been enunciated in the governing party's manifesto of 1989.

10. NATIONAL EXAMINATION IN COMPUTER STUDIES

CINTEC has launched a National Examination in Computer Studies (NECS) [7] to assist those who do not enter university to become computer professionals. Those successful at both stages of the examination, taking two years of study, would then be able to obtain work experience and eventually qualify for membership of the Computer Society of Sri Lanka. Similar possibilities already exist for Sri Lankans to become members of the British and Australian Computer Societies.

Rushing in to follow computer courses would not always lead to employment. A careful study of the options available to suit ones achievements and preferences for employment need to be made before embarking on a training program. There is no short-cut to becoming a computer professional, by-passing the necessary training and work experience as is the case in all other disciplines. This has been our message to the younger generation who have shown a remarkable interest in IT.

11. CENTRES OF EXCELLENCE

The development of human resources was identified by CINTEC to be one of its priority tasks. At its inception itself, CINTEC commenced negotiations with the Japanese government for the establishment of a Software Training Centre modeled on the Japan- singapore Institute of Software Technology of Singapore. This initiative culminated with the establishment of the Institute of Computer Technology at the University of Colombo [8] with Japanese Government assistance. The ICT provides a conversion course of one year duration to produce Analyst/Programmers out of graduates from a variety of subjects other than Computer Science. CINTEC was also instrumental in initiating two UNDP funded projects -- the CAD/CAM Centre at the Department of Mechanical Engineering of the University of Moratuwa and the M.Sc. in Computer Science program at the Department of Statistics and Computer Science of the University of Colombo (DSCS). The former is administered by UNIDO while the latter is administered by UNESCO with the Department of Computing Mathematics of the University of Wales College of Cardiff acting as the TWIN institution. The twining arrangement has resulted in staff development and the use of staff from the TWIN department for curriculum development, teaching (initially) and examinations thus providing a guarantee on the standard of the degree. At the moment 45 students are in the second year and 50 in the first year of this two year part time course. The University of Colombo with the ICT and the DSCS housed in a single four storied building constructed with state funds at a cost of 1.5 million US Dollars in 1989 provide a wide variety of services in addition to a first degree course in Computer Science and the above postgraduate courses, making use of its resources both material (NEC mainframe and three super mini computers with a work station lab and a large PC network planned for next year) and human (combined staff of 45 graduates).

The University of Moratuwa also has a Department of Computer Science and Engineering and has a total of five mini computers. The Arthur C. Clarke Centre for Modern technologies at Moratuwa, the National Institute of Business Management (NIBM) and the University of Peradeniya are other institutions identified by CINTEC to be developed as Centres of Excellence. The Open University of Sri Lanka also conducts computer appreciation courses

island wide and a degree course in Computer Engineering. NIBM has for the last decade or so continued to conduct a very popular Diploma Course in Computer Systems Design for school leavers. More recently, a Higher Diploma was introduced under a UNDP/ILO funded program which linked NIBM to the University of Dublin. Two other state universities and a private university also offer Computer Science degrees while the Informatics Institute of Computer Studies offers the Computer Science degree of the Manchester Polytechnic.

Thus, the production of Computer Science graduates has commenced and university departments are engaged in staff development and research. Library facilities exist but are inadequate to keep pace with the fast changing technology. University based consultancy work and University - Industry cooperation has helped increase the earnings of faculty and also their experience of real life problems.

12. SPECIAL INTEREST GROUPS

Universities alone cannot develop the IT profession in a country. The professional body of IT personnel has a very heavy responsibility. The Computer Society of Sri Lanka (CSSL) established in 1977 has come of age and has a membership of over 200 full members. They hold a well attended three day annual conference and exhibition and conduct in Sri Lanka, the British Computer Society and Australian Computer Society examinations. The CSSL as well as CINTEC are represented in Committees coordinating the university and school computer studies programs.

CINTEC took the initiative in the formation of two professional bodies recently. They are the Computer Vendors Association and the Association of Computer Trainers. These together with the CSSL has helped CINTEC to maintain professional, educational and other standards.

13. DECENTRALISED ADMINISTRATION

The Government of Sri Lanka with the introduction of the 13th amendment to the Constitution, brought in changes to devolve power to the provinces. The administrative structure has thus to change from a highly centralised system to a decentralised system. This task is certain to be facilitated by the use of IT.

The use of microcomputers at the level of Divisional Secretaries offices (Sri Lanka has 8 provinces, 24 districts and 370 divisions) has been recommended by a CINTEC report to the World Bank [9]. Data relating to a division would be keyed in at the division and used for planning at that level. Aggregated data would be sent up to the district and provincial administrations and also to central government agencies. This would also allow for the disaggregation when and where needed.

The very successful use of computers in the Integrated Rural Development Programs (IRDP) has resulted in the availability of a core group of planners and administrators who are able to use IT for planning and plan implementation [10].

The concept of IT use in decentralised administration is extended to other projects that cater

to the rural masses. The poverty alleviation program "Janasaviya" introduced on an initiative of H.E. the President of Sri Lanka two years ago is a massive endeavour to provide assistance to the poor for a fixed period of 2 years so as to enable them to get started on self-employment, human development etc [11]. This program would benefit much from the use of IT for project monitoring as well as for the building up of resource data bases.

14. IT IN NATIONAL LANGUAGES

Use of Computers in a decentralised environment necessarily raises the question of the language of operation. Use of English as the functional language for computer use would restrict its use to only a few senior administrators, leaving out the large number of lower level administrators, development officers and the population at large. Thus a policy decision has been made to develop and promote the use of national languages in IT.

The experience of Thailand, India and to some extent even that of Sri Lanka in the mid eighties prompted CINTEC to work on a national standard for Information Interchange as a first step. Accordingly, in January 1991, CINTEC released a draft Sri Lankan Sinhala Standard Code for Information Interchange (SLASSCII) similar to the ASCII standard we are familiar with for the Roman alphabet [12]. This is now with the Sri Lankan Standards Institute who are expected to adopt the same as a Sri Lankan standard and also submit it to the International Standards Organisation. Similar work is continuing in Tamil while taking into consideration the use of Tamil in other countries such as India, Malaysia and Singapore.

The importance of English in Computer Studies has resulted in creating an advantage for those who are proficient in English. With school education being in the national languages (Sinhala and Tamil) there arose a need to introduce computing in the national languages at least at school. Towards achieving this, a glossary of technical terms has been compiled by CINTEC for Sinhala with work on the Tamil glossary still continuing.

However, the importance and necessity of English has been accepted and stressed.

15. UNEMPLOYMENT

Computerisation has not created un-employment in Sri Lanka. On the contrary, enterprises such as Banks that are using IT have expanded their activities thus resulting in an increase in the work-force.

The highly literate work-force available in the country has enabled the employer to re-train their employees in the use of IT thus avoiding the replacement of the work-force. The acceptance of computerisation at large organisations such as Banks, Customs, Inland Revenue and the Port of Colombo is largely due to this reason.

With the development of an IT-Industry in the country, particularly in software, employment opportunities in this sector would increase.

A major concern at present is the brain-drain of IT professionals out of the country, attracted

by relatively large salaries. The establishment of R & D Centres with state of the art facilities and a critical mass of personnel together with the opportunity to handle a wide variety of challenging assignments would drastically reduce the drain. The developments at the University of Colombo aimed at creating a satisfactory environment for IT professionals are showing signs of success [13].

16. CONSTRAINTS

Some of the constraints in the use of IT in national development as observed by the author are given below.

- The major constraint is the lack of authority which causes difficulties in implementing decisions taken on the basis of national policy
- Lack of appreciation of the need for IT, among Senior Management particularly in Government. All correspondence regarding IT is most often passed on to DP personnel with no initiative being taken by management to recognise information as a vital resource and to utilise IT for the needs of the management
- Sharing of resources and information is virtually non- existent. Some co-ordination has been possible through a few individuals serving as members of advisory committees/technical evaluation committees
- Inadequacy of high level Research and Development Centres and the skilled manpower needed for such centres

17. STRATEGIES

In order to build on initiatives taken by developing countries in the use of IT for national development, the following strategies are recommended. These are applicable to most developing countries.

- Formulation of a National IT Plan. This would be the responsibility of a body having adequate representation of professionals, academics, key ministries, the IT industry and the private sector
- Ensure strict adherence to, and the implementation of the policy decisions by various ministries and institutions. This is a pre-requisite for the success of a national IT plan. In the context of the allocation of ministerial functions, such implementation would be best achieved by allowing the national IT policy body to operate under the Ministry in charge of Policy Planning and Implementation, ensuring the required coordination and collaboration among these agencies
- Promote the effective use of IT in Government. This would result in the elimination of duplication and waste, the timely collection of revenue, effective sharing and exchange of information among institutions and the establishment of an integrated Government Information System which may include an electronic mail facility. Such a step would also result in the provision of on-the-job training facilities
- Promote the sharing of information and resources, integration of information systems and facilitate the smooth flow of information
- Provide the necessary infrastructure such as access to international data networks and a

national trade data network to supplement the proposed data communication network

- Promote the use of IT in the national languages so as to encourage the appropriate use of IT in decentralised Government activities and to enhance the productivity of the middle scale industrial and business concerns
- Cater to the needs arising out of the modernisation of industry, trade and commerce by way of legislation, and the provision of standards and infrastructure
- Provide adequate safeguards for the protection of data, software and hardware design
- Take measures to ensure the security and integrity of data and the improvement of audit procedures
- Provide for computer literacy and relevant application skills, in particular, at the level of secondary education and at the entry level to all professions
- Develop a network of centres devoted to education, research and development in IT, both within and outside the university sector, so as to produce a pool of skilled IT professionals
- Encourage and assist the association of IT professionals in order to maintain professional standards and provide for career development. The body of IT professionals would eventually conduct examinations leading to its membership.

18. CONCLUSION

Information Technology has provided countries like Sri Lanka the opportunity to make use of its literate manpower for national development, thus reaping the benefits of its investments in education. IT does not affect the environment nor does it exhaust natural resources. An integrated approach to the use of IT ensuring that its benefits reach all sectors of the population would result in the enhancement of the quality of life of the nation as a whole.

It is upto the decision makers to make best use of the human resources if we are to achieve such a result.

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AN APPRAISAL OF THE DEVELOPMENT IMPACT OF THE MICROELECTRONIC PROGRAMME OF FORMER GDR

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ABSTRACT

The former German Democratic Republic possessed the most extensive and ambitious microelectronic programme of all East European countries in the then CMEA (Council for Mutual Economic Aid). At the same time, a lot of mistakes were committed due to the failure of real socialism in general and for high-tech industry, like microelectronics, which the DC's can avoid. On the other hand, this paper identifies a number of special factors, which operated in GDR and may not be found in DC's. After the German unification there are obviously special circumstances and environment for technical modernization and development. In this paper an attempt is made to document these experiences from the viewpoint of development related aspects and to highlight the lessons for national information policy in DC's.

1. INTRODUCTION

At present there is hardly another technical development, which leads to such profound change in the structure of economy, society and other spheres of life then information technology (IT). Microelectronics play a kind of overlapping role as transverse section technology. Therefore, it opens mankind to innumerable new options in the economic, social, ecologic or cultural fields.

One expects big economic effects from the further development of the microelectronics and at present one supposes that at the moment only 20 per cent of the effective potential has been realized. For example, flexible production systems can contribute to increasing capacity utilization of resources and to lower the average costs of production by 10 per cent including the expenses for labour input by 30 per cent and the total time for production by 40 per cent in comparison to the fordistic production schemes [1]. Such systems like computer aided design (CAD), computer aided manufacture (CAM), computer numerical control (CNC) and robotics are mainly used in the industrial countries. In a few cases they also exist in the newly industrializing countries (NIC's) like Argentina, Brazil, India, South Korea or Taiwan. These are countries occupying a sort of intermediate position in the technological gap between developing and developed countries. In this group, South Korea ahead of other countries in

terms of the intensiveness of development and the use of microelectronics.

To illustrate these dry facts, one could review the textile industry. It is a branch in which some of the DC's have a commanding position on the world market. Yet such sectors of production like the joining of components remain mainly a labour intensive activity. In comparison, a great number of CAD-systems are installed in the textile industry of the industrial countries. Only 10 of the 700 registered CAD-systems of the textile industry were concentrated in the DC's in 1985 and these were largely in the NIC's. A similar situation exists in other spheres (for instance concerning mechanical engineering, car industry and ship building) [2].

The main problems of most of the DC's are obvious. In the industrial countries a comprehensive industrial infrastructure has existed for a long time. It can absorb these new technologies, which are applied to raise the productivity as an integral essential part. This infrastructure does not exist in most of the DC's. Only very few of the DC's (mainly the already mentioned group of the NIC's) have at their disposal a certain amount of capability of their own for development, production and diffusion of hardware and software. Their efforts are spent in using imported IT. In general the main spheres of installation of IT lie in the economic, administrative and military sector. To a smaller extent it is applied in agriculture, health, education and production of energy. Generally the following factors contribute to successful implementation: hardware and software, infrastructure, cost factors, skilled workers, time factors and staff.

As a key technology for industrial competitiveness, IT has a fundamental influence on those branches which are profile-determinant. In the F.R.G. these are exportable products. For example electrotechnics, mechanical engineering and car industry. IT also plays an increasingly important role in services and public administration. Research and development have significant rate of innovation of IT. A framework should be developed that will raise the innovation activity and the preparedness of small and middle enterprises to innovate. The performance level of small and medium enterprises will finally determine the international competitiveness.

The principal task remains the development of software. All efforts in research and development are concentrated on it. The development level is decisive for the advantage in competition. While counting on a world-wide rate of increase in the production of information technology by an average of 13 per cent per annum between 1986 and 1995, one expects an increase of 20 per cent on software production during the same period. OECD estimated a value of total production of nearly 500 billion dollars having been reached in microelectronics and electronic equipments in 1985. This represents 4.7 per cent on the world gross national product (GNP). It is intended to increase this share to around 8 per cent by the year 2000 [3].

An important indicator of the competitiveness are the expenses for research and development (R&D) of the enterprises in this field. World-wide, around 65 billion dollars are spent annually for R&D nowadays. This corresponds to nearly a third of the global expenses for R&D. Of this, 55 per cent are apportioned to the U.S.A., 27 per cent to Japan and 18 per cent to Europe. The 130 or so countries which make up what is regarded as the developing world account according

to UNESCO, for only about 6 per cent of global expenditure on R&D. By contrast, the Federal Republic of Germany alone accounts for some 10 per cent. It can therefore be deduced that the enormous expenses of the leading industrial countries are higher than GNP of some of the DC's [4].

Considering the development and the use of microelectronics DC's can be grouped in four categories:

- the industrially advanced DC's in East Asia South Korea. Taiwan, Hongkong, Singapore have gained noticeable positions on the world market as exporters and manufacturers. South Korea and Taiwan began with component and consumer electronic products to advance in some high-tech spheres
- industrially advanced DC's with an preponderantly home-trade orientated electronic industry (Brazil, Mexico, Argentina and India), but distinct policy bias against foreign enterprises (Brazil, India)
- countries which perceive the meaning of microelectronics within the bounds of their industrialization and further their improvement both by national programmes and by export platforms of transnational corporations (Malaysia, Thailand, Philippines, Venezuela and some African and Caribbean states)
- the prevailing majority of DC's, which at present have not built up an electronic industry, but where IT is already included in administration, services, education and public health administration [5].

The East European countries can also be arranged in this rough classification after the collapse of real socialism. Although the change to the market economy and the beginning of democratization improves the condition of information technological infrastructure too, these countries have big economic and social problems just now. Therefore, only a slow enforcement of a technological strategy of modernization will be possible.

Perhaps an exception is the shock treatment in the former G.D.R. after implication with the F.G.R. accelerated the pace of radical technological modernization in comparison to the remaining East European countries. It worthwhile to analyze experiences and particularities in creating a microelectronic basis in the East German region (until the union in October 1990 in the G.D.R. and after that in the new federal countries) and compare it with the characteristic features and aims of national information politics in the DC's. It is interesting that seemingly similar countries can have dissimilar IT developments [6].

2. THE RUNNING AROUND OF THE MICROELECTRONIC PROGRAMME IN THE FORMER G.D.R.

It is an interesting phenomenon that the former G.D.R. as a leading but small country in the then CMEA (Council for Mutual Economic Aid), possessed most extensive and ambitious microelectronic programme of all East European countries. The launching of this programme took place in 1977, a very late moment compared with other developed countries. It was supposed to guarantee the entry into an informatic age on its own base, more or less covering all spheres of the IT. This delay is also symptomatic for other East European countries and DC's as latecomers.

At that time, Commodore and Nixdorf had made proposals to deliver PC's, but these were rejected partly because of reasons of prestige and partly because of lack of foreign currency. This corresponded to a certain extent politics of import substitution. The East Asian countries had earlier recognized these limits and even such countries as India in 1984 (Ghandi government), or Brazil in 1985 ("Nova Republica"), moved to a liberal policy of imports.

A further obstacle was the fact that microelectronics could only be developed by state protection and subvention. In the G.D.R., there were 152 centrally led combines until 1990, but no private enterprises in IT industry. A combine is a type of production unit in the various sectors of the former GDR economy consisting of several juridically independent enterprises and managed by a director-general responsible for concentrated use of all the resources at the disposal of the respective enterprise. This almost meant that the microelectronic industry in the G.D.R. from the beginning of the programme was inefficient producing expensive hardware. Nearly 1.7 billion marks were spent every year for subventions on the microelectronic industry, which means that every G.D.R. produced chip has been subsidised with about 1600 marks [7].

Although microelectronics was the most beloved favourite of the former party and state leadership, they didn't recognize the full consequences of the transition to an information society. The real purpose of the programme was sacrificed to a great extent for propaganda purposes (for example, by a public ceremony of delivering of the 1 megabyte storing chip). When one had demanded that the number of industrial robots be raised to a level comparable to Western industrial countries, the ignorance of economic reality by the governing party and its inclination towards propaganda value reached a culmination. From than onwards, every penny-in-the-slot machine for tickets was counted as robot, a method, wrong public information. In the last party-congress in 1986, the party planned an application of 85,000 industrial robots until 1990, which was a bare illusion compared with the saving-affected in the OECD-countries through robots of about 2,5 working places per CAD/CAM station.

The strategy of "island solutions" hardly led to an extended push of productivity. Microelectronics in the former G.D.R. was entirely concentrated on the three former combines with round 160,000 workers of which 41,000 were directly employed in the IT-sector. But there was no diffusion of the national production and research base and no international specialization and cooperation beyond this potential.

The former state enterprise Robotron Dresden, with about 65,000 workers and employees, supplied about 60,000 PC's and about 300 of the 32 byte processors per year. Robotron had realized net earnings of 2,4 billion marks, but had to deliver the profit nearly completely to the state. At the same, it had to take credit for investments to the tune of 1 billion marks. In addition, the imported machines and equipments from western industrial countries were given on credit in a proportion of 1:1.4. With the currency union in July 1990 and the conversion of debts of plants in a proportion of 2:1, the liabilities to pay have doubled at once. With the immediate abolition of subventions and world market competition the enterprise is facing a difficult situation [8].

In the former state enterprise, Mikroelektronikwerk Erfurt, the development were similar.

Already when GDR still existed, the production of the 232 micro-bytes processor remained more than 3 years behind the rest of the world level.

Only the enterprise, Carl Zeiss Jena, could recover some of the former production and research capacities, because of the fusion with an enterprise with the same name in the old FRG. Before the implication large subventions were put there and, in 1989, the plant could develop a 1 mega-byte chip with an enormous expense of 1/2 billion marks. Apart from the high scientific and technical accomplishments, the enormous expenditure was an economic blow. While the G.D.R. sold altogether 6000 pieces in one year, Toshiba sold more than 100,000 pieces during the same time. Pursuing the aim of producing the 4 mega-bytes chip was in fact economically devastating [9].

In some respect this national exclusive action also was a vote of distrust against the soviet "perestroika". The former Soviet Union already had their own mega-byte chip since 1988. Certainly these exclusive actions were also promoted by the embargo measures for exports of high-tech products to the former CMEA-countries (COCOM-list) which the USA pursued vigorously.

As has been discussed the former GDR had an insufficient international competitiveness, although one of the most developed regions in the former CMEA. In terms of the technological level in the IT sector, the G.D.R. had in the last year of her existence the standards of Japan 30 years back and of Western Europe 10-20 years back. The total sales in microelectronics only contributed 1 per cent to the GNP, while in Japan the corresponding contribution is nearly 30 per cent. Thus, in Japan, the production of chips amounted to a 100 per capita in 1989, in the U.S.A. 50 and in the former G.D.R. 9 (with only 17 million inhabitants). Even some of the Asian NIC's have managed to achieve a higher standard in the meantime.

The precondition for a complete modernization of the IT industry in the East Germany means first of all, to be fully acquainted with the technology by more effective research and development, more capital, better management including business trade and training of appropriate specialists.

3. THE MODERNIZATION OF TECHNOLOGICAL INFRASTRUCTURE IN THE NEW FEDERAL COUNTRIES OF GERMANY

At present it is very difficult to describe the economic situation in the Eastern part of Germany. It is more difficult still to assess a particular sector of the economy. The main problem lies in the fast management of transition of the former centrally planned economy of soviet type to a market economy. Historically seen, this is unique. Although the conditions were more favourable in many respects in comparison to the other East European countries, there was first of all a considerably under estimation of effort and resources required for the modernization of the former GDR.

The outlook in terms of time it will take to adjust to the West German level of technology and productivity vary from 3 to 90 years. Many experts recognize that the former G.D.R. will be a relatively underdeveloped region and not a new economic miracle like the Italien

Mezziogorno. In the last year of its existence, the G.D.R. reached a level of industrial productivity corresponding to 28.5 per cent of the Federal Republic at that time [10].

First of all, the following conditions were underestimated:

- the insufficient infrastructure of telecommunications, especially in the transmission of information and traffic,
- considerable lack of motivation as a result of vague property rights and the high burden (environment, debts),
- the imperfect procedures in the tax, social, regional and structural policy, leading to a lack of initiative by small enterprises.

The consequences are delayed investments in infrastructure, dragging private investment decisions and a further fluctuation in manpower levels. This evidently makes the region into an area requiring subventions and accelerates the breakdown of the existing structures of production and employment [11].

The rate of economic growth of over 8 per cent in the FRG in the 1950's, in Japan in the 1960 and 1970's, and in the South East Asian NIC's in the 1980's were produced by devalued currencies and export-orientated growth. On the other hand, the pattern of export-orientated growth failed in many DC's, because of the non-existence of the corresponding framework. In the new federal countries of Germany as well the sudden introduction of the currency union made the exports more dear and increased the value of D-mark. It contributed to the breakdown of the Eastern European markets in the former CMEA-area too.

The modernization in the new federal countries of Germany is not taking place through international competition but by developing the combined markets of the combined countries like in the old FRG, Japan or South East Asia.

In the new federal countries of Germany, there exists an uncoupling of the wages from productivity. Even the programme "Rising East" made available more than 12 billions DM in 1991 for the support of enterprises. In the former GDR, about 11 000 marks per capita were injected. Every DC would be fortunate if it could get only a fraction of this capital transfer. (The German development aid amounted to about 8 billion DM).

At the same time, the industrial production in the former G.D.R. declined rapidly with the introduction of the common D-mark (in the second halfyear of 1990 by 27 per cent and in the first halfyear of 1991 by 25 per cent). So the economy of the Eastern part depends on the West German budget and on the tax-payers.

The social dissatisfaction of citizens in the new federal countries is bigger now than ever. Official figures show that there are about 1 million unemployed and about 2 million part-time workers, amounting to more than 30 per cent unemployment. This is a very sad record in German post-war history. By the end of the year, this figure could be 40 per cent for East Germany while in the West, 5.6 per cent is the most favourable index for a long time [12].

By the instalment of technology parks, state and communities can support the development

of innovation centres. In this way, they create longterm employment and prevent brain drain. The Federal Research Ministry has made available about 11 billion DM for the construction of 15 technology parks. They should facilitate enterprises, working in specialized technologies and services to step into independent activity. In this way, a small portion of the 140,000 professionals employed in R&D formerly could continue their work. Considering the current outlook in the East German microelectronics industry, not more then 1500 of the 41,000 jobs that will be sustained. In the old FRG, there are now about 85 such high-tech centres, working for about 1800 enterprises.

For example the centre in Magdeburg, collaborating closely with the Technical University Otto von Guericke, made a successful beginning. Pro DV Dresden, being run by former members of the staff of the old state-owned electronic factory, and the Technical University of Dresden offer highly qualified computer programmers whose services are also being purchased.

But privatization of the whole economy and the decentralization of the 316 state-owned enterprises (of them, 152 were centrally led) remains the main problem of further modernization. The fact is, that neither the FRG government nor the so called Treuhandanstalt (trusteeship), being ordered to carry out the privatization, have made determined efforts.

In this connection, two main problems were not solved:

1. In the short run how a majority of the over 8000 industrial plants be made competitive?
2. In what forms and with what steps, the change of all existing state-owned property should be carried out?

The "Treuhand" favoured complete privatization. This finally led to a real liquidation of productive potential. This prevented a sensible and efficient integration of the East German industrial potential into the whole German industry [14].

The principle, to bring a medium of efficiency of the enterprises before privatization, was not followed. The spin-off offers many advantages compared to management buy-out, especially for creative industrial sectors. It is valid for flexible automatization, processing technology and software engineering and so on. A further possibility would be the sanitation of enterprises by taking over the risk of state. Therefore, a decisive role of the state during the transition period should be demanded. Even in Japan, Western Europe and many DC's there are longtime experiences in handling stateowned enterprises in a market economy. With the sale of 2100 enterprises they only sold the "raisins". In these enterprises 350,000 employees work, but this number only corresponds 10 per cent of all industrial employees. The "Treuhand" therefore should pursue a mixed economic strategy [15].

4. THE SPECIAL CASE OF EAST GERMANY - LESSONS FOR DC's

The political aim after the first free elections from March 18th 1990 was the union with the F.R.G. and the taking over of her economic and social order as a tested and successful system. This didn't allow bringing in alternative models at the same time. An essential speciality was the introduction of the convertibility of the D-mark as one of the most steady currencies in the

world before the unification.

Further specialities were the relative stability of prices in the old F.R.G., of less than 3 per cent in 1989/90 and 3.5 per cent in 1991, compared with a rise of prices in the East of 24 per cent in 1990, and 15 per cent in 1991. The balance of payments was positive until 1990 and became deficit for the first time in 1991. The economic growth amounted to 3 and 4 per cent during the last years. For 1992, there is expected a slow decrease of less than 2 per cent.

In March 1990, an EC membership was practically achieved. The massive deployment of West German human capital (here they would be treated as an assistance for development) in administrative management is also one of the special circumstances. There are a number of special factors of market transformation and technological modernization, which are not transferable to DC's. On the other hand, many of the mistakes are to be noticed, shown by the failure of real socialism in general and for high-tech, like microelectronics, which the DC's should not copy.

One of the greatest mistakes of the failed information policy consisted of ignoring the advantages and potentials of international specialization and cooperation. A further mistake consisted in the ambition of developing an indigenous national informatic industry on a broad scale. Instead of concentrating on the software and application sector, one concentrated on those sectors where the production costs and R&D needed highest efforts. Even various DC's successfully concentrate on the software and application sector. But there were insufficient linkages between primary and secondary sectors. Therefore, a real modernization of production structures was not achieved.

The experiences in particular of DC's prove that there is a need for a decentralized economic structure and an efficient implementation of some important institutions (liberal government, private and public research institutions and enterprises). Some parts of the former electronic industry, mainly the application orientated, less expensive sections, can be converted into efficient production units. This manner of selective adoption and diffusion was followed by South East Asian states before they could change to export-orientated production.

To sum-up, it can be stated that technological modernization in the new federal countries of Germany is characterized by a number of special factors, which do exist in DC's. At the same time the failed high-tech policy in the IT sector consists of experiences which can be of use for the planning of a national information policy. The building up of a national information policy can neither succeed in national isolation nor under abandonment of self-reliance.

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A STRATEGY FOR THE SUCCESSFUL DEVELOPMENT OF AN INFORMATION TECHNOLOGY INDUSTRY IN CHILE

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ABSTRACT

Chile, a developing country with one of the healthiest and most stable economies in Latin America, is rising as a promising Information Technology (IT) exporter, not only to the rest of its region but to the international community. In this paper we describe the current state of the Chilean IT industry in terms of productivity and maturity, analyzing the conditions that are enabling this industry to develop. We also propose policies to ensure the success of this effort, including the roles of government, industry and universities. Finally, we describe the social expectations and implications that this process is effecting.

1. INTRODUCTION & BACKGROUND

Chile, with 13 million inhabitants, is a long and narrow country located in the South of Latin America. In the tongue of the local aborigines, the name "Chile" means "the end of the world." Even though the country shares most of the cultural assets of other Latin American countries and Spain, there are also important differences.

First of all, Chile has a well-established tradition in education, supported by good international school teaching standards and some of the best universities in the region. One proof of this is that the country enjoys one of the highest literacy rates in Latin America, and the Chilean universities have become a pole of attraction to students who want to do graduate studies in the region.

As is still the case in many countries in Latin America, Chile used to be a "one product producer," i.e., copper. Its entire economy was based on the international price of this mineral. This fact implied enormous problems to the stability of the economy.

Chile decided to implant an "open market economy" model far before anyone in the region, and currently enjoys one of the healthiest and most stable economies in Latin America. Since 1975, the country has had an economy open to international trade, currently having many important industries such as mining (not only copper but also gold, silver, iron, etc.), fishery, agriculture (fruit, vegetables, wine, flowers, paper, wood, etc.), weapons, and processed-food, among others. As a matter of fact, copper currently represents monetarily less than half of all exports.

In the last few years, a promising Information Technology (IT) industry has appeared in Chile, currently producing goods and services not only for the internal market but also for the rest of the Latin American region and for the international community. Some national IT companies have grown to become multinational companies.

Due to this initial experience, it seems that the country may have the necessary conditions to become an important IT producer and IT could be yet another product successfully exported to the rest of the world. Because of this, the actors involved in IT are pushing to make it happen.Universities are interested since they are the ones who prepare the people who will later work in this industry. Also, having a robust IT industry would give their technology faculties access to interesting challenges and generous funding.Government is also interested in developing the country's capacities in order to increase the GNP, since it is non-polluting, requires a smaller initial investment than other industries, and provides relatively high salary standards to people involved in this activity. Consequently, there is some interest to support initiatives in this area. Industry is obviously interested in developing an area which has proved to be a good business.

2. IT HISTORY

Chile has had a relatively long history in terms of developing and introducing IT. Specifically, there are certain events that need to be mentioned, since they have influenced the creation of this industry.

In the 1950's and beginning of the 60's, the country's industry-based information technology was almost non-existent. Thus, the process of technology transfer was mainly done through some of the universities. Electricity or Electronics Departments were the only ones who knew about the state of the art of analog and digital systems.

The origins of commercial activity in software development are in the late 60's, when some universities and industries bought third generation computers. Many industries rented computing time slots on those machines in order to manage administrative processes such as accounting and personnel. The most frequent mode of operation was for each company to hire programmers, who used punched cards to process their jobs in the computer during the time assigned to them.

The first consulting companies dedicated to software development appeared during this time, producing "tailor-made" products. The idea of standardized products took a while to develop. In those days, important efforts to teach the foundations of computing to self-made programmers were made by a couple of universities and some consulting companies. This was

the beginning of academic Computer Science Departments.

In 1975, the country decided to open its markets to the world, giving special benefits to the importation of computers. This, together with the appearance of multi-user minicomputers, provided new possibilities to industry for using computers. Some companies dedicated to renting or leasing computers appeared in those days, offering computing services as well. During that time, the first companies that specialized in building standard products appeared. The first companies to represent international software products also appeared, creating the space for an internal software market by adding value to the hardware.

By the end of the 70's, many companies had automated their internal administrative processes such as payroll, accounting, inventory, and sales. Also, people incrementally were being exposed to the benefits of IT. Utilities generated automated bills, so errors were less frequent than before. Furthermore, it was easier to get answers to complaints. Banks made deposits available sooner and quickly extended the range of their services; one of the first was that a check could be cashed in any branch of the same bank. In fact, the first data processing network was implemented by a bank at the end of the 60's.

Other public services were being computerized during this decade. A good example was the National Registrar, which provides identity cards, birth certificates, passports and other official documents. Its file of 14 million records was transferred to a computer database, and the corresponding information system meant a significant reduction in the time spent asking for a document, and the delay in receiving it. Especially important was the improvement for distant communities from the capital city: previously, many documents were only issued at headquarters and thus, the delay due to the manual processing for any document request had to be added to mail delays.

In the 80's, the Chilean IT industry grew steadily. In this decade, microcomputers were introduced into the market, providing the possibility for a large number of people to have a PC at work. Since the demand on IT systems grew, and since there were already qualified people in information technologies in Chile, this decade is characterized by the appearance of many specialized IT companies. Some of these companies have developed their own products, while others have represented international products in the Chilean market. Due to the open market economy, locally developed IT products had to evolve rapidly to meet international quality standards.

At the end of the decade, there were a relatively large number of IT companies in Chile offering quality products produced locally. Large contracts for "tailor-made" software have also appeared during this time, as a consequence of the technological transformation of the national industry. Also during this decade, the software industry started to export locally produced IT systems not only to the rest of the region but to the rest of the world.

3. PRESENT

In this section, we describe the current status of the IT community in Chile, formed by people at universities, government and industry. As will be said later, the development of IT is being

realized through the interaction of all actors involved.

3.1 University research centres

The main research centres of technological development and technology transfer are located in the Engineering Faculties of a few universities, although most universities in Chile have Engineering Faculties, and some of them are slowly becoming the centres of technology transfer for their local region.

It is necessary to say that to date, neither the IT industry nor the government has given university IT centres any special treatment, with the exception of a few isolated cases. There is a law that gives tax credits to industries providing grants to universities. Even though, industries have made donations only if with that, they could sell their hardware or software. However, this law is not only applicable to IT departments but to the entire university.

3.1.1 Development Programs

A few Engineering Faculties of local Universities have been investing heavily in the future during the last ten years by sending their academic staff to do graduate studies abroad. Other universities are slowly moving towards sending people to do graduate work. The two main universities in Santiago have implemented successful graduate programs that provide Master's level studies to academic staff from other Chilean and Latin American universities.

3.1.2 Undergraduate Programs

There seems to be a special glamour for Chilean students who get involved with computer systems, which have increased the demand for undergraduate studies in computer science, so almost all universities in Chile are currently offering Engineering degrees in computer science. Some private universities offer this degree as their principal one.

3.1.3 Current Research

In Chile, Computer Science Departments do most of the research in IT. Even though these Departments are relatively young, a fair amount of research is being produced. This is shown by an average of over 50 scientific papers per year in Computer Science and related fields published in refereed international journals by the academic staff in Chile during the last few years [1]. Also during this time, Chilean computer scientists have been increasingly attending Latin American computer science conferences, and assuming important roles in Latin American IT organizations.

3.1.4 Technology Transfer

University centres providing IT transfer are located in Engineering Faculties of traditional universities. IT transfer is realized through training, consulting and development. Training via courses is probably the most common and easiest way of carrying out technology transfer. In one way or another, this kind of technology transfer is done by many universities in Chile.

The options go from simple spreadsheet courses to degree-granting courses in computer science for people with industry experience.

It is common these days that industries request large technological developments from universities. Since Chilean industries are required to have the latest IT developments to be competitive on a worldwide basis, a lot of funding is being poured into universities to develop state of the art solutions to their IT problems. It is not uncommon to see funding for large and complex industrial planning systems, expert systems, neural network applications to specific problems, learning systems based on fuzzy logic, and so forth. However, the IT industry in Chile is not yet prepared to develop those areas.

3.2 Government

Government has not yet shown any special treatment for IT exporters. Thus, there are no policies or incentives specifically applied to this industry to motivate investment in this area. However, there are policies to encourage export industries, and there are being applied to software exporters.

A few examples of IT systems developed by government agencies follow. The National Registrar currently has 18 million records in its database, and is fully automated, having offices throughout Chile. Since this was the first large-scale experience in implementing IT systems by the government, the software does not provide connectivity to other applications, such as police or tax revenue systems.

Also, and since the hardware is already aged, the National Registrar looked to the IT industry to redo its automated systems. They will modernize their hardware and redo the software. This is a US$ 8 million project, which will be done by a local software house, based on standard software products.

Several banks went broke in 1982. As a consequence, the Comptroller of Currency has tightened its control over lending practices by the financial institutions. One of these measures has been the construction of a central debtors information system. Each bank periodically submits computer tapes with the updated information on its outstanding loans. The Comptroller of Currency consolidates this information and redistributes tapes with the loans awarded by all financial institutions. With this information, each bank is well-informed about a customer before awarding a new loan.

For the last four years, the Chilean Tax Revenue has had a large IT system to check annual tax declarations from companies and individuals. The system does cross checking between tax declarations of companies and individuals, and between declared income and large expenses and investments, being able to detect a large number of frauds. Also, this system is supported by a geographical satellite to analyze the type and areas of plantations in order to decrease tax frauds from farmers.

During the last ten years, the country has had to reduce the size of the government to one third of its original one. This could not have been done without the introduction of IT systems.

Currently, almost all Ministries have some kind of IT systems available for their use, leading to faster decision making at reduced cost. Most of these systems will be connected through an "inter-ministry network," which will enable the Ministries to obtain information faster and cheaper.

3.2.1 Research Fund

The government administers a fund, called the "Science and Technology Research Fund" (FONDECYT), that enables academic staff to apply for funds for basic and applied research. It funds projects of about US$ 30,000 per year, enabling academic staff to hire assistants, attend conferences worldwide, get basic hardware and software, and so forth. This fund started ten years ago, and has improved scientific and technological skills in universities, both in quantity and quality. The fund has grown significantly in the last two years.

3.3 IT Industry

In this section we will analyze the state of the Chilean IT industry, from the point of view of IT producers and IT users.

3.3.1 Producers

In Chile, IT industry is mainly dedicated to software development. Almost no hardware is being produced, since due to the reduced volumes, companies would not be able to benefit from scaling economies.

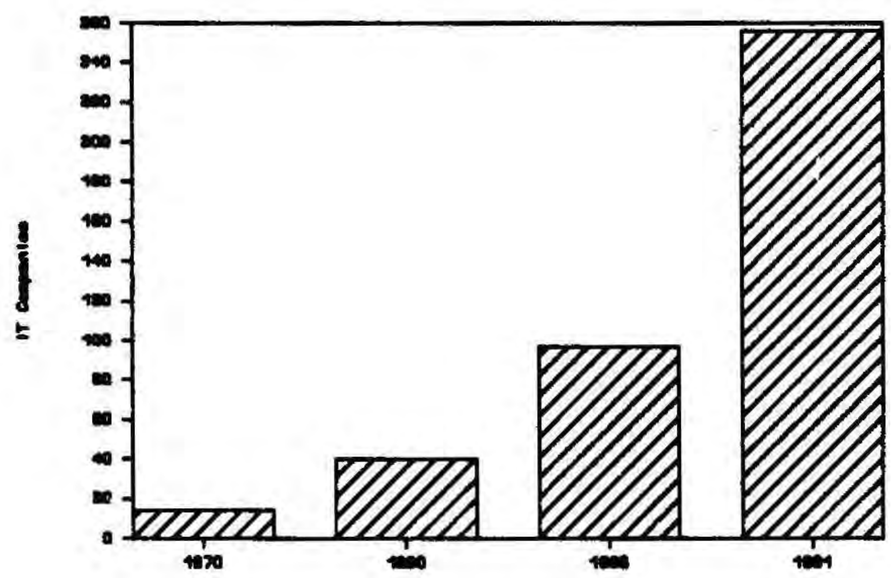
It is important to show some numbers which will illustrate the growth of this industry. In 1970, there were 14 companies dedicated to offer computing services and consulting. In 1980, there were 40 companies offering computing services and consulting. This number also includes the first software houses in Chile. In 1988, there were 97 software companies, some of them representing international products. Finally, in 1991 there are 256 software companies which offer products in 88 entries [2]. This is an exponential growth on IT services during the last 20 years, shown in Figure 1.

Many local software houses have already exported software, mainly to Latin America, but also to the US market, Europe, the Middle East and South East Asia. Since we share a language, culture and traditions with most Latin American countries, it has not been difficult to Chilean software houses to sell their products to them. For example, large software systems built for local banks do not require to be modified excessively in order to be used in other Latin American countries. Also, there are cases where US hardware producer installed a software house in Chile to produce software products for Latin American countries.

Chile exported software for US$ 1.4 million in 1989, and US$ 2.8 million in 1990 [2]. Initial estimates for 1991 are US$ 10 million. In other words, software exports have been doubling for the last three years. Some associations involved in software development would like part of this growth rate to be sustained until the end of this decade, requesting for this the collaboration of sectors involved in software development. If this could happen, it would mean

to have software exports of US$ 1 billion by the year 2,000. Will the local IT industry be able to sustain such a growth rate? Are the actors involved in this process taking care of all the necessary provisions to make this happen? What are those provisions? What are the risks involved in this? We will analyze these questions in the rest of this paper.

Figure 1 *Growth on IT services*



The government has just created an Inter-sector Committee, composed by people from industry, university and government, presided by the Minister of Economics, in order to define, implement and control policies that will help the IT industry to rise up. This is the first step from the government towards studying ways of boosting this industry.

IT systems rely nowadays on fast and reliable communication links. Fortunately for local IT producers, the Chilean communications industry is one of the most developed in Latin America. This industry has invested heavily during the recent past in modernizing communications in the country.

3.3.2 Users

It seems important to describe the culture of the typical IT user in the Chilean market, in order to understand the motivation that makes him to buy and use IT in his job. Five years ago, software piracy was the name of the game. Today, this fact has changed dramatically, perhaps as a consequence of the appearance of software dealers and local software houses, which have taught people to buy this good, and have influenced the law system to protect the rights of the software producers. Currently, software is protected under the copyright law, which give authors the right to prosecute infractors.

Many important companies, banks and industries have been caught in illegal software usage, having had to pay large fines. Banks and government institutions, attract their clients based on a trustful image of the institution, relying heavily on the customers trust. Affairs like the above, affect the prestige of the institution, reducing the trust and therefore, their customers. In this kind of institutions, employees are strictly forbidden to use any non-licensed software.

If anyone is caught in such a situation, he will immediately be fired. And there are plenty of cases testifying this fact.

These laws have made possible to IT users in companies to get used to the idea of having to buy their software. This is applicable to small applications running on microcomputers, and on large machines.

Nowadays, there is a large number of companies requiring IT systems and services, such as software and hardware products, training, consulting and development. There are many users which have developed or bought extremely complex systems. The financial and productive sectors are the largest IT consumers in Chile.

For example, banks have invested large amounts of money during the last five years in developing IT systems. Bank customers demand efficient service and the best available technology. Thus, all banks in Chile have their branches on-line throughout the country, provide automated cash dispensers along the country, some provide the possibility of using a microcomputer at home to connect to the bank's computer to get the balance, pay utility bills, etc. The stock market and the electronic stock market (i.e., transactions are dealt by a computer) in the capital city of Santiago provide users the possibility to connect to their computers.

In the productive sector, mining industry is the largest IT consumer. They use from small systems such as spreadsheets and word processors, to large management information systems, expert systems, collaborative systems, planning systems, etc.

4. STRATEGIES FOR THE FUTURE

We think that we have given enough evidence to prove that there are good arguments to believe that a new IT industry is being developed in Chile. The question is whether this industry will be able to grow to be a significant producer in the international software market. In this section, we revise the future of each of the actors in the IT community, suggesting actions which we think are essential to allow this industry to have a healthy growth.

4.1 IT R & D Centres

It is important to discuss the role that research and development centres should play in order to have a successful IT development in Chile. Until now, government has not yet provided any specific policy to the development of IT industry. In this sense, we think that it is absolutely necessary to develop a strong scientific and technological know-how in the country with two actions. The first one is to make university IT research centres to grow and increase collaboration between them, with the help of government and industry. The second is to create new technology centres. Here, we shall propose one way of doing this.

Since Chile is not known in the international community as a technology producer, university IT departments will need to be extremely active to show that the country has a scientific and technological capacity. We estimate that in 1994, there will be approximately 70 academic staff

with PhDs in Computer Science and related fields in the country, most of them working in one of the two main traditional universities.

This is not enough if we have to train undergraduate and graduate students in the latest IT developments, do state of the art research and do technology transfer and applied research. It is clear that the strongest Computer Science Departments should help the Computer Science Departments of other universities. There are two actions which need to be taken.

The first course of action is to produce a *Computer Science Development Program*, which should define the way of making the Computer Science Departments of the two main traditional universities to grow and collaborate among themselves and industry. This is important since it is necessary to produce a synergistic effect as soon as possible. This plan should be financed by industry and government. It is necessary to increase the academic staff members of both Departments, hiring interested people with PhDs abroad. Some of them could be Chileans doing research abroad, who until now could not return due to the lack of opportunities in the country. Also computer equipment is needed.

This plan was recently submitted and is currently being evaluated by government and industry. If the proposal is accepted, the two Departments will create a Joint Research Centre composed by academic staff of the two Departments. Obviously, this Centre does not pretend to destroy the two Computer Science Departments. It will only be the way for academic staff to collaborate, creating a better research environment and an opportunity to work with industry. Also, this Centre should create Ph.D. studies in Computer Science.

An interesting line of development of this Centre could be the quality control of the locally produced IT systems. This should include the checking of quality standards in the software, hardware if any, documentation, maintenance, assistance, training, etc. The certification of the Centre should be internationally recognized as a quality seal.

The second course of action is to produce a *Development Program* for computer science departments of other universities. This starts by sending their academic staff to do graduate studies to the Joint Research Centre. This will be considerably less expensive than sending them abroad. Also, staff from other universities with acceptable research levels should have the opportunity to spent time as guest members in the Centre, collaborating with people of the Centre and the industry.

4.2 Government

Government is an important agent in the IT community. It should support the IT industry with special policies to finance research in IT to create a mature scientific and technological ability in the country, passing tighter copyright laws, supporting the creation of new IT enterprises, creating export channels for locally produced products, supporting graduate and undergraduate students in IT, supporting IT events, etc.

We would like to see the government much more active to develop this new IT market than what is has been until now. If this does not happen, the country runs the risk of not being able

to grow at the necessary rate, and therefore, never being able to have a successful IT industry in Chile. We think that IT products cannot be treated as yet another product to be developed locally. There are many reasons that sustain this hypothesis. First, an IT product requires "brainware," a scarce human resource which has to be "cultivated" locally. Second, software can trivially be "reproduced" by users, and hence, it needs special protection to avoid this. What would be the price of oranges if everyone could "reproduce" oranges trivially after buying the first one? Third, it is quite easy to smuggle software to or from the country. This means that some companies might be paying custom taxes for the used and produced products, and some others might not. Finally, this product requires maintenance and continuous updates.

4.3 Industry

Up to now, IT industry in Chile has just had the will to start a business which appears to be good. They have generally not invested on creating a scientific or technological capacity. Only a few rare exceptions exist. In this sense, industry has treated university IT centres as yet another customer, using the Law of Donations because that would allow them to make a business. Also, they have been requesting state of the art developments because for them, it is cheaper that way. We expect from industry a more active approach for the future. Otherwise, they will be the first ones in having problems.

4.3.1 IT Producers and Exporters

In the near future, we see new IT companies being created, developing their own IT products for the national market. The current technological renewal of the Chilean industry has room for more IT companies, specially in state of the art systems.

On the other hand, technology developments in neighbouring countries is almost non existent. For example, Argentina is currently opening its market to international trade. It is expected that they will soon provide a vast market for technology products to rebuild its old, non-competitive industry. Since they have its university educational system in "bad shape," it would take them far too long to do it by themselves. Bolivia is also showing some needs for technology systems. Although Peru is still having serious economical problems, sooner or later they will require technology. The same applies to other Latin American countries such as Ecuador, Colombia, Uruguay, Paraguay and even Mexico. The local IT industry should be ready to take those opportunities.

There are already some experiences exporting IT products to other Latin American countries. But if this is to be done massively, it is necessary to create distribution channels in those countries. In that sense, some local hardware distributors started by using their channels to distribute software locally, and then, they used the channels of the companies they represent. It is important to mention the experience of a local company representing Digital Equipment Corp. computers in Chile. They have been growing steadily since they started in the mid seventies. They currently sell solutions to IT problems, where the hardware is only part of the solution. They have obtained the exclusive DEC representation for all the Latin American countries (with the exception of Brazil), becoming the first Chilean multinational IT company.

4.3.2 Private Publishers

To produce IT systems is only one part of the story. The other part is to sell them. If the local IT industry seriously wants to get into the export business, it will necessary to have local software publishers with the responsibilities of exporting locally produced software worldwide. There are some local IT companies exporting to US which are doing their own publishing, i.e., they have established offices in the US, do marketing, look for distribution channels, maintain the products, do training, etc. Obviously, this is far too expensive to be done by individual companies.

In the near future, it is necessary to have local publishers with the responsibility of selling locally developed software systems in the US, Europe and Latin American countries.

4.4 Joint Ventures

Government is currently investing a large amount of money to increase the scientific and technological capacity in the country and to speed up the process of technology transfer. There are two funds which were launched in 1991.

The first fund, called Development Fund (FONDEF), is a US$ 70 million soft loan from the Inter-American Development Bank which will be used to increase infrastructures and applied research. Universities and research centres are eligible to apply for this fund, requesting projects with a time span of four years at most, and a minimum of US$ 100,000 yearly. Also, they require that the project has a profitability with an internal revenue rate (IRR) of 12% or higher, although universities will not have to pay the loan back. This restriction is only to make sure that the local industry will have an interest in the technology being developed.

The second fund, called Technology Fund (FONTEC), is a fund set up by the government to allow local companies to develop specific innovative technological projects. This Fund provides soft loans to local companies to develop technology, hopefully with the help of university centres.

We expect that these two funds will help in creating better opportunities for information technology, although these funds are intended to develop all priority defined technology areas, not only IT.

5. CONCLUSIONS

It is clear that the local IT community has matured, having good quality standards which has allowed IT companies to export software products to other countries. Universities are well known in the region, offering undergraduate and graduate studies in IT related subjects such as computer science, electrical and electronics engineering.

The state of scientific and technical research in IT deserves special attention. The government has allowed a very small budget for university research as compared with industrialized countries. However, computer science and related IT researchers have managed to publish

more than 50 papers per year in international journals with editorial committee during the recent past.

Government has not yet created specific incentives to increase IT activity, and IT industry and government have not invested in creating good and enough quality IT R+D centres, which could train people, do state of the art development and technology transfer.

It is locally accepted that the country has the necessary conditions to become an important IT producer in the world, IT being yet another product that could be exported successfully. However, we think that the future development of this industry remains uncertain. If the government and IT industry do not make an important effort together with university IT research centres, the growth of this industry will not be sustained, losing the opportunity of an important business, losing a leadership position in Latin America, and losing the opportunity of breaking a technology dependence of industrialized countries.

There are direct and indirect social implications that the development of a local IT industry is effecting. A direct beneficial consequence of the IT industry growth is the relatively better salary standards that people in this activity have. Alsc, improved services are currently being enjoyed by customers since local companies and government have their processes automated. Thus, bureaucracy - a known problem in Latin American countries - has been reduced significantly.

Some projects are being implemented by the Health Ministry to improve service at hospitals and reduce costs. Also, the Ministry of Education is developing a regional schools computer network to be used by children, lecturers and parents. It is expected that this network will provide opportunities to students in remote locations. These opportunities include access to discussion panels, data bases, information exchange, contests, knowledge in different formats, and so forth.

However, there are also some negative direct implications in this process. For example, the Reinsurance Company of Chile had to fire some employees after having had their systems automated, since they refused to get trained on the new systems. Other examples of the same type of negative impact probably have occurred but are less known.

An important indirect implication is the increase of the GNP by the creation of new products and services, and the improvement of productive processes and additional competitiveness of the exports. Of course, higher GNP means higher buying power for the average citizen and hence, better living standards than the current one.

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PRINTING INDUSTRY IN BANGLADESH: A LEAD SECTOR IN COMPUTER APPLICATIONS

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ABSTRACT

Most of the available literature on application of computers in less industrialized countries (LICs) describe what ought to be the 'policy' and how policy is affecting the application. It is time to investigate what the "free market economy and competitive environment is indicating?" Computers have been around in LICs for the last about 20-30 years. It is also necessary to look back and observe the natural trends of application. Though initial applications were mostly pioneered by government, per capita computing power and positive impact on growth rate may be enhanced more effectively by private sector participation. Myriads of market forces interact in such applications and worthiness of computer use can be evaluated by analyzing change in rate of return. This paper traces the use of DTP applications in Bangladesh. DTP has proved to be profitable against metal-casted technology, atleast in certain processes of printing industry. Out of the prevalent printing machines, offset is compatible with DTP and is going to survive. Two aspects become prominent here. Firstly, computer applications diffuse faster in a market driven environment than government pushed acquisitions. Secondly, adverse impacts created by computer caused labour force displacement need to be forecasted and managed efficiently. Government's timely intervention in this respect is more important than getting into the web of over-policy and central planning.

1. INTRODUCTION

Bangladesh which is population-wise the eighth-largest country in the world has about 7,500 micro-computers and around hundred medium systems of varying capacity. With a population of 111 million this gives a ratio of fifteen thousand people per computer. As per computer Industry Almanac of 1988, Indonesia has about 70,000 computers-resulting in a ratio of twenty five hundred people per computer. Bhatnagar [1] highlights the shortcoming of such a ratio saying: Traditionally the differences in computer uses have been measured through indicators relating total computing power to total population i.e. on a per capita basis. However relating computing power to economic activity seems to be a better indicator. Thus LICs desiring to benefit from computers naturally try to increase the number of computers and their effective use. Since computers are relatively expensive in developing countries their utilization tends to be higher. A few emerging applications of micro computer

are listed below:

- DTP: About 95% of Macs (which is approximately one third of national total) are engaged in this activity. Trend of using IBM compatibles for DTP is also gaining momentum.

- Banks: Private banks are using IBM compatible PCs quite efficiently. Few nationalised banks are also joining the user groups.

- Business: Some forward looking business entrepreneurs/firms are acquiring this new technology and trying to make worthy use.

- NGOs: Few hundred foreign based non-profit philanthropic organisation (NGOs) operate in Bangladesh. Most of them use microcomputers with remarkable efficiency.

- Computer Training Institutes in Private Sector: There are about 100 training institutes of varying size/capacity in the major cities of the country. They operate about 600 microcomputers for training mostly young educated unemployed persons.

- Academic Use: All the eight universities, four engineering colleges (BIT), twenty one polytechniques offer basic courses in computing and the only engineering university (BUET) offers graduate and post-graduate level courses in computer field.

- Public Sector Organisations : History of computing started in Atomic Energy Commission in 1964 with a IBM System-1620. By now about half of the total microcomputers are owned by different organisations of the public sector, and acquisitions are on the increase. Most of the hardware comes through donor's fund and recommendations.

The number of operational computers, rate of growth, application areas and intensity of utilization are very vital statistics in evaluating impact of this technology. In recent years Bangladesh printing and publishing industry has seen a minor revolution through the use of DTP. Although this is not a conventional number-crunching use, it qualifies for an in-depth study, because of its economic and social implications.

Printing and publishing sector is remarkably active even in less industrialized countries. A rich vernacular adds more impetus to publishing activity. This paper will focus on applications of microcomputers in publishing, its impacts on the industry and occupations with reference to Bangladesh. Such an application is generally termed as Desk Top Publishing (DTP). The term DTP is somewhat a misnomer [2]. So far computer is being used only for some processes in the lengthy chain of publishing activity. DTP is not in its full application as yet. For the sake of accuracy, the term Computer Aided Publishing (CAP) will be used synonymously alongwith DTP.

2. PRINTING INDUSTRY IN BANGLADESH

The printing industry consists of approximately 1100 small (having a treadle and minimum peripherals), four hundred medium and about thirty big printing houses in private sector [3].

Government also operates a large printing establishment for official use.

In terms of printing hardware approximate number of machines of different technologies are given in the table below.

Installed Base of Printing Hardware

Machine-Type	Approximate Number
Manual Metal Compose	1000
Automatic Metal Compose	150
Photo Type-setter	12
Computer Type-setter	2000
Treadle	1100
Flat Bed Auto	500
Offset	150

The total investment in fixed assets in this sector is around Tk. 1.6 billion (US $ 40 million, @ 1 $ = Tk.40). Annual gross turnover of the sector is around Tk. 3.0 billion for printing service charge. This sector uses paper worth approximately Tk.7.0 billion.

Output of the printing/publishing sector are varied and difficult to group. For an overview, these are classified under the following general titles [4]:

Daily Newspaper	119
Weekly Journal	444
Fortnightly Journal	88
Monthly Journal	269
Creative Writing (No. of titles)	600
Text Book	1500
Other Unspecified	1000

DTP was initiated in 1986. It's biggest achievement is in daily and weekly media. Almost all of these are being published using DTP or CAP.

2.1 OCCUPATIONS AND EMPLOYMENT

ILO groups "Printers and Related Workers" in Code 9-2. Bangladesh Standard Classification of Occupation (BSCO) has incorporated following printing/publication related trades/vocations in its 1982 edition [5].

Code	*Occupation Title*
Pre-Press	
9-21	Printing Compositors & Typesetters
9-21.20	Printer General
9-21.15	Hand Composition
9-21.20	Linotype Operator
9-21.25	Monotype Keyboard Operator
9-21.30	Type Casting Machine Operator
9-21.35	Page Maker-up
9-21.40	Imposes-Printing
9-21.50	Photo-Type Setting Machine Operator
9-21.90	Other Compositors and Type Setters (here the "computer typesetter" may fit in)
Printing Press	*Machine Operators*
9-22	Printing Press Operators
9-22.20	Cylinder Pressman
9-22.30	Platen Pressmen
9-22.40	Offset Press Machine Operator
9-22.50	Rotary Pressman
9-22.60	Roto Gravure Pressman
9-22.90	Other Printing Press Machine Operator
9-23	Stereotypers and Electrotypers
9-23.20	Stereotype Caster Moulder
9-23.30	Electrotypers
9-23.90	Other Stereotypers and Electrotype
9-24	Printing Engravers (Except Photo e.g Gravers)
9-24.20	Engraver - Metal
9-24.20	Etcher - Metal
9-24.40	Engraver - Wood and Rubber
9-24.90	Other Printing Engravers
9-25	Photo Engravers
9-25.10	Photo Engraver - General
9-25.20	Cameraman - Photogravure
9-25.30	Retoucher (Similar to cutting and pasting in DTP)
9-25.40	Transferor - Photo Mechanical
9-25.50	Etcher - Photogravure

9-25.60	Retoucher-Etched Printing Plates
9-25.90	Other Photo-Engravers

Occupations are mentioned to highlight variety of craftsmanship and skill needed to print any material using traditional technology. In addition there are five occupations in binding job and nine more in other non-paper printing vocations. DTP environment is pushing many of the listed occupations in obsolescence. As per the latest Labour Force Survey, about 40,000 skilled and semi-skilled workers are employed by the industry in 9-22, 9-23, 9-24 and 9-25 occupational code groups [6]. Introduction of offset machine supported by computer typesetting displaces about 70% of the earlier work-force. Only an insignificant percentage need to be retrained to operate computers. Offset machine operators, front office staff and security personnel remain undisturbed.

In Bangladesh computer aided publication was initiated on purely commercial basis by owner of a weekly in 1987 as an attempt to save his business. It was a weekly Bengali journal. The machine was an Apple Macintosh (Mac). He made skilled use of "FONTASTIC" and "FONTAGRAPHER" software to create script and postscript BANGLA fonts respectively. Another innovator also introduced Bengali WP software and patented in the name "SAHEED LIPI". However the weekly owner applied his version for journal publication before others. It was a success and word spread around in daily and weekly media community. The journal owner then started vending Macs. Business soared. Comparative statistics of two main types of microcomputers in the country will indicate the trend [7]:

Type	1986	1988	1990
Mac (APX)	5	600	2000
IBM Compatible (APX	1000	3000	5500
Total	1005	3600	7500

Printing houses, banks and private training institutes buy computers with a profit motive. There is no additional promotional measures, incentives or concessions from the government for such organisations. Competitive environment of market economy has ushered them in the era of computer technology.

About one third of the total microcomputer population is engaged in DTP. Investment-wise two thousands Mac-based DTP units cost more than rest thousand five hundred non- DTP IBM compatibles. Post-script laser printers and proprietary nature of Mac components enhances the price of existing DTP units. It is estimated that about Tk.0.7 million has been invested in two thousand DTP units, whereas Tk.0.6 million was enough for five thousand five hundred non- DTP IBM compatibles.

In the last 3-4 years about five hundred entrepreneurs have joined the business and more than four thousand new jobs have been created. In a LIC like Bangladesh, DTP is the most recent area of computer application. Computers used in DTP have seen a phenomenal growth

from five in 1986 to 2000 in 1990. Number of non-DTP microcomputer was 2,000 in 1986 which rose to around 5000 in 1990. DTP investment is encroaching into traditional printing houses and also attracting new entrepreneurs in the sector. Printing industry is about hundred years old. Whereas DTP component in the industry is only 4-5 years old. In such a short span of time it has demonstrated a very high growth-rate. There exists great potential to increase number of microcomputers in DTP use.

4. POSSIBLE TREND IN HARDWARE USE IN DTP

The DTP technology was ushered by Apple Macs on the basis of high quality printing capacity of vernacular language-Bangla. Mac's use of post-script laser printers - which are more than twice as expensive compared to non-post script laser printers. In terms of monitor and CPU costs also Macs are relatively costly compared to IBM compatible PCs. Currently there is keen competition between these two technologies. In last 3-4 years vendors of IBM compatibles could not get a slice of the DTP market because of their technological weakness in adopting vernacular "Bangla". But the growth potential in DTP and comparative slackness in non-DTP market has forced them to become active in DTP also. Mac has a major disadvantage. The parent US company does not permit local SKD or CKD assembly of these machines in Bangladesh. So the custom-duty concession cannot be availed by Mac vendors. On the other hand IBM PC compatible computers are being assembled in Bangladesh forcing the price down and ensuring reasonable after-sales-service by the entrepreneurs.

Bringing Bangla to IBM PC has been a field of intense research by some PC promoters in last few years. Already three W.P. innovations and 1-2 spread-sheet and database software have hit the market place. Two of them are card based and one is software based. The Bengali WP which can serve as a commercially dependable DTP is not yet available in PCs but break through seems to be around the corner. Once this happens, post-script based Macs will be replaced by PCs in a market created by Macs. PC based WINDOWS 3.1 has a great potential in creating delicate Bangla fonts which will be competitive with FONTASTIC and FONTAGRAPHER of Mac.

If Macs remain relatively costly and PCs can match Macs quality at a lower cost , printing machines not compatible with DTP will be sold out even at the price of scrap. This will be a remarkable tremor in 1.5 billion Tk. industry employing about 40,000 personnel. The owners will be able to buy low cost PC based DTP even with price of scrapped machine.

The issue of retrenchment of about 70% workers will pose to be a very serious problem. Big printing houses with huge investment are not going to shift to DTP until and unless the DTP technology be comes dependable [13].

5. FACTORS WHICH WILL RETARD DTP GROWTH

Inspite of the potential of DTP discussed earlier there are factors which will inhibit its growth. New acquisitions of traditional machines have come to all time low. Price of used machines have also dropped. This is a scenario of transition to DTP, with certain exceptions. So far DTP or CAP occupy a defined "process-stage" in the whole printing activity/input-output

flow. DTP is a threat to some earlier machines and semi-skilled personnel but not yet a threat to the whole industry. The offset machine is still a "necessity" for mass publication of computer type-set text. There are only one fifty offset machines, in relation to sixteen hundred other types, not compatible with DTP.

Labour Displacement: About 70% of traditional printing industry labour force is threatened if DTP is introduced by all the existing printing houses. At the most 10 % of the existing workers need to be retrained which will be enough to run DTP based offset presses. This estimate excludes binding and packaging personnel. Offset machine operators, front-office and security personnel are not threatened with a loss of job.

Investment Factor: Existing pre-DTP technology based hardware of about Tk. 1.6 billion is not yet old enough to be declared unusable and sold as scrap. In any developing country tendency of replacement or scraping is very slow.

Slow obsolescence of Non-offset Non-DTP Technologies: Around 500 Flat bed Auto and 1100 Treadle machines are not going to be thrown overnight. The publishers and printers are classifying the jobs and utilizing the obsolete machines and redundant personnel as far as possible.

Initial euphoria of transition to DTP has slowed down. Limited-copy-life-bound laser printer has forced some DTP houses out of business. The DTP units having close association with established offset printing houses are doing well. Other stand-alone DTP units are facing problem to find enough jobs to sustain.

Cheap labour cost has not yet given enough advantage to alternative cost of DTP in many cases. Labour Unions are strong enough in some large printing houses to restrain the management from installing DTP facilities.

Overall assessment of DTP use and its future potential is positive. Apart from issues of labour displacement, DTP has created maximum number of new jobs. Infact few new professions, vocations and skills have come up in this sector. So far only Tk. 0.7 million has been invested in a sector where Tk.1.6 billion worth machinery is functioning. So if cost effectiveness of DTP in terms of profit and surplus- labour-rehabilitation can be maintained the growth potential is enormous. Thousands of microcomputers can be profitably used by this sector. Government subsidised textbook publication alone has a budget of Tk. 0.75 billion each year. Printers are finding it economical to use DTP for this job also.

Almost all the microcomputers in DTP function remain operational for two shifts and in some cases three shifts. On the other hand non-DTP microcomputers have average 2-3 cpu hrs. per day. So utilization-wise computers in DTP use are much ahead of non-DTP machines.

6. CONCLUSIVE REMARKS

Existing computers in LICs need to be effectively used. Ineffective use is resulting due to a

lack of prior needs assessments; inadequate attention to socio economic factors and lack of adequate emphasis from the chief executives/policy level personnel. Properly trained manpower in computer field supported by computer superior officers is also a pre-condition for successful computer application.

LICs must be careful about "UNplaned Acquisitions Without Accreditable REsult (UNAWARE)," which hinders growth of computers and their effective use. One case of "UNAWARE" stops many potential users.

Issue of labour displacement due to effective use of computers needs detailed study and acceptable solutions must be reached by multi-lateral agreement between employers, employees and government labour agency. ILO policy and national policy on compensating workers rendered surplus because of technology should be updated appropriately. Employers should shift to computer technology only when it is profitable even after paying adequate compensation to surplus workers.

Should governments be the prime movers of IT in LICs? Whenever the donor countries talk about computer to their client LICs, the issues of "Computer Policy", "Information Technology Strategy" and other high sounding terminologies become their 'catch word'. LICs' administration also has a liking for various forms of control in the name of policy and central planning.

In a non-communist economy, however insignificant, the market-economy based applications must be examined with serious attention. In industrialized free-economies, private sector application is much ahead of government in computer technology. In LIC's the role of governments has been over emphasized. Government agencies begin with a promotive stance but soon degenerate into a regulatory agency with undue monitoring of hardware, software, procurement, etc. It is as if the greatly applauded reality of "Market-Economy" is not applicable for computer technology in LICs.

With fresh memory of failed experiment of seventy years in central planning by the Eastern Block, LICs should give competitive computing a fair chance. Printing sector of Bangladesh is a suitable case in reference. They must find out their own natural competitive lead sectors - from footprints of empirical application history, rather than pseudo-logic of "what ought to be". Computer experts, for a while should study computer-economics and nurture the lead sectors. Government must ensure open competition. ILO regulations need to be suitably amended and updated to keep the labour sector satisfied by reasonable measures. This approach of promotion will have better chance to ensure effective utilization, increased acquisitions and optimum individual/organizational productivity as well as efficiency.

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INFORMATION TECHNOLOGY : GENDER DIFFERENCES AMONG OFFICE WORKERS IN MALAYSIA

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ABSTRACT

Under the Sixth Malaysia Plan (1991-1995), information technology has been singled out as one of the five key technology areas to pitch Malaysia as a developed country by the year 2020. In order to be successful in this highly competitive field, the development of a productive and skilled labour force is strategically important. The paper discusses the gendered impact of this new technology on the employment opportunities of office workers, the main users of IT in the country. It points out how IT in line with Malaysia's privatization policy, has brought about changes in the employment pattern of office workers, creating new opportunities in some occupations while putting at risks other jobs. A case study of a telecommunications company is utilised to illustrate the trends at the macro level.

1. INTRODUCTION

By the year 2020, Malaysia aspires to become "a united nation, with a confident Malaysian society, infused by strong moral and ethical values, living in a society that is democratic, liberal and tolerant, caring, economically just and equitable, progressive and prosperous, and in full possession of an economy that is competitive, dynamic, robust and resilient" [1]. To achieve this vision, the establishment of a Science and Technology Policy in 1986 has been considered a major milestone in the development of "a scientific and progressive society, a society that is innovative and forward-looking, one that is not only a consumer of technology but also a contributor to the scientific and technological civilisation of the future" [2].

In the recently unveiled Sixth Malaysia Plan [3] information technology (IT) has been singled out as one of the five key technology areas to pitch Malaysia as a developed country into the 21st Century. According to this Plan, information technology in its broadest sense refers to all technological elements that enable the acquisition, storage, processing, transmission and presentation of information, with the involvement of primary technologies such as micro-electronics, computers, telecommunications and software technology. In order to be successful in this highly competitive field, the development of a productive and skilled labour force is

direly needed, especially in the country's current structural transition from an agricultural to an export-oriented industrial base. Indeed with the present economic boom, Malaysia has to rely heavily on migrant labour, many of them illegal, to work in the plantation, construction and manufacturing industries.

Given this scenario, what will be the impact of new technology on the employment opportunities and risks of the labour force? This paper focuses on the gendered impact of employment among office workers - the main users of IT in the country. Women form the bulk of the clerical workers who will be feeling the effects of the current information revolution. After providing a brief introduction to the IT scene in Malaysia, the paper will proceed to discuss the employment situation both at the macro and micro level. Specifically, the empirical data will zero in on a case study of the telecommunications industry to enhance the discussion at the national level[1].

2. INFORMATION TECHNOLOGY IN MALAYSIA

The computer industry has become one of the fastest growing industry in Malaysia, with the biggest users in the financial sector, followed by businesses services and the government sector. Between 1978 and 1987, its market size more than quadrupled from US$52 million to US$224 million i.e. an average per annum growth rate of 21 per cent. The 1987 Asian Computer Directory listed Malaysia as the fourth largest user of computers in Asia, after Japan, Singapore and Hong Kong. The number of mainframe/minicomputers installed in the country increased from 625 in 1982 to 916 units in 1986, with the government sector accounting for one-quarter of the total number of installations in 1986. Growth in the usage of microcomputers (or PCs) has also been astounding in the past few years - from 3,500 units before 1984 to over 82,000 units in 1986 in the private sector. It has been estimated that the market size for microcomputers and peripherals is about US$40 million annually [4].

The public sector has been a key user of IT, particularly in the past few years. Acquisition of mini and mainframe computers increased from three units in 1966 to 226 units by 1986, while the number of microcomputers accounted for 8,000 units in 1989. From 1977 until 1988, the government spent about US$196 million on the purchase of computer systems, while for 1989 alone, another US$63 million was approved for computerization projects. Computer applications have also grown more sophisticated. According to a recent government report [5] "In the early 1970s, public sector data processing facilities were mainly used for routine functions like accounting, payroll and personnel. The mid-70s marked the emergence of management information systems in the areas of personnel administration, agriculture, land administration and finance. Networking and distributed processing started around mid-1980s... Beyond the 1990s, it is expected that more emphasis will be given to the development of integrated databases in which data will be treated as a corporate resource".

Since the early 80s, the state has been increasingly steering Malaysia into an industrialised path with a distinct shift from public sector participation in economic development towards privatisation of the economy. Previous public services such as telecommunications, water, electric services and recently the postal services have been or are now being privatised. In this respect, IT has been given significant prominence, as the transformation to a "corporate

economy" has entailed large capital investments in upgrading computer systems towards more productive, efficient and profitable services. The question is -what has been the score on human resources development?

3. EMPLOYMENT OPPORTUNITIES AND RISKS IN IT

It has been popularly claimed or believed that automation will eliminate jobs in the wake of the robotised office and factory floor. Studies in post-industrial societies such as North America and Europe have shown that the micro-electronics revolution has led to a loss of jobs in certain key industries and services [6]. However, other studies point in the opposite direction. A recent study in the United States revealed that there has been a tremendous growth in clerical employment until the mid 1980s, although there has been a reduction in the rate of increase in the proportion of clerical workers to the total labour force [7]. The latter further argue that there has been a big increase in the number of computer and peripheral equipment operators (a 22 per cent annual average rate of growth), although there has been a decrease in stenographers and telephone operators.

Another key issue in the employment debate has been the argument on whether the logic of accumulation in capitalist production will deskill the labour process, inexorably producing degraded, routine and fragmented labour in manual as well as non-manual work. The work of Braverman entitled *Labour and Monopoly Capital* [8], has been instrumental in initiating the debate on this controversial issue.

Feminists who agree with Braverman point out that particular technologies have been, and will continue to be developed primarily based on the interests of capital. In so far as the gender division of labour exists, they discuss how women's work in clerical occupations becomes more fragmented and isolated, their output highly monitored and their pace and stress of work increased. Thus computers support the capitalist system by moving information and skills from workers to managers, and reinforce patriarchy by pushing women into low-skilled, low-paying and highly controlled work [9]. On the other hand, there are also those who argue that the development of IT in the post-industrial society has brought about possibilities of radical decentralisation and less functional specialisation making office work more flexible, creative and interactive.

The Malaysian case-study argues that there are no black and white answers as the impact of IT on employment depends on a variety of factors, such as the historical stage of industrial development, the context of specific existing social relations, the period of installation, the types of occupations being affected and how power in the office is being negotiated. Let us now turn to examining the transformation of the employment pattern among office workers in Malaysia.

4. OFFICE OCCUPATIONAL STRUCTURE AND CHANGE IN MALAYSIA

In Malaysia, the impact of IT on employment is not homogeneous. The period of expanding automation also saw a general expansion of the clerical work force as a result of the rapid growth and structural change of the Malaysian economy. Indeed, by the end of the 1980s the

Gross Domestic Product (GDP) registered a 10 per cent growth rate, even outpacing the rate of growth among the Asian Tigers. By the mid-80s manufacturing had overtaken agriculture as the largest contributor to GDP and by the end of the century, industrial production is targeted to account for 80 per cent of GDP. With the current plan to develop "hi-tech" industry, the employment pattern has also shifted with the secondary and tertiary sectors predominantly absorping new entrants into the labour force. There has been a notable increase of white collar-workers who make up about 21 per cent of the labour force in 1990 compared to six percent in 1957.

As can be seen from Table 1, employment in the clerical and related group more than doubled within the period from 1975-1987. A few patterns emerge. First, there is a dramatic growth in occupations associated with computerisation. For example, systems analysts grew more than twelve-fold (from 172 to 2177), computer programmers more than nine-fold (from 335 to 3185) while automatic data processing machine operators increased more than six-fold (from 1038 to 6869). Second, there is a marked decline in jobs which have been displaced by the computer, such as card and tape-punching machine operators, and book-keeping and calculating machine operators.

Third, the number of clerical jobs more than doubled, as a result of the expansion of the public and business sectors, although its growth was disproportionate to the number of clerical supervisors and executive officials which increased more than three-fold. This could imply an increase of management control and surveillance over workers, as automation with larger capital investments in the present climate of privatisation and profit-making, demand more productivity per worker. At the same time, the nature of more sophisticated and complex businesses would require proportionately more "hi-tech" than "hi-touch" workers, as was the case before in assembly-line operations.

Fourth, jobs become more differentiated with the changes and dynamism in IT. Some jobs change and expand, others become more defined and specialised, particularly in the more technical, higher paying fields. A recent newspaper report quoted an estimate from the Economic Planning Unit of the Prime Minister's Department that 26,485 EDP personnel needed to be trained for the period 1990 to 1995. These job areas include systems programming, software specialisation, data communications/networking, computer security, hardware maintenance, management information system and systems integration [10]. Indeed, the private sector is presently facing a serious manpower shortage, clamouring for "critical" personnel from analysts programmers and systems designers to datacom engineers and cellular technologists.

Fifth, changes in gender composition reveal some interesting patterns. The higher paid more technical occupations (systems analysts) are overwhelmingly male, as are the supervisory and the executive positions. However, it is interesting to note that there are slightly more female than male programmers, pointing to the opening up of new opportunities for women in the computer professions at this middle level.

Gender polarisation is also evident in the jobs which are overwhelmingly female - data entry operators, stenographers, typists and clerks. In fact there has been a shrinking of male intake

in these categories through the years , although traditional male clerical occupations like bookkeepers and stock clerks are still male arenas. While the gender segregation is not so clear-cut, there seems to be a trend for the higher technical and management personnel to be male-dominated, the middle-level to be gender neutral, while at the clerical level, the expansion is increasingly female, at the expense of men. However, the creation of new jobs at the higher level do not seem to benefit the (female) workers displaced by automation, as a new breed of specialised graduates, mainly male, are brought in, creating a new stratum in the office. Also, increasingly so, there is a gap between higher level female professionals and the lower level clerical and data-entry level female operators. To what extent is this pattern reflected at the micro-level?

5. EMPLOYMENT PATTERN AT TELMAL[2]

This section discusses the employment situation at TELMAL, a telecommunications company in Malaysia. Although TELMAL embarked on computerisation in the early 70s, its applications until the mid-80s were mainly in the areas of billing, accounting, inventory, staff record and payroll systems. It has only been in the last six years (TELMAL being privatised in 1987) that there has been a major upgrading and development of new systems.

As of October 1990, there were 28,015 employees at TELMAL, compared to 28,385 in 1987 and 28,041 in 1989. Women comprise 24 per cent of total staff (N=6,730) compared to 76 per cent for men. In terms of occupational hierachy, only five per cent of the total staff are in the executive category, out of which 29 per cent are female. This means that 6.1 per cent of total females are in the executive category compared to 4.8 per cent of all males, quite an unusual pattern in the Malaysian context. However, on closer examination, most, if not all of the top decision-making positions of senior managers and directors are male dominated.

Table 2 shows the distribution of non-executive employees by gender and the employment pattern of computer-related jobs in TELMAL.

To a large extent, the gender composition at TELMAL reflects the pattern at the national level in which the decision-making tasks at the executive level are dominated by men, particularly at the very senior management and director levels. The technical slots are also the domain of men while the women crowd around the data-entry, clerical and telephonist positions. While there is an almost equal number of men and women in computer related jobs, the majority of women are lower-level computer operators or data entry workers. It is only at the level of systems programmers that women compete, although the main decisions regarding computerisation remain with systems anaylsts, three-quarters of whom are men. With the setting up of four data centres, there has been an expansion of higher level computer operations. However, the present intake consists of "outsiders" rather than through an internal promotion. The more than 40 data entry operators who will be deployed elsewhere later will never be able to enter these more technical and better paid occupations.

What is the impact of computerisation on the organisation of work in the office? The first applications of IT in TELMAL involved simple mechanisation of high-volume activities such as processing forms, billing subscribers and answering telephone calls which involved key-

punch operators using batch systems, typists and telephonists. The shift from manual to computerised performances was fairly straightforward as task fragmentation (Taylorisation) had already routinised these functions in the first place. Thus this early phase of automation conformed to the pre-existing division of labour in rationalised bureaucracies. The result was task fragmentation and the intensification of work which was decentralised into geographically separated and gender segregated units.

The next more intensive phase of automation seems to coincide with the period of a reduction in staff from 1987 to 1990 (minus 370 workers) despite the expansion of its services, customer base and the substantial increase of profits through the years. According to the Union President at TELMAL, management had stated that the TELMAL computerisation exercise had led to an overstaffing of between 4,000 - 5,000 workers, mainly at the technical and clerical levels. However, apparently there have been no retrenchments so far because of the strength of the union which had argued for retaining the staff as a result of privatisation. But it seems that while the union can save people, it cannot save jobs; nor does the union have a say in the hiring of contract staff, as was recently done with the intake of new telephone operators.

It is true that with the development of the rather sophisticated customer automated services system (CASS), many routine clerical and technical tasks have been eliminated. With the mechanised service order system, all information about the subscriber is automatically processed, recorded, updated and stored, eliminating time-consuming paper work. Data-entry operators will no longer be needed if the system is fully implemented. With the upgrading towards the Digital Switch System, several exchanges have been closed and telephone operators made redundant. One of the CASS managers estimated that there had been a reduction of 200 staff who have been re-deployed to other sections, while new staff, mainly systems analysts and programmers have been recruited.

The combination of computerization and privatization seem to have led to increased stress for the lower level staff such as the data entry operators (who are required to key in berween 10,000 - 14,000 strokes per hour) and telephone operators (who have a quota of 3,000 calls per day or 10 seconds per call). On the other hand, clerks and secretaries seem to have more control over their work which becomes more flexible with computerisation, although at the same time their work load increased due to the increased productivity expected from them. This is the case of decentralised, and small work groups which are able to work relatively independently in their own work stations.

7. CONCLUSION

The introduction of IT has brought about changes in the employment pattern of office workers in the country, creating new opportunities in some occupations while putting at risks other jobs. It can be said that overall, there has been an increase of IT related jobs especially at the higher levels due to the Government's focus on hi-tech industry since the mid-80s. With the structural shift in the economy and the present economic boom, there has been a severe shortage of IT professionals.

The data show that at the macro level, certain jobs have been displaced or eliminated with the onslaught of the first phase of automation. In a sense it is inevitable that machine-card punchers will be made redundant with the introduction of the computer. New jobs have been created, the obvious ones being data-entry operators and computer professionals. However, with the present phase of more integrated systems, it is possible that the era of the data-entry operator might soon be over as can be seen in the case-study of TELMAL. At the same time, it might be too premature to predict their demise particularly with the increased flexibility of IT which allows for decentralisation in the preparation and data entry part of information. Several developing countries have been the recipients of such telework whereby data entry work has been internationally re-located to save labour costs in the developed countries [11].

However, the conditions of employment depend also on how power at the office floor is being negotiated. As can be seen with TELMAL, the union has managed to fight for the retention of its staff despite management claims of job redundance as a result of computerisation and privatisation.

Employment for women workers is also changing. It is not entirely true that women will be inevitably pushed into low-skilled dead-end jobs as a result of automation. Nonetheless, it is true that the increasing clerical force is slowly becoming "feminised", while the lower-level data entry operators are largely female domains. Women's position in the labour market is still secondary and ideologically constructed. At the same time, in the Malaysian IT industry, at least more so than in other technlogical fields, women are making headway into middle-level professional and management occupations, although the decision-making processes are still heavily male-dominated. This means that gender segregation, as well as stratification among women along class lines will be probable future trends in the IT sector in Malaysia.

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ENDNOTES

[1] The data is based on research on New Technology and Office Workers conducted by the authors between 1989 and 1991 with the assistance, at various stages of Zak, Carol, Roslan, Henry, Rustam, Wan and Nik. This paper draws on work undertaken when the first author was on her sabbatical leave in 1991, part of which was spent at the Institute of Social Studies (ISS), The Hague, Netherlands. She would like to thank Thanh-Dam Truong and Gary Debus from the ISS for their helpful comments in the writing up of the research findings.

[2] TELMAL is the fictitious name for the telecommunications company.

Table 1 *Peninsular Malaysia: Employment by Selected Occupations (3-Digit Level) and Sex, 1975, 1985 and 1987*

Occupation	1975			1985			1987		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Group I - Professional, Technical and Related Workers									
Statistician' 245	71	316	97	n.a.	97	47	103	150	
Mathematicians & Actuaries	NA	NA	0	NA	NA	0	93	NA	93
Systems Analysts	91	81	172	903	492	1395	1770	407	2177
Computer Programer & Stat & Math Tech	335	NA	335	1231	1051	2282	1529	1654	3183
Group 3 - Clerical and Related Workers									
Clerical Supervisors	5011	419	5430	7643	2150	9793	15054	4665	19719
Govt. Exe. Officials	13948	1388	15336	36812	6157	42969	36241	7362	43603
Stenographers, Typists & Teletypists	4220	22962	27182	3663	47439	51102	2485	47351	49836
Card & Tape-Punching Machine Operators	336	768	1104	198	557	755	199	376	575
Bookeepers Cashiers & Relative Workers	28017	21008	49025	43444	70764	114208	37889	70571	108460
Bookeepers Cashiers & Relative Workers NEC	2665	710	3375	1974	2425	4399	1928	2570	4498

Occupation	1975			1985			1987		
	Male	Femal	Total	Male	Female	Total	Male	Female	Total
Book-keeping & Calculating Machine Operators	226	1285	1511	88	157	245	212	348	560
Automatic Data Processing Machine Operators	91	947	1038	1165	3525	4690	2098	4762	6869
Stock Clerks	16542	1401	17943	39250	8105	47355	36606	8015	45621
Material & Production Planning Clerks	80	258	338	1068	624	1692	485	815	1300
Correspond ence & Reporting Clerks	40983	26854	67837	58341	103548	161889	59478	110771	170249
Receptionst & Travel Agency Clerks	521	2661	3182	2425	7469	9894	2348	6009	8357
Library & Filing Clerks	1185	671	1802	2995	1985	4980	2992	1893	4885
Statistical Clerks	NA	NA	0	661	451	1112	346	499	845
Census, Market Research & Relative Field Workers	NA	NA	0	1833	530	2363	1395	317	1712
Clerks NEC	14856	3611	18467	16911	10203	27114	18200	8141	26341
TOTAL	129352	85041	214393	220702	267632	488334	222395	276629	499024

Note : NA - Not Available
Source: Department of Statistics: Labour Force Survey (Unpublished Data)

Table 2 *Distribution of Non-Executive Staff by Gender - TELMAL*

Category	Male	Female
Technical	7936	1272
Clerical	1437	2560
KPBK	6627	161
Teleprinter	38	291
Telephonists	694	1398
Sub-Total	16732	5682
Computer-Related Occupations		
Systems analysts	117	38
Systems programmers	37	24
Computer operators	42	23
Data processing machine operators	12	117
Sub-Total	208	202

INDIAN MANPOWER DEVELOPMENT IN INFORMATION TECHNOLOGY

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ABSTRACT

With the rapid growth of the computer industry, the availability of adequate trained manpower has become a major issue for any nation. We are witnessing Information Technology Revolution. Within Information technology, software is an intelligent and innovative input. Software is based on human resource. In view of the availability of highly educated manpower in the country, the Government of India has taken a number of specific steps to use this manpower for the development of software industry. In this paper, we examine the Government of India's policies and schemes regarding computer training and education. A comparative study of courses conducted by Government supported institutes and private institutes is made.

1. INTRODUCTION

The development of Information Technology is one of the most important achievement of the present century. Computers are being used in all areas of Government administration and business management.

In India there is all-round awareness regarding the importance of computers in national development. The success of recent annual convention of Computers Society of India (CSI-91) with the theme 'Information Technology in Everyday Life' is indicative of vast scope for employment of computers in India. If implemented, it can play a vital role in almost every facet of life. In view of important role of Information Technology (IT) in office automation, in telecommunication services, in Water Engineering, in Human Resource Development in Social Welfare, in Weather Forecasting, in Entertainment Industry in Indian Languages, in Agriculture, in Rural Development and in art and cultures, the Government of India gave utmost importance to manpower development in Information Technology. The Department of Electronics has taken number of steps to create manpower in the area of IT and use it for the development of software industry.

2. COMPUTERS SOFTWARE AND THE INDIAN SCENARIO

The Government of India has identified software exports as a major thrust area. Taking into

consideration the availability of a large number of highly educated manpower in the country, the Government of India has taken a number of specific steps to use this manpower most effectively for the purpose of development of software industry. In 1986 the Department of Electronics has brought out specific policy for this purpose. Within a short period the Indian software has grown considerably. Till 1988 there were about 400 consultancy organizations, 150 indigenous Computer manufacturers and about 25 distributors of foreign suppliers. These organizations have developed expertise in the following areas.

- System Software Development
- Design and implementation of Management Information System.
- Financial control and accounting systems.
- Micro based Software
- Application Software development for specific industries like Banking, Insurance, transport
- Project Monitoring System
- Government Information system
- Telecommunications Software
- Software Maintenance

Most of the basic system software i.e. operating systems available on various indigenous micro and mini computer systems are imported but our manufacturers have developed expertise for porting the software on a variety of hardware. Number of software houses like CMC, Softek, Integra have developed expertise in compiler and interpreter writing and DBMS packages which are being used in number of indigenously available computer systems.

The software export have grown from Rs 70 million in 1950 to Rs 2000 million in 1990 and the number of exporting companies have risen considerably. The Government of India has introduced a new section in Income Tax Act whereby profit from Software export will be fully exempted from the Income Tax. Software Packages can be directly imported by Actual User, Manufacturers of computers and Registered Software Exporters

The computer Industry in India shall gain a lot from the new industrial policy. Following are some of the vital points of new industrial policy:

(i) No licence is required for setting up new unit for mini-computers or peripherals,
(ii) Foreign equity participation has been increased to 51%,
(iii) No permission is required for hiring foreign technicians,
(iv) Training institutions recognized by DOE can import computer system by paying 25 % custom duty and without export obligations.

The DOE target for software export for the yea: 1994-95 is Rs. 20 billion.

Reliable communication facilities, requisite hardware/software resources, post development software maintenance are some of the important inputs for software export but the main requirement for software exports is skilled manpower. This is more relevant in view of current technology trends in application software and system software. This calls for proper curriculum developments in the area of programming languages, DBMS, UNIX O.S., Graphics and

software engineering.

3. TELECOMMUNICATIONS IN INDIA

India is offering consultancy services for the development of telecom services, operation and maintenance of networks for large users in many countries. Developing countries need to modify and develop suitable technologies consistent with their national objectives and priorities. It is well known that multi national companies do not transfer Core Technology. Developing countries need to evolve suitable strategy towards coordinated approach in telecommunication technology. It is possible to introduce new telecommunication services at reduced cost in view of advances of digital technology. Consultancy service, research and development are important areas of cooperation for pooling of experience in the telecommunication technology among the developing countries.

Telecommunication is the capital incentive business. India is in a position to help other developing countries in setting up industries for manufacture of telecom equipment and for human resource development. Cooperation can be extended to train and develop manpower. Computer Integrated Manufacturing (CIM) is an important area of cooperation amongst developing nations. International Telecommunication Union (ITU) and Integrated Services Digital Networks (ISDN) are making their tentative debut. The telecommunication network grew significantly in the recent past in India. Telephone services are now available in cities, towns and thousand of villages. Department of telecommunication is committed to introduce and manufacture optical fibre cables. India has good manufacturing capabilities in telecommunication sector for production of transmission equipment, switching system, cables and wireless equipments, satellite communication system, telephone instruments, tele- printer and telex machines.

Indian Telephone Industries Ltd. is involved in the manufacture of various kinds of transmissions and terminal equipments.

Centre for Development of Telematics (C-DOT) have developed a family of digital electronics,switching system suitable for Indian environment. C-DOT has also developed expertise for transfer of technology.

To train manpower in the rapidly changing field of telecommunications, India has large number of training centres but lot more is need to be done in designing special courses to suit the requirements of developing countries. The country has witnessed a tremendous growth in the field of computers. By 1987, India had about 4100 Super, Main and Minis and 20,000 micros but the cost of large computers continue to be high. To optimize investment large computers are being located at strategic locations. For small organizations it is more economical to invest only in small computers and use common facilities offered by network.

4. COMPUTER EDUCATION IN INDIA

In order to meet the growing need for trained manpower in computer applications, the Government of India initiated programmes on generation of manpower for computers. Several

committees were formed and workshops were held to determine the manpower requirements in the area of Information Technology. Rajaraman Committee presented requirements during 1980-85 and Sampath Committee evaluated the requirements during 1985-90.

Table 1 *Rajaraman Committee report*

Estimated Manpower Requirement for 1980-85	
Ph D	250
M Tech	2500
B Tech	1500
Special systems analysis training	2500

Table 2 *Sampath Committee Report*

Requirement of Manpower during 1985-90							
Year	Ph D	M Tech	B Tech	MCA	DCA	Operator	Data Prep. Assistant
1985-86	71	825	495	195	750	2000	3500
1986-87	79	1050	630	210	1000	2500	4000
1987-88	88	1275	765	230	1250	3200	5000
1988-89	97	1500	890	250	1500	4000	7500
1989-90	105	1725	1000	265	1700	5000	800
Total	440	6375	3780	1150	6200	16700	28000

No doubt, the emphases of the above mentioned committees were more on Formal Education but soon it was felt that Non-Government sector in the field of Computer Education has an important role to play. This was reflected in the Government of India's new- education policy announced in 1986. Under the programme on Generation of manpower for computer, computer courses aimed at developing computer professionals were initiated at about 250 institutes in the country. The Combined output of these institutes in Ph.D, M.Tech, B.Tech, MCA, DCA, B.Sc. (Computer Science) was about 7000 in 1987. Government of India had a massive programme of introducing computer courses in about 100 higher educational institutions every year.

According to one estimate the number of organizations providing formal computer training till 1988 at different levels is as follows:

Course	No. of Insitutions	Output Per Year
Ph D	20	20
M Tech	20	400
B Tech	50	1000
M C A	20	600
D C A	100	2500
B Sc Computer Science	30	400

MCA and DCA courses were introduced in 1983 recognizing the acute shortage of manpower in Computer Applications. The model curriculum were developed by DOE. Due to rapid Changes in Technology, a review of curriculum was essential DOE,asked the Indian Society for Technical Education (ISTE) to prepare a revised curriculum for these courses.

The ISTE formed a working group consisting of representatives from institutes conducting these courses, DOE, MHRD, UGC, industry and professional societies which prepared and published a revised curriculum in 1990 for the guidance of institution conducting their courses.

In 1983-84, the DOE gave approval and financial sanctions to nine institutions to establish MCA degree programme. This program was very well received by several organizations and so the number of institutes offering MCA was gradually increased to sixty. One of the major problems in running MCA program was the shortage of trained teachers. Summer and winter schools are being organized to train teachers teaching these courses.

Defence Research and Development Organization(DRDO) had a Comprehensive Scheme of running M.Sc Computer Science program in seven institutes in different parts of India. These courses were completely sponsored by DRDO. The students are being given fellowships and are absorbed as scientists in DRDO.

The NIC provides informatics services to the Govt. of India at different levels NICNET nodes throughout the country connected computer systems at Central Government Departments, State Govt. Secretariats and District Collectorates.

Computer literacy is an important activity of NIC. Training divisions are established at most of the District Centres of NIC.

Following is the classification of training programmes of NIC.

- Training Programme for apprentice software user

- Management training programme
- Training programme for government officials
- In-house updation programme

Beside the Government Departments the universities and national institutes two of major professional bodies namely IETE and CSI have many activities to provide computer education in India.

5. THE INSTITUTIONS OF ELECTRONICS AND TELECOMMUNICATION ENGINEERS (IETE)

IETE is one of the most important institutions that caters to the needs of students, technicians, engineers, scientists at all levels in the field of computers, electronics and telecommunications. This was established in 1953 and now has 17 centres and 9 sub-centres spread all over India. It has over 30,000 members. IETE constantly interact with industry and is well represented in the Government and other special committees. It has been organising seminars and symposia on various topics in the area of electronics, computer and telecommunications. It has bilateral relationship with foreign institutions. Recently, IETE signed a Memorandum of Understanding with IEEE. It is publishing, Journal of IETE, Students Journal and IETE Technical Review. It has published special issues in the recent past to provide state of the art in the selected topics. It is also offering Advanced Level Course in Computer Science(ALCCS) (Deemed to be equivalent to M.Tech)

6. COMPUTER SOCIETY OF INDIA (CSI)

CSI is a registered society of computer professionals and Information Technology experts all over the country as well as from foreign countries. The society was registered in 1965. It has 50 chapters and 33 students' branches all over India. Its total membership is above 13,000 with about 800 institutional members.

The various activities of the society are conducted at Chapter, Divisional, Regional and National level. The workshops at various levels, quiz and essay competitions, Annual Conventions and Exhibitions are some of the important activities of the Society.

In view of the global shortage of qualified manpower in the computer, the society has not only conducted activities to spread computer education but is also involved in testing the level of expertise and skills acquired by the trainees. the society conducts tests at various levels.

The society has formal association with sister organizations from other countries like International Federation for Information Processing (IFIP), South and East Asia Regional Computers Confederation (SEARCC), Computer Society of IEEE. CSI brings out following publications:

- CSI Communications
- CSI Digest
- CSI Student Journal
- Computer Society and Informatics

7. DEPARTMENT OF ELECTRONICS ACCREDITATION PROGRAMME

The Government of India was made to realize through the recommendations of various committees that it was necessary for the Government to involve non-government sectors in the crucial area of education in Information Technology. The sudden boon in the demand of computer skills resulted in thousands of commercial institutes in computer education, many of which were not able to provide minimum gravity for the amount of fees they charged

In order to provide stability to Computer Training Industry the DOE began coordinating with leading institutes in 1984 to define a method of providing locus standi to private institutions. DOE has taken a policy decision in 1985 to encourage non-formal training by giving recognition to selected private training institutions which come to certain standards in regard to imparting computer training.

Government has been exploring avenues by which the effort of private institutions can be utilized properly leading to quality product which could help the employers recruiting professionals in the areas of Information Technology. The Government modified its Computer Policies-1986 by approving schemes by which private sectors & training institutes meeting certain norms, will be approved for conducting certain specified courses.

The DOE decided to implement the scheme through two professional societies-IETE and CSI. These societies conduct examinations for four levels of courses, namely, "O" Level (Foundation Course), "A" Level (Advanced Diploma Course), "B" Level (Graduate Level Course), "C" Level (Post-graduate Course).

Most of the private institutions are imparting training in the areas such as —

- Computer Fundamentals
- Programming Languages
- Structured Analysis & Design
- Business Data Processing
- Database Design
- Database Management System
- Operating Systems
- Fourth Generation Languages
- Project Management
- Distributed Information System
- Office Automation
- Management Information Technology

All these subjects are covered in the form of short term part- time courses and also in the form of full-time diploma and certificate courses. The Universities and other government institutions have more or less similar programmes such as B.Sc. with Computer Science, B.Sc. Electronics, M.C.A., D.C.A., M.Tech. (Computer Science), Ph.D. (Computer Science).

The contents of these programmes are generally based on the guidelines prepared by the Department of Electronics. In addition to the formal class-room teaching, students are required

to work in some organizations for a project to develop real time software or they may work on some application area. On the other hand, the private institutes provide training mostly on business application through their consultancy divisions. The Computer Maintenance Corporation (A govt. of India Undertaking) and private consultancy companies offer consultancy in wide range of areas including selection of hardware/software, development of applications software, system management, project management, office automation, AI and Expert Systems, Local area network and in the areas of telecommunication services. Defence Research & Development Organization (DRDO) has also made substantial contribution towards manpower development in the Information Technology. Working for over a quarter of a century at the frontiers of hi-tech technology, the DRDO have been developing hardware and software for armed forces which they are now trying to make viable for commercial use. They have recently tied up with ECIL for marketing their products within India. Their hardware products CAD/CAM, image processing products are being appreciated. In recent CSI conventions they have displayed a processor that can be used with both the Motrola and Intel chips. ANUVEC (a scalar accelerator that can be used to develop powerful graphic work station personal super computer) and Chatur Robot (a product of Centre for Artificial Intelligence & Robotics).

The private training institutions have contributed significantly in the area of manpower development in IT. It is estimated that top ten training institutions are training 40,000 per year. About 2,50,000 students are undergoing courses as a part of their school curriculum.

The Government institutions being unable to entirely fulfil the increasing demand for admission to computer course, the students are increasingly approaching private sector institutions for the same. This resulted in the need for standardization of curriculum, certificates/diploma being awarded. On one side the Govt. of India is working on a policy to involve private sector organizations in developing manpower in IT, some of the private institutions have formed Manufacturers Association for Information Technology (MAIT) to complement Govt. education system in computer Manpower Development. The DOEACC programme is one such step. The 'O' level computer course under DOEACC scheme has been initiated all over the country.

The A,B and C level courses are comparable to formal DCA,MCA and M.Tech programs respectively.

DOE schemes of accreditation of private institutes is a long awaited measure and has been welcomed by all including the Manufacturers Association for Information Technology (MAIT). It is felt that this will lead to organize a responsible computer training industry. Till september 1991, 123 private institutions have been given provisional accreditation under DOEACC schemes.

8. CONCLUSION

Today India is witnessing a computer boom. Computerization has been the driving force for the development of Information Technology. India has a large number of Government institutes universities and private institutes offering formal and non- formal courses and

training programs in the areas of Information Technology. Computer education, consultancy assignments, training and software development require effective methodology to ensure high quality products. India requires high quality human resource for creation of trained manpower in the areas of information technology. It is encouraging to note that the Department of Electronics has launched schemes to encourage private sectors in computer training and have brought together experts and professionals from universities, professional societies and industries to evolve standards to cope up with rapidly changing curriculum requirements. NIC involvement should not be restricted to training of Government officials but should also be extended to train the teachers of Government and private institute offering computer science courses. The Department of Electronics must assure active support and participation for joint initiative with CSI, IETE, CMC etc., for developing mass scale application of Information Technology. No doubt, the academic standards of formal DCA, MCA programmes are the responsibility of the concerned universities but DOE has an effective role to play to ensure that these programmes produce well trained professionals.

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III

DECENTRALISATION OF INFORMATION SYSTEMS IN DC'S: POWER TO THE PEOPLE?

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ABSTRACT

This paper describes three case studies of large-scale decentralised computer-based information systems, two from developing countries and one from the U.K. Some reasons for their relative success and failure are analyzed, and impacts on the empowerment of staff and management control are discussed. These issues are related to a simple categorisation of decentralised information systems dependent on their primary purpose and the approach taken to their design and implementation. Some conclusions are drawn on future desirable approaches to the development of large-scale decentralised information systems in a developing country context, and on the possible impacts of such systems for the empowerment of different social groups.

1. INTRODUCTION

Computer-based information systems (IS) are becoming increasingly common in many developing countries, but there is some evidence in the literature that successful applications are the exception rather than the rule, particularly in the case of large-scale systems. For example, Odedra [1] described six case studies of IS applications from both government and private sector organisations in three sub-Saharan African countries, and concluded that in only one organisation was the application successful. Kaul et al [2] described thirteen case studies of IS applications in various government departments in seven Asian countries. Some of these were clearly unsuccessful and, in a number of other cases, it is not possible to determine whether the systems were being used successfully since, as noted by Walsham et al [3], the sociopolitical and organisational dimensions of the cases were treated rather superficially. In at least one of the cases, known to the author, the system was 'implemented' in a technical sense, but was not being used to any substantial extent. There are no comprehensive surveys of IS applications in developing countries, so the above evidence is largely anecdotal. Nevertheless, the general impression is one of relative failure rather than relative success in the implementation of large-scale computer-based IS in developing countries.

One of the reasons why systems may fail, which is explored in some detail in this paper, is that the initiative for such systems, and their design and development processes, often reflect a top-down approach, with those at the centre of a government department or the senior levels

of a private company deciding on the scope and detail of the systems. One problem with this approach is that the systems developed often do not support the work activities of people at lower hierarchical levels in the organisation. Indeed, such people sometimes regard the new systems as an additional burden, since they are required to provide the data and maintain the systems in addition to their existing work. An alternative approach to system design and development would be to work from the bottom-up, aiming to provide systems which assist and complement the human capabilities of people at lower organisational levels, with data for central control being regarded as an important issue, but not the only one considered in system design.

One of the reasons why senior managers and politicians may resist a move towards this form of decentralisation of computer systems is the fear of empowerment of those at the periphery, at the expense of themselves at the centre. However, whilst this can undoubtedly occur, computer systems can be designed to provide information to lower-level employees of direct relevance to their job and, at the same time, provide information on the performance of employees for management control. In other words, IS can allow for delegation without the loss of control. Zuboff [4] coined a new word 'informate' to describe the process, seen in her U.S. case studies, whereby information technology not only automates procedures and approaches but, simultaneously, produces new information. Activities and events are made more visible when a technology informates as well as automates.

Zuboff also argued that these new processes, in the context of the U.S.A., would have significant impacts on traditional aspects of power and authority in organisations, with more widespread intellectual skills being developed and used at all organisational levels. This can be related to a further reason why senior people in developing countries may resist decentralised computing systems, namely that traditional cultural attitudes favour centralised systems and autocratic approaches to decision making, and that these are threatened by decentralisation of authority, even if performance can be monitored. This is not merely conservatism, but reflects self-interest on the part of the existing elite, who wish to ensure that their privileged position is not undermined by new approaches such as decentralised computer-based information systems.

In the main body of this paper, three case studies are used in order to investigate decentralisation of computer-based IS and related issues such as control, empowerment, and the impact of cultural attitudes. Prior to this, in the next section, a simple polar categorisation is developed of decentralised large-scale IS, which will be used as a vehicle for discussion of the case studies. In the final section of the paper, some conclusions will be drawn with respect to future approaches to such systems in developing countries, and their possible impacts on various social groups.

2. A POLAR CATEGORISATION OF DECENTRALISED LARGE-SCALE IS

It is difficult to define the meaning of 'large-scale' computer-based IS in any exact way, but the essence of the concept is that the system should involve a considerable number of organisational personnel, normally in different spatial locations, and that the cost should be a significant item of expenditure for the organisation. The addition of the term 'decentralised'

implies that the primary focus of the system involves people and activities at lower levels in the organisational hierarchy. Examples of large-scale decentralised IS include government systems which are implemented across all administrative districts, or a banking system which is used in all of a bank's branches. In this section, a simple categorisation is developed of such IS applications on the basis of the purpose of the application, and the approaches taken to design and implementation.

Type A applications have as their primary purpose the provision of information on activities at lower levels, so that it can be accessed and used for control purposes at higher levels. The approach to design of such systems is for those at the higher levels to determine the information which they need for control, and to design the system to provide this. The approach to implementation is to provide training to lower level staff on how to provide data to the system, how to maintain it, and ideally some notion of its purpose in terms of higher level control. These attributes of a Type A system are summarised in Figure 1 below.

Type B applications have as their primary purpose the support of lower level staff in performing their job; this does not exclude the use of selected information for higher level control, but this is not the initial focal purpose. The approach to design of Type B systems is to involve staff at local levels in order to understand what information they would find helpful in order to support their work; ideas can be generated either by central staff or by those at lower levels. The approach to implementation involves training, but also a process of continuous learning from local experience in order to modify and improve prototype systems. These attributes of Type B systems are shown in Figure 1. The approach of Type B systems is generally similar to that advocated by Bhatnagar and Patel [5] for decentralised computing for rural development, and by Sanwal [6] for end-user computing in development administration.

Figure No. 1 *Two Polar Categories of Decentralised Large-scale IS*

	Type A	Type B
Primary Purpose	Information for higher level control	Information for lower level support
Design Approach	Designed at centre	Designed by local/centre interaction
Implementation Approach	Training for lower level staff on data collection/ input	Training, but also continuous learning and system modification

It was noted in the previous section that there are good reasons why most large-scale IS in developing countries may incline towards Type A; these reasons were fears of loss of central power in any move towards Type B systems, and the close link between Type A systems and existing cultural attitudes favouring autocracy. A further reason which has been given to the author by central planners in support of Type A approaches to design is that lower level staff

in developing countries have poor levels of education and training, and thus are not suited to being consulted as in Type B systems. This reason is strongly related to cultural attitudes to power and authority, and a wide perceived difference between staff at different hierarchical levels.

It is important to note that the systems described above are 'ideal types', in the sense that any real system will be much more complex than is represented here, and will normally contain elements of both Type A and Type B systems. Nevertheless, it is suggested that the two types provide a useful analytical basis for the discussion of real systems; three case studies of actual systems are now presented, the first two from developing country environments and the last one from the context of the U.K.

3. CASE 1: INTIS

3.1 Outline Description

INTIS is a central government integrated development project information system in an Asian country. The system was initiated in 1981 following a study which identified various limitations on the government information systems for managing development projects. These limitations were that some projects were not reported by the implementing agencies; there was incomplete, inaccurate and late reporting; and the systems run by central agencies were not being properly co-ordinated. In order to resolve these problems, a central Development Co-ordination Unit (DCU) was charged with designing the new system INTIS, using parts of existing systems where appropriate, for 'the purpose of planning and controlling development projects as well as making necessary decisions'. Some further background on this case is given in [7].

The twin objectives of INTIS were to provide a common database with a common data source, and to provide end-user facilities to government agencies to plan and control development projects. The INTIS Distributed System was made available in 1987, and various government ministries and state development offices were provided with a computer and printer which were linked directly to the main computer system at the DCU in the capital city. The system provided the facility to input, update, store and transmit simple output formats. Some query programmes were also provided for access to the main database.

The system could appear successful from the preceding description, but in fact it was not considered valuable by many of the participating agencies. A senior official in a central government agency said:

"The work involved in providing information for INTIS is additional as we do not want to use the more micro-level information INTIS requires. ... For the micro type of data INTIS requires, it should be decentralised."

The information needs at the ministry level also differed from what was provided by INTIS. According to an official in one Ministry responsible for providing input to INTIS:

"INTIS, being designed for all ministries for all types of development projects, is too simplified to be of use to this Ministry. What the Ministry keeps track of and what is given to the DCU (for INTIS) are two different things. INTIS is useless to the Ministry."

At the state level, the difficulty lay in providing data from the relevant agencies working in the field on actual projects. Thus, an officer from one State Development Office said:

"They (local agencies) don't keep records and don't have the required data. We (the State Development Office) have our own format for data collection, and don't use the DCU's prescribed format. In addition, we have detailed information on problems in project implementation, which are not required by the DCU but are required by the State Secretariat."

In addition to the criticisms from the individual agencies above, it should also be noted that the measures of performance on development projects provided to central government were inadequate. Qualitative criteria such as continued dependence on government versus self-reliance were important measures of development not captured by INTIS. Even the measures of financial and physical progress in terms of 'percent spent' and 'percent completed' were relatively meaningless indicators given the complexity of most development projects which cut across various ministries, as well as the absence of any comparison with performance standards. Thus, the information provided by INTIS did not enable senior government officials to judge the impacts or cost effectiveness of programmes towards national or sectoral goals.

3.2 Analysis

The INTIS project can be classed as strongly Type A. The primary purpose of the system was information for higher level government control of development projects. The system was designed at the centre by the DCU. The approach to implementation involved training for various staff in the agencies involved in data collection and input to the system. The approach to system design and development was suited to the cultural style of this Asian country, which is hierarchical and authoritarian in its approach to management and decision making. The system can be considered a failure by most criteria, other than perhaps as a learning experience, and two key aspects of this are now discussed.

The first point to note is that the system did have some element of Type B purpose, in that it was aimed to provide useful information to agencies such as government ministries and state development offices. However, no attempt at Type B design was made, in that the various agencies were not consulted in any detail about their own information needs and provision capabilities. Thus, not surprisingly, the completed system was of little use to them, and indeed was regarded as a burden by officials in these agencies, particularly those charged with providing data for INTIS. Even if Type B design had been attempted, there is a serious question as to whether the vision for an all-encompassing system of value to all agencies was flawed in principle. The type of information needed for management and control purposes varies between different agencies and at different hierarchical levels; a system providing the same type and detail of information to all levels is an inappropriate approach.

A related and crucial point with respect to the largely Type A approach of INTIS is that, in addition to not being highly valued by the contributing agencies, the information provided for central control purposes, the *raison d'être* of the system, was ineffective for the purpose. The information was not distilled from a real sense of the complexity at the lowest levels in the villages and districts; this illustrates a major problem with Type A systems, namely that information for control imposed top-down may well represent the variety at local levels so inadequately that it has little value at the top level. Indeed, in giving a false sense of the realities at the lower levels, it could be considered counterproductive to effective management and control at the centre.

4. CASE 2: CRISP

4.1 Outline Description

The Computerised Rural Information Systems Project (CRISP) was an initiative of the Government of India aimed at providing a microcomputer-based information system for decision support and report generation in District Rural Development Agencies (DRDAs). The system was linked in concept to the Integrated Rural Development Programme (IRDP), which aimed at alleviating poverty in rural areas by providing sustained self-employment to selected families through the provision of subsidy and credit for the purchase of an asset such as a dairy cow. The description of CRISP and IRDP in this section draws heavily from Madon [8,9].

CRISP was based on the experience of an experiment in the Karwar district of the state of Karnataka, where the project director of the local DRDA introduced a microcomputer-based information system to improve the local level of decision-support. Systems design and development involved the active participation of the staff, who were also provided with training on how the computer could be used to help them in their work. The project resulted in a marked increase in the district's performance, according to Patel [10], in such areas as an improved database concerning local development activities, improved co-ordination with the banks, and more time freed up for field visits.

Based on the Karwar experience, the Department of Rural Development extended the project initially to 10 districts throughout the country, and then soon after sanction was given to all DRDAs in India to purchase micro-based hardware and particular software. The software comprised the menu-driven CRISP, developed by the National Informatics Centre in New Delhi, and several other tools such as Wordstar, Lotus 1-2-3 and dBase 3+. The initial version of CRISP was basically a report-generating application. The specific objectives included the provision of an easy method of generating various reports prescribed by the Central and State Governments, and the creation of a record of beneficiaries and projects connected with the monitoring of the IRDP.

Detailed research in the 19 districts of a specific state, that of Gujarat, has shown that, in every one of them, the manual monitoring system still prevails and the CRISP system is not used for report generation. A number of reasons have been given for this state of affairs including: inadequately-trained staff to operate the system; a mismatch between the reports generated by CRISP and the reports required to be prepared by the DRDA for the Gujarat

State Government; political rivalries between the Central and State Governments; and the massive data requirements of CRISP involving around 100,000 beneficiary records per district. With respect to this latter point, it is important to note that serious doubts have been expressed about the IRDP programme as an instrument for poverty alleviation, with evidence suggesting that the genuine poor are rarely helped. It is beyond the scope of this paper to discuss such issues in detail, but it is worth noting that the task of adequately identifying and monitoring the large number of potential and actual beneficiaries of the IRDP programme is well beyond the resource capabilities of the local DRDAs.

This brief description of the CRISP project can be ended on a slightly more encouraging note. The author recently interviewed the head of computer training in the Gujarat State Government, who said that, although CRISP had failed in Gujarat, the hardware is being used in a number of districts, in connection with the spreadsheet, database and wordprocessing software provided earlier, to produce financial statements, maintain simple databases, and compile reports. In commenting on the failure of CRISP itself, this official mentioned that Karwar district was an English-speaking area of a 'very different' State, and that the language issue was another reason why the centrally-developed CRISP failed, since Gujarati is the main working language in his State.

4.2 Analysis

The initial experiment in the Karwar district can be classed as a strongly Type B application. Although the initiative for the project came from the project director of the local DRDA, the emphasis of the system was on helping all staff levels to do their job. The approach to design involved active staff participation, and good staff training was seen as a key to successful implementation.

The idea from Karwar district was taken over by Central Government, and developed as a largely Type A project, at least with respect to CRISP. The primary purpose was seen as the provision of information for higher level control by State and Central Government. The CRISP system was designed by personnel in New Delhi, with little or no consultation with district level staff. The Karwar district director who pioneered the initial system was co-opted to the Central Government project, but he switched roles from end-user to systems manager when 'replicating' the system across all districts. The training focus was on the data input needed by CRISP and the amount and type of training was inadequate, at least in the Gujarat experience. It is interesting to note that, although CRISP failed in Gujarat, the availability of hardware and simple software at district level has led, latterly, to some Type B development in some districts. In other words, local staff have started to develop some applications to support their own work, in a genuine sense of end-user computing.

A further qualification to the initial implementation failure of the CRISP system reported above is that the detailed research took place in only one state. There is some evidence that other states may not have fared so badly and indeed that the system is seen as relatively successful by the Central Government. It is clear that success will be viewed differently by different stakeholder groups such as clerical operatives in the districts, managers of the central unit, and system developers. Nevertheless, from the perspective of the districts in

Gujarat, the CRISP system can be seen as a failure in terms of providing them with a useful monitoring and report generation system.

A final comment on this case is that computer-based information systems, no matter how they are implemented, do not solve basic issues of inequity, corruption and incompetence which are some of the main criticisms of the IRDP itself. At best, IS can perhaps make such issues more visible, with the hope that this supports those people who are attempting to intervene for the benefit of the genuine poor and powerless. Even this modest aim is unlikely to be achieved by Type A systems that attempt to define measures for central control which are meaningless in terms of what is happening at the grass roots.

5. CASE 3: SKY

5.1 Outline Description

Sky Building Society was a medium-sized U.K. building society with around 250 branches at the time of the research study, whose primary business was the provision of mortgage loans to individuals for the purchase of houses using capital invested by account holders. A new Chief Executive, who will be called Brown, was appointed in 1981 and remained in office until 1987; during this time, a number of new computer-based IS were designed and implemented and the key ones for the discussion here involved the decentralisation of investment account processing and mortgage applications processing from the mainframe system at the administrative centre to branch front counters. These two systems enabled improved customer service in terms of up-to-date account information and a much quicker turnaround for mortgage applications. Further benefits of the new systems included the availability to management at the centre of an instant profile of the Society's lending on a branch and regional basis. Elements of this case were described in [11] and a much fuller description is given in [12].

A key element of Brown's vision for Sky was a focus on customer orientation which, if followed through to implementation, would provide high levels of growth and profitability for the Society, which indeed did occur during the period of his leadership. With respect to IS, Brown's vision involved decentralisation of IS to support staff at the branch offices to deliver better service, and in the process better information on performance for senior management monitoring and control. He said the following about this approach:

"So many management information systems I've seen have been corporately imposed downwards ... They are not there to help run the business; they are designed to provide more figures for a centralised management ... So the first thing we did ... was to bring computer service right up to the customer interface for investors and subsequently in 1985 for mortgage lenders too ... But you also of course get the spin-off of management information which comes from being able to capture information economically, in quantity, precisely, with an identified individual who did it ...".

It is interesting to note Brown's view on how to manage the process of design and delivery of computer-based IS which genuinely support branch staff in doing their jobs:

"So what I did in Sky ... was to introduce a half-baked system which was then modified by a lot of feedback (from branch staff) - trying it on and polishing it until it fits the business ... The important thing is that you keep on evolving the system, and that enables you to keep it relevant. So at no point are people going to say 'this system is never going to work ... let's ditch it' ... That sort of responsiveness is very important, otherwise I think there is a view that 'this system is being imposed on us'. You must overcome that negative attitude developing."

Brown's attitude to the work of the branch staff represented a commitment to their importance. This commitment was symbolised, and the process of cultural change in the organisation was mediated, through a major and costly training programme. Brown described the rationale and the process of this as follows:

"So staff training is important, communication, you do need to spend more ... on continual training, monitoring. So that you go through a period when you have a peak in costs, when you have costs associated with introducing a new system, and costs still associated with running and then running down the old system. This is always the time when confidence is lowest ... That's the time when you have to be fairly tough and stick with it until it works. Then you come out into the Promised Land in that respect."

5.2 Analysis

This case is a good example of a sophisticated Type B approach, where the primary purpose of the computer-based IS was to help local branch staff to provide improved customer service. Nevertheless, although this was the initial focus, the systems enabled much improved and timely information for high level control. Indeed, Brown himself used a personal computer, linked to the mainframe database containing summarised branch information, to directly monitor the activities of the branches. It is interesting to note Brown's learning approach to systems design and development. He talked of his inability to know exactly what was needed at the 'sharp end of the business', and thus the right approach being to develop 'half-baked' systems which were consistently improved with use until they 'fitted the business'. Brown's approach to implementation is bound up with these elements of organisational learning and with his heavy emphasis on the importance of relatively costly training programmes.

This application of computer-based IS took place in a developed country context, but it is important to note that there are also many examples of failed systems and Type A top-down applications in these contexts. A second comment on this case is that Brown was not a hero who could do no wrong; space does not permit much detail on this aspect of the case, but it is worth noting that Brown's goals were rather short-term in nature and, in the view of a number of colleagues, aligned with his own self-interest. In addition, he practised an autocratic approach to high level strategy and decision making, which left a senior management vacuum after his departure in 1987. The main reasons for the inclusion of the case in this paper are, firstly, that it provides an excellent illustration of a Type B approach to the development of computer-based IS; and, secondly, that it provides important lessons for the purpose, design, and implementation of large-scale decentralised IS in the context of developing countries.

6. CONCLUSIONS

In this paper, only three case studies have been described in outline, and any conclusions drawn must be regarded as provisional in nature. The conclusions will be focused on large-scale decentralised IS in developing countries, although some of the empirical work was conducted in the U.K., and themes such as delegation and control are important in all contexts. A further qualification is that the developing countries are highly heterogeneous, for example in terms of attitudes to authority, and any conclusions need to be tempered in view of this diversity. [See [13], for example, on attributes of Chinese culture related to computer-based information systems].

The first conclusion is that *Type A applications in developing countries are unlikely to be successful in any substantial sense.* Type A applications do not assist staff at lower hierarchical levels in doing their jobs since, as was seen in both the INTIS and CRISP cases, they are not designed in conjunction with such staff, are seen by them as an extra burden, and are not utilised when 'implemented'. In addition, the information for higher level control provided by Type A applications is likely to be inadequate for the purpose, again as seen in both the INTIS and CRISP cases, since good higher level information needs to be distilled from lower level data which is a fair reflection at that level. This is unlikely to be achieved unless the lower level data relates well to people's jobs at that level. If this first conclusion is valid, then scarce resources are being wasted in a profligate way by Type A applications; yet this approach may be quite common in developing countries at the present time.

The second conclusion is *that developing countries should try to move towards Type B approaches to decentralised IS.* Such applications should be geared to providing genuine assistance to staff in doing their jobs. There is every indication that such assistance could be provided by computer-based IS in areas such as the planning and monitoring of development programmes at district level. The small-scale applications of spreadsheets, databases and word processing in some of the Gujarat districts is an illustration of the potential. The vision for such systems, and necessary elements of co-ordination and integration, may indeed come from higher levels. A further supporting argument for some central direction and control in developing countries is that it limits the scope for corruption at local levels. However, detailed design and implementation must be conducted in close co-operation with lower level staff. One approach to design and implementation with elements of central direction and local involvement is to use several iterative stages or phases, where learning takes place during each phase which can be used in subsequent phases. Jain and Raghuram [4] provide an example of a railway freight information system in India which is following this phased approach to system implementation. One argument as to why Type B applications may not be common in developing countries, particularly in the government sector, is that they are not suited to current cultures and management approaches which favour centralisation and autocracy of an established elite. This may well be the case but, as we see in the current movement in Africa towards multi-party democracy, political and cultural systems are not static, and a move towards Type B systems can be perceived of as an example of constructive change.

The third conclusion is that *Type B systems do not necessarily decentralise power to local levels.* Type B systems empower staff at lower levels to do their job more effectively but, as seen very clearly in the case of Sky with respect to branch staff, this can result in closer central surveillance and overall control of local activities. The desirability of tighter surveillance and control is a contentious issue and no generalisation is possible since it clearly depends on the circumstances in particular contexts. However, it is worth noting that, even where Type B systems result in closer central control, lower level staff who are empowered to do their job more effectively may start asking more searching questions about the quality of higher level management and decision making. This 'undermining from within' of the basis of autocratic control may be a reason why self-serving elites would wish to avoid Type B approaches; and provides a further reason for suggesting a movement in this direction.

Finally, turning to the title of the paper, are decentralised IS in the developing countries a way of giving more power to the people? The 'lower level' people discussed to date have been those at lower hierarchical levels in government and large private sector organisations, who are themselves members of the elite in developing countries in comparison to most people in the villages, rural areas, or urban slums. This leads to the final conclusion that *decentralised IS do not empower the disadvantaged in a direct sense, but well-designed local IS can perhaps be of some indirect help.* The first part of this conclusion is probably uncontentious, but what support can be given to the second part? A decentralised IS in a district of Gujarat, for example, which really helps local planners in monitoring and controlling local development projects, should offer some hope that such projects will be more effectively conceived, carried out and implemented. However, if the projects themselves, as is suggested by commentators on the IRDP in India, do not reach the disadvantaged in any significant way, then the only benefit of the use of computers may be increased visibility for this effect. A more positive contribution of computerisation, in assisting in the planning and execution of projects targeted at the genuine poor, depends on the commitment and political will to help the disadvantaged which is needed on the part of people throughout the world, and this human commitment cannot be provided by computers.

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COMPUTER-BASED INFORMATION SYSTEMS FOR DEVELOPMENT PLANNING: A CASE STUDY

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ABSTRACT

Administrative reform currently being undertaken in a number of developing countries is focusing on the introduction of microcomputers as a tool for the decentralisation of development administration. However, with all these experiments, the major objective of improving the effectiveness of development planning remains unfulfilled. A major reason for this has been inadequate attention paid to the social context within which the technology is implemented. In the literature, however, there is little discussion of how the social context of development administration interacts with the process of technology adoption. This paper describes a case study of the application of computers for development planning in India. The complex interaction between the social context of development administration and the process of systems implementation is examined longitudinally. The findings reveal that an understanding of this interaction is crucial if information technology is intended to play a meaningful role in managing development.

1. INTRODUCTION

Administrative reform in a number of developing countries has recently been directed at achieving decentralised rural development planning through the diffusion of technology to a relatively small area of administration known as the district. In India, district planning by elected representatives is being introduced in the states with the National Informatics Centre placing microcomputers in each of the 439 districts. In Africa, the Resource Management for Rural Development Project of Kenya is currently engaged in the introduction of microcomputers in the districts. In South-East Asia, Malaysia is extending its Integrated Development Project Information System (SETIA) to the districts [1].

With all these initiatives, however, the main object of improving the planning and monitoring systems of rural development remains unfulfilled. Evidence suggests that the main reason for failure stems from a lack of understanding of the functioning and dynamics of administration at the local level [7]. However, in the literature, analyses of organisational factors invariably focus on issues related to human resource development, infrastructure and resource management [6]. There is little explicit mention of socio-political factors in the planning environment and how they interact with the process of information systems implementation.

Avgerou [2] argues that the problems experienced in many situations stem from the fact that systems developers assume that development planning is a rational process. This view ignores the informal aspects of the organisation which affect the success of any modernisation effort such as the introduction of computer-based information systems. This is reflected in a number of empirical studies which highlight the importance of understanding informal work practices and decision-making systems that exist in the situation being investigated [3,5,8].

Analysis of the formal and informal relationships which exist in the environment within which the information system is implemented brings social and political interaction to centre stage, and with it the importance of stakeholder perspectives. A few studies have proved useful in developing conceptual models for analyzing the perspectives and information requirements of the various stakeholders in development administration. Sundharam [9] provides a vehicle for analyzing the informal negotiations of the planners at different levels of administrative hierarchy. In a similar vein, Kasimin's [4] study of information systems for development planning in Malaysia analyses the formal and informal context of planning and develops a framework to help planners analyze their systems and to specify their information requirements. The contribution of these two studies beyond the previous authors is their attempt to recognise the plurality of goals, perspectives and interests of the various stakeholders involved in the planning process.

Nevertheless, these conceptual frameworks provide a static view of informal subsystems and do not place explicit focus on highlighting the ongoing interaction between the context of development administration and the process of information systems implementation. This paper offers a contribution towards improving understanding of this dynamic interaction. It analyzes Computerisation of Rural Information System Project (CRISP) program by Government of India as a part of their effort of computerization of government departments in the districts.

2. RESEARCH METHODOLOGY

The broad research question that the current study attempts to address concerning the uses and consequences of CRISP is as follows:

Research question: The extent to which CRISP will either reinforce existing socio-economic and cultural patterns, or provide leverage points to change those patterns. This question suggests the following analytical elements of interest:-

- The shifting perspectives of key stakeholders within the problem domain
- The sources of power that exist amongst the different interest groups and how that power is wielded during the course of development planning
- The congruence or incongruence between the rational decision-making practices and information flows for development planning as conceived by the government and informal practice at the local level
- The impact of wider socio-economic and political variables on the local context. The analysis needs to be broad enough because the impact of many government interventions that take

place extend beyond the individual institution.

The research adopts a qualitative mode of inquiry. The description of the context within which CRISP is implemented is in terms of wider socio-economic issues and in terms of local work and decision-making practices surrounding CRISP. The table below represents the categorisation of contextual factors surrounding CRISP.

Contextual Factors Surrounding CRISP

Context	Factors of Interest
Outer	National development policies National technology policies Structure of institutions Infrastructure
Inner	Formal and informal work patterns Perspectives of stakeholders

The table describes the outer context as referring to the objectives and orientation of government policy towards rural development planning and towards information technology, and to the prevailing institutions that influence the development process. The inner context includes factors such as the local infrastructure, informal work practices and the perspectives of stakeholders at the local level.

The study draws on these contextual factors to describe the process of change brought about by the CRISP intervention. Within India, the case study focuses on the state of Gujarat where the author has spent several months of fieldwork. This state is relatively more progressive in terms of computerisation: it has actively been involved with computerisation at the state government level since the 1980s.

The main contributors of data at different levels of administrative hierarchy included a variety of administrators and politicians at central, state, district, block and village levels. The main means of data collection was via semi-structured interviews, in order to enable respondents to introduce variations on their choice of answer. Interviews with higher level officials and non-officials tended to be more structured, while interviews with lower-ranking staff and the local public took the shape of informal discussions. A longitudinal research design was adopted in order to explore patterns in the co-evolution of information systems and social settings. Even though causality between linkages may not be proven, it was assumed that the ability to understand how conditions change over time and evolve would provide important information for future studies. The researcher aimed to return to the research situation at intervals of about nine months in order to see how the situation had altered.

3. MAJOR FINDINGS OF STUDY

Drawing on the case study findings of the wider and focal contexts within which CRISP is implemented, the main thrust of the study lies in analyzing how the process of information systems implementation draws on structure and changes structure. This process is broken

down into three stages which represent natural breaks in the course of events over time.

3.1 Phase 1 : The Pre-CRISP Phase prior to 1987

The lack of an integrated policy for IRDP had resulted in the creation of a multitude of programmes aimed at alleviating poverty, but which lacked strategic focus. In an attempt to coordinate these disparate efforts, a number of centrally-sponsored programmes emerged. However, these programmes aimed to rationalise planning at sub-national levels, without understanding the dynamics and causes of inefficiency at the local level. This tended to undermine the planning role of the state government and led to power conflicts between the centre and the state which exist to this day.

At the local level, the lack of strategic focus to rural development and the reluctance to devolve power meant that the planning and service roles of the District Rural Development Agencies (DRDAs) were downgraded. Planning for the DRDA has been reduced to the ritualistic observance of targets set by higher authorities to be achieved for each district. This target orientation has resulted in IRDP performance being measured in terms of financial expenditure and the number of households assisted, rather than in terms of alleviating poverty.

The hidden costs of imposing administrability through target setting by higher levels has been to shape the values of administrators at the local level. The task of IRDP implementation is viewed by them as an impersonal and mechanical exercise of little value since they are not given any opportunity to interact with superiors or become involved in planning. This has led to feelings of neglect and apathy among local administrators towards their duties. It has also had the effect of promoting vested interests in terms of political and social status. There is a general consensus amongst administrators about the kinds of demands that can legitimately be entertained. There is a reluctance to undertake any activity which is conceived in the wider interests of the programme, but which does not make the business of reaching targets any easier.

Over the years, the systems described above has generated a particular work culture which has shaped the attitudes of officials and set the pace of work. This has had the effect of creating an iron frame within which to manage the IRDP. Attempts made at introducing new structures soon had to be abandoned as it proved difficult to modify relationships between different echelons of the hierarchy. It was in this scenario that the CRISP initiative was born.

3.2 Phase 2 : 1987 - 1990

Perhaps the strongest enabling factor for CRISP was the change in attitude of India's political leadership in the mid-1980s. This triggered off a drive towards computer applications of a development-catalytic nature. However, once the impetus for change had got under way, various historical and contextual aspects influenced the process of systems design :-

- The inherent rigidity of the administration which had hampered previous attempts at reform to modify structures influenced the process of systems design. This rigidity

manifested itself in the deliberate design decision taken by the central government to develop CRISP as an overlay of the existing IRDP manual monitoring system in order to increase its chances of acceptability. However, by doing so, the data sets were not derived from a model which reflected the reality of the local environment. As a result, CRISP served to perpetuate the practice of reducing the complex task of rural development to simple administrative procedures.

- Historic tensions which had existed between the centre and the state were further aggravated by the launching of CRISP. While the cornerstone of the CRISP project was to be decentralisation of the technology diffusion process, in practice the system was designed and developed without any consultation with state governments concerning their requirements. The initiative therefore served to rekindle a context of hostility between the centre and state administrations which caused the state government to act as an opposition group to the CRISP project soon after it was launched.
- The problems encountered during initial attempts to implement CRISP can to a large extent be attributed to the lack of adequately trained data processing personnel at the district level, and to the lack of awareness among administrators about the potential of computers for IRDP. Computer training was inadequate in terms of course content, duration and frequency. Most of the trainees were novice users and found that courses were of insufficient duration to enable them to grasp even the basic concepts and to be able to retain the knowledge they had gained during training. Faced with a shortage of manpower to operate the equipment, junior clerks were put under increased pressure to perform data entry in addition to their regular duties. Rather than computerisation resulting in less 'pen-pushing', this group saw a rapid expansion of their duties which provided a serious disincentive for them to use the equipment.
- Human resource development had also been hampered by the language barrier. The CRISP user interface was in English while the main language of communication at the local level was Gujarati. Another obstacle was the transfer structure prevailing in the bureaucracy. Senior officers felt that they had little incentive to send their staff for computer training since they were all on deputation and may be transferred at short notice. This meant that efforts at computerisation were staggered. The frequent transfer of directors also affected continuity of computer activities within district offices. The importance given to the concept of the 'leader' in the administration meant that the attitude of the director was a crucial catalyst in the success of computerisation. In districts were leadership messages were strong, positive and consistent, acceptance of the computer was established more quickly. However, in the majority of cases, the computer represented an alien object for the directors who were sceptical about its advantages.
- When users returned to their offices after training, they were often unable to practice what they had learnt because the machines were invariably out of action. There was lack of accountability of the part of maintenance companies, and on the part of state support cells. Despite several pleas for assistance, district offices were sometimes kept waiting for up to six months for help to arrive. The CRISP monitoring cell established by the state government maintained a progress report of CRISP usage in the district offices. However, progress was measured in terms of whether hardware and software was installed. Such performance indicators were input-oriented and reminiscent of the manner in which the IRDP itself was evaluated. The cell kept no record about qualitative aspects of the CRISP initiative in terms of how the equipment and personnel were functioning.

- The value attached to status and hierarchy by administrators was an important influence on the diffusion of technology at local level. According to central government guidelines, the computer was to be located in a cabin, adjacent to the director's cabin which was to be prepared prior to installation. In the majority of cases, however, the popular choice of location was the director's cabin. This choice was driven by the importance attached to status among senior administrators in the bureaucracy. The computer was seen by directors as portraying power and authority. In many cases, the computer caused a distraction to both the director and the user : the director himself was often too busy to use the machine and the user felt intimidated to use it in his presence. As a result, the computer was grossly underutilised.
- While the stated objectives of CRISP was to promote decentralisation of IRDP management, the process of systems development did not allow any consultation with district administrators who play a leading role in the decentralisation process. Bureaucratic inflexibility led to the establishment of centrally-defined data sets without regard to local conditions. Lack of user involvement in systems development served to perpetuate the feels of neglect and apathy towards the task of rural development felt by local administrators. However, another serious consequence was the mismatch that resulted between the reporting requirements of the district offices and the reporting capabilities of CRISP. As a consequence, local administrators had no incentive to use the machines since the regular reports still had to be produced manually.
- An important characteristic of development administration was the one-way communication from higher to lower echelons of the hierarchy which often manifested itself in the form of target-setting without any feedback loops. In a similar vein, the lack of any channel of communication between systems developers and user has prevented users from being able to communicate their concerns about the system. The only recourse has been for users to signal the problem through resistance to change.

3.3 3rd Phase : 1990 onwards

The problems experienced during the first three years of the CRISP experiment meant that by the end of 1989, there was the distinct possibility of the CRISP project stagnating. In most of the district offices, the computer was not being used and administrators had reverted to the manual system of functioning. During the latter half of the year, senior officers at the centre and state began to realise that a lot more than technical inputs were required for the successful implementation of CRISP. Attention began to focus on how technology could be harnessed in a more dynamic way and some concrete strategic moves were taken by the centre, the state and the DRDAs in terms of modifying strategies and structures within the administration.

An effort was made to strengthen the capabilities of the state-appointed training institutes in terms of equipment and strategy. Concern over lack of technical support offered to the DRDAs during the initial few years has prompted the centre to consider placing CRISP completely under the National Informatics Centre rather than allowing states to decide on training and support issues. However, this issue has opened up debate about the future of computerisation at DRDAs. On the one hand, the state administration believes that the future of computerisation lies in local initiative-building with appropriate technical support. On the

other hand, the NIC believes that it is better to have a menu driven system rather than ad hoc systems using spreadsheets and databases at district level. In one sense, this debate draws on the prevailing contextual factors concerning the reluctance of the centre to devolve power to the states. In another sense, by supporting district initiative, the state has taken a new stance of encouraging local capacity-building at sub-state levels thereby devolving power to local levels. While the debate concerning the future direction of computerisation at district level continues, the state level training institute has had a more practical and pivotal role to play in steering the way towards end-user computing. This has had the effect of altering the balance of power between the centre and the state in favour of the latter.

With all the initial frustrations encountered with the CRISP initiative, the sheer existence of the microcomputer at the DRDA has prompted some degree of curiosity and self-learning among administrators at the local level. State level support towards end-user applications has triggered off initiatives from many DRDAs towards the provision of local infrastructure. Most DRDAs have started to employ persons on a daily wage basis for data processing at the DRDA. In addition, some DRDAs have recently taken the initiative to engage local consultants to conduct training to its staff on general computer awareness and on the use of high level languages.

There is also growing realisation among DRDA directors that the current use of computers does not afford any real decision-support for IRDP planning at the district level. Some districts have realised that the plethora of information generated should be put to some managerial use rather than just looked at as a requirement from the government. As a result, some districts are beginning to identify useful categories of information for planning and monitoring purposes.

The trend towards end-user computing applications has also triggered off changes in the normal functioning of IRDP administration. In a few districts, the director has decided to generate more accountability and involvement in IRDP implementation amongst village level workers. The use of the computer has also brought about a change in working group relationships within the DRDA. Errors are immediately detected within the processing system and responsibilities for errors easily traced. Each individual is more aware of his and other peoples' contribution. Change in working group relationship between the director and his staff was also reported. Up till now, a formal relationship existed between juniors and seniors with seldom any contact between the two. As junior officers begin to perceive the value of computers for their daily functioning they are brought into direct contact with the director in order to discuss potential applications for the DRDA.

4. DISCUSSION AND CONCLUSION

Research on information systems for development planning has rarely addressed systematically the crucial influence of contextual variables on the process of information systems adoption. This paper has aimed to make explicit the interaction between context and process in a particular planning situation over a period of time. While these findings refer to selected districts in Gujarat, it is believed that this case is representative of the difficulties and challenges encountered in implementing technological change in other developing countries.

The period up till 1990 revealed that the CRISP system had served to reinforce many of the existing structures and power relations within the administration. The initiative was not accepted during this period for a variety of reasons. Users had been locked into a rigid system in which they had no control to change the way the system behaved, and no sense of ownership of the data they were generating.

Since 1990, the data has revealed some patterns of change and a trend towards initiatives by both central and state governments, and by local administrators. The CRISP initiative appears to have served as an occasion for administrators to reflect on the existing inefficiencies in the IRDP system, and in the administration. Users have been inclined to develop useful applications because they have begun to perceive that they have some control over their use. The main catalyst for change appears to have been the active promotion of end-user computing by the state government. This has enabled users of information to perceive the value of technology for their work.

These results can be analyzed in terms of Walsham's categorisation of large scale computer-based information systems into Type A and Type B systems. The design of CRISP reflected the Type A approach of a centralised, top-down system which had the effect of reinforcing existing bureaucratic inefficiencies and of evoking resistance at the local level due to the non-participation of users in systems development. After 1990, the results revealed a trend towards the Type B approach which resulted in greater empowerment amongst local administrators. Acceptance and usage of new technology appear to derive from local administrators having the flexibility to direct the technology towards their own requirements. These are indeed encouraging trends because they present an alternative to the top-down approach to information technology adopted in many developing countries.

Despite these encouraging trends, however, unless there is effective management of the process of change brought about by computerisation, such encouraging trends may not gather enough momentum to continue, or may lead to anarchy at district level. The research findings suggest that management requires a broad vision of the purpose of district level computerisation and an understanding of the organisational and human factors involved in achieving this goal.

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IMPLEMENTATION OF THE OPERATIONS INFORMATION SYSTEM: THE CASE OF INDIAN RAILWAYS

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ABSTRACT

The implementation of geographically dispersed information technology projects involving large financial outlays is a complex task, more so in a developing country context. This paper is based on a case study of Indian Railways decision to implement a large information technology network for the management of it's freight operations. This case highlights some of the issues of concern for decision makers in information technology projects such as technological self-reliance vs imported systems, choice of network configuration, appropriate organisational structures for project implementation, management of turf wars and system implementation strategy.

1. INTRODUCTION

The implementation of geographically dispersed information technology (IT) projects involving large financial outlays in a developing country context is a complex task. Lack of experience of implementing such projects elsewhere in similar political, economic and social contexts makes it harder for the various actors to find a basis for their decisions [1,3]. The newness of the technology and the large amounts of money involved lead to a scenario where decision-makers are apt to postpone taking hard decisions. Added to the complexity of the decision process is the multiplicity of dimensions on which choices need to be made. Some of these are:

1. Should this opportunity be used for aiming towards technological self-reliance vis-a-vis importing proven foreign systems? Would adaptation of such systems to suit local conditions build enough indigenous local expertise? Should this opportunity be used for acquiring latest hardware/ software/communication technology or could incremental upgradation of the existing technology serve the purpose?

2. Geographically dispersed computer networks may be architecturally implemented in a number of ways. Which architecture reflects the managerial decision context of the organization the best? Which architecture is economically and technologically feasible?

3. What shall be the organizational structures and mechanisms for implementing this system? Would the implementation of such a system necessitate organizational restructuring?

4. How to evolve appropriate mechanisms for management of the inevitable territorial turf-war between the user department (e.g. railways) and technology departments (e.g. electronics and communication)?

5. Which system implementation strategy is bound to be most cost-effective? Which strategy will ensure smooth transition from manual to computerized system?

This paper is based on a case study which highlights the issues discussed above in the context of the Indian Railways (IR) decision to implement a large IT project called Operations Information System (OIS) for the management of its freight operations. This case study is based on extensive interviews with officers in IR and Centre for Railway Information Systems, New Delhi, India and in-depth study of documents related to OIS. The authors take full responsibility for the viwes expressed [3].

2. OPERATIONS INFORMATION SYSTEM IN THE INDIAN RAILWAYS

2.1 OIS

The OIS was expected to be an integrated computer-communication network, designed to keep the current information of all operations activities. The system would enable IR to provide qualitatively better customer service. It would also enhance the level of service currently provided by giving information on sensitive or high value commodities, keeping watch on critical stocks of sensitive customers like powerhouses, and furnishing reports to major rail users like Coal India, Food Corporation of India etc. The system was expected to provide quick tracing of wagon or containers and timely forecasts of trains. It would monitor performance of all activity centres connected with freight traffic management on IR. It would maintain a data bank of all fixed and rolling assets to help evaluation and optimisation of their use. All dynamic data would be captured on-line at source. Since the whole system would address a complex activity, it would necessarily consist of many sub-systems.

2.2 Indian Railways

IR is Asia's largest and the world's second largest system under a single management [4]. The responsibility of the management and other administration of IR rests with the Railway Board under the over all the supervision of the Ministry of Railways. The Railway Board consists of the Chairman, the Financial Commissioner for Railways and five functional members for Electrical, Engineering, Mechanical, Staff and Traffic. An organisational chart of IR is given in Figure 1.

On operational and managerial considerations, IR is divided into nine zonals, each of which is under the control of the General Manager. Each zonal railway comprises a number of divisions headed by Divisional Railway Managers. There are a total of 54 divisions. The division controls the field activity centres like yards, locomotive sheds, goods transhipment and

goods packing sheds, carriage and wagon depots etc. Apart from the operating zones, IR has six production units and six training and research centres.

The IR is expected to meet the socio-economic objectives of all sections of the community and also generate sufficient resources to meet the working expenses and liabilities. It must also provide additional funds for projects for renewing its assets and undertake expansion and development of the existing infrastructure. The IR is not free to adjust the fare and freight rates to fully cover the necessary prices for various inputs used by it. Proposals have to be made, both for projects and fare revisions to the Parliament, which then has to approve it. Political executives of the Railway ministry exercise a strong influence during the debate on such proposals.

The IR operates a multiple (broad, metre and narrow) gauge network of about 62,000 route-km. It carries over 330 million tonnes of freight traffic and 3650 million passengers every year. There is a fleet of about 8500 locomotives, 31,000 passenger service vehicles and 350,000 freight wagons. The total investment in the system today is Rs. 146,000 million (one US dollars was equal to Rs.18 till July 1991, when the Rs was devalued and is now equal to Rs.25). The regular work-force totals 1.65 million employees. Of the three gauges, the broad gauge is the most significant since it carries over 90% of the freight traffic and more than 83% of the passenger traffic.

Developmental activities across the nation over the years have contributed to increased freight and passenger traffic. The freight traffic has increased from 44 billion tonne-km in 1950-51 to nearly 260 billion tonne-km in 1990-91. The passenger traffic has grown from 66 billion passenger km in 1950-51 to 285 billion passenger-km in 1990-91. The focus of IR's efforts in dealing with increasing volumes of traffic over the years has been to improve the utilization of locos, coaches, wagons and tracks. For example, on the broad gauge, the wagon km/wagon/day has increased by nearly 1.8 times from 62.3 in 1950-51 to 112.1 in 1989-90. The gross tonne-km hauled by IR has increased by nearly 323%, while the number of locos had increased only by 4.6%. The wagon turnaround time which was 15 days in 1973-74 has been reduced to 11.3 days in 1989-90. There was a feeling that further operational improvements in IR could now be brought about only by improved information systems.

2.3 Expected Benefits of OIS

The computerised OIS was expected to improve the quality of decision making regarding better management of assets, which had not grown at the same pace as the output. It was felt that management spent more time in collecting and processing information than on trouble shooting. Modernisation of technology in other spheres like locomotives, traction, signalling etc. also necessitated modernisation of information technology. There was a need to improve customer service especially with regard to tracking of wagons and forecasting of freight train arrivals. The latter issue was quite important to IR since the freight trains did not run to schedules, but as per route and load availability.

Improved utilisation of assets, which this system was expected to offer, was crucial since the growth of traffic was primarily on the trunk routes between the four major metropolitan cities.

Over 70% of the traffic was carried on about 20% of the route-km. A specific manner in which the OIS would improve asset utilisation was in reducing the wagon turnaround. Of the 11.3 days of turnaround time only 1.5 days was spent on loaded movement from the origin to the destination. Apart from another 0.5 days in maintenance, the rest of the time was distributed over waiting in yards, waiting at the loading and unloading end, and in empty movement. Lack of real-time information, primarily regarding status and location of the wagon, handing and taking over wagons to/from the customer and train forecasting resulted in avoidable delays.

Given the nature of above benefits, it is difficult to precisely quantify them. However, the rate of return for OIS have been estimated between 20% to 30% on a capital cost of Rs.10.98 million. Other estimates have shown that if the OIS was not implemented, it would cost the IR Rs.27 million to acquire additional infrastructure.

Railways in USA, UK, Canada and France visited by a study team in 1979 had reported a 10% to 20% reduction in fleet due to computerisation. Specifically, it was estimated that computerisation in British Railways had brought about a savings of approximately $6.2 million a year. Savings on the Canadian Railways were greater, amounting to $450 million on equipment alone. The system had also brought about reduction in wagon turnaround time from 17.5 days in 1975 to 13 days in 1978.

2.4 The OIS Project

From 1960 to 1977, IR had been using IBM-1401s in the zonal headquarters and the Railway Board. The increasing volume of operations over the years and the consequent complexities necessitated upgradation of the technology and greater computerisation. A railway task force was set up in 1977 to study possible areas of computerisation. Among many others, it identified freight operations information system (OIS) and Passenger Reservation System as two key applications. A study team in 1979 recommended that a freight operations system implemented on an IBM computer developed by the Southern Pacific Railway (USA) called TOPS (Total Operations Processing System) be suitably modified and implemented in the four major cities of Madras, Bombay, Calcutta and Delhi along with Passenger Reservation System. It estimated the total project cost (OIS + Passenger Reservation System) to be Rs. 2100 million of which Rs. 1000 million was for communication. The team estimated that adapting a TOPS based system would take 5 years whereas developing a new system afresh could take 8-10 years.

In May 1981, a separate directorate was set up in the Railway Board for implementing OIS. The Director (OIS) reported to the Chairman, Railway Board. Given the large magnitude and implications of the OIS project, the OIS directorate recognised the need to involve other ministries like the Department of Electronics, Department of Telecommunications and other related organisations in the public sector like Computer Maintenance Corporation for computer related consultancy and Electronics Corporation of India for communication consultancy in the country. An inter-ministerial working group was set up to examine various issues related to implementing OIS. The issues of major concern were a) whether to develop software indigenous or it imported and b) whether IR or DOT would manage the telecom network.

As recommended by the inter-ministerial group two studies were undertaken during 1982-83. One of the studies was focused on studying the details of the OIS in five railways abroad. The other was a pilot OIS project study on the Northern Railway.

The major conclusions of the team that went abroad were as follows:

1. The team had not seen a proven totally distributed system. TOPS based systems (implemented on Southern Pacific Railway - USA, British Rail and Canadian National Railway) were superior to other systems. Foreign consultancy support for the core function of TOPS would be needed. Canadian National would be a good choice since the operating conditions (large geographical spread) and telecommunication technology (microwave channels) were similar to the Indian context.

2. Adapting a proven system took 4 to 5 years for implementation while developing a fresh system took 8 to 10 years.

3. All the railways visited owned their own communication network. Even Canadian National, which had earlier handed over the communications to a sister organisation, now operated the network by itself due to problems with the other management.

The pilot project team evaluated two configurations. In both cases, all the identified core functions were to be processed on a central system. The difference was that the decentralised functions were to be processed either at the respective zonal/regional systems or at the respective divisional systems. The team went into great details regarding specification of hardware, software and telecom requirements for the two configurations. The investment cost estimates for the two configurations were Rs. 4780 million and Rs. 5200 million respectively. The cost of communication component was about 70% of the total cost in both the cases. The foreign exchange component was 29% and 26% respectively. Subsequent studies chose the configuration requiring the zonal systems. Figure 2 provides the details of the chosen configuration. Both the studies estimated the total time for project implementation at 10 years.

During 1983 the Railway Board approved the OIS project with a financial outlay of Rs. 5,200 million. In the meantime, IR went ahead with the Passenger Reservation System implementation independent of the OIS, possibly because of the high public visibility of this project and the political mileage it provided. Due to the focus on Passenger Reservation System implementation, no progress was made on the OIS. Subsequently, in July 1985, the Railway Board set up a separate organisation named Central Organisation for Freight Operations, Information and Control Systems under the Executive Director (OIS). This organisation was expected to set up a consultancy arrangement for OIS and start preparing the Detailed Project Document (DPD) consisting of the specifications and estimates for computer hardware, software modifications, telecommunications, and staffing, training and implementation schedules.

CANAC, the consulting arm of Canadian National, was selected as the consultant for supplying and modifying TOPS for IR (for on-line applications only), training people and

assisting in the preparation of the DPD. The major responsibility for design of the computer systems for handling zonal functions was given to Computer Maintenance Corporation. Electronics Corporation of India was given the responsibility for the design of the data communication equipment required to interface between the computers and the transmission media. In January 1986, M/s.DETECON, a telecom consulting organisation, were appointed as telecom consultants for preparation of detailed design of the transmission media infrastructure for meeting OIS requirements and for the needs of IR upto the year 2000.

The DPD for OIS, submitted in October 1986, with the report of Ms/DETECON, for the communications component, estimated the total cost of the project at Rs. 17770 million, which was over three times the already approved cost. The difference in the estimated costs between the DPD and the pilot project was primarily due to the telecom components.

As the DPD was being finalised, the Railway Board set up an independent society, called the Centre for Railway Information Systems (CRIS) with the objective of planning and implementing the OIS (Table 3). CRIS took over the Central Organisation for Freight Operations, Information and Control Systems. At about the same time, an organization called IRCOT was set up to manage the telecom requirement of OIS.

On submission of the DPD in October 1986, serious concern was voiced by the other involved organisations about the steep escalation in the cost of the project. The Department of Electronics, submitted alternative proposals with distributed architecture in April 1987, with the costs assessed at less than Rs. 5000 million.

CRIS felt that the Department of Electronics proposals were not realistic. According to CRIS, the user needs were not fully understood by Department of Electronics, and attributed this to the fact that no railway official had been involved in Department of Electronics's estimates of data flows. In the area of computer architecture, the Department of Electronics proposal went to the beginning, re-examining decisions already taken (like distributed processing not being feasible and the software at the central system being TOPS with modifications, etc. to which Department of Electronics were themselves a party). In response, CRIS prepared a series of revised estimates by pruning the computer segment cost and the telecommunication cost (by envisaging a mix of digital microwave and satellite based communication) and came up with a project cost of Rs. 12,160 million. An outcome of the CRIS-Department of Electronics exchange was that the Planning Commission (an apex body which has an influential say on large investment projects), instructed the Railway Board to undertake a fresh appraisal of costs and benefits of the OIS and to work out the plan to finance the project. CRIS accepted the option of sharing some of the telecom lines with Department of Telecommunications.

In the meanwhile, CRIS effected further revisions in the costs by removal of the provision of disaster back-up and reducing the number of applications to be implemented. This brought down the cost from Rs.12160 million to Rs.10980 million. In late 1988, the Planning Commission approved the revised proposal by CRIS.

Subsequently, one IBM 3090 machine for the central system and one PSI-Bull DPS-7000 for the zonal system has been installed in the CRIS office for developmental work. Modifications

to the existing TOPS based programmes has started. Training programs for different levels of railway functionaries have been outlined and initiated. Out of the OIS project funds, Rs.450 million were allocated in 1991-92 for field trials in a portion of the Northern Railway. It was expected that the remaining amount of about Rs.2500 million for field implementation on the Northern Railway would be released in the next two years. Subsequently, the other zones on IR would be taken up for computerization. A summary of the various stages of the project and key decision points is presented in Table 4.

3. ISSUES

3.1 Technology Management

Two concerns in this area are achieving the right balance between the imported and indigenously developed technology, and choosing between a quantum jump and upgradation of existing technology.

Whereas, it is relatively easy to assess the requirement of hardware imports which would primarily be driven by the non-availability of relevant technology, decisions regarding import of software involve factors which are more difficult to quantify. The possibility of customising software, the assessment that modification of existing proven system would result in development of indigenous expertise and the faster speed of implementation of foreign systems are some of the considerations which govern this choice. Some other factors which play a role in this decision are the requirements of maintenance of the current project and possible pressures from financiers.

The IR decided to select a proven foreign system for the central core of the OIS since this would take only 5 years for adaptation as opposed to 8-10 years for developing a fresh system. It decided to develop the zonal systems and other applications indigenously in order to build up local expertise. This was in spite of the suggestion of the World Bank (which was to finance a part of the project) that all systems be imported. Initially, the local expertise was sought to be built as a collaborative effort between IR and other computer related organisations. Delays in the start of project implementation gave the IR team ample opportunity to not only develop local expertise, but also in-house expertise. Consequently, IR has decided to do away with even local consultants for project implementation.

New projects may demand a quantum jump in terms of infrastructure and technology, qualitatively and quantitatively. However, in a developing country, it may be difficult to implement decisions which opt for investments in technology afresh rather than those which specify incremental upgradation due to managerial inertia and resource limitations.

The report of the telecom consultants, which estimated the telecom requirements of OIS and IR afresh with a quantum jump in technology, upto the year 2000 A.D., resulted in an escalation of the total project cost. This led to a series of reappraisals of the cost, causing delays. Subsequently, CRIS had to revise its estimates. The revised estimates took into account the existing telecom channels, upgradation of existing channels and a mix of digital microwave and satellite communications.

3.2 Choice of Network Configuration

Lack of experience in the user organisations in implementing networks leads to differing perceptions among the user organisations and consultants about the suitability of various network architectures for decision making.

IR had evaluated distributed systems for implementing OIS initially. Based on in-house discussions, experience of foreign railways and the results of the pilot project team, it had been decided fairly early that a centralised system with zonal systems was appropriate for OIS. Department of Electronics, though, initially of the same view had subsequently felt that a distributed architecture was more cost-effective and suitable for OIS. After an exercise in convincing Department of Electronics the decision of a centralised system remained.

3.3 Organisational Structures

Implementation of complex technological systems may necessitate a variety of organisational structures. Possibly, because of the newness of the technology, the user organisation itself may not have it's own expertise and requires to interface to other organisations and professionals to assist it in the implementation. Issues which are of concern are, what shall be the relationship of the new organisations to the user organisations, what will be the composition of the new organisations - will it consist of professionals from the user organisations and the consultant organisation, or will it consist of professionals from the user organisations and fresh IT professionals, what shall be the relationship of professionals from the user organisation to the parent organisation etc. Further, the evolution of the project from a formulation stage to an implementation stage may require different kinds of organisational structures.

The decision to implement the OIS by IR led to first setting up of OIS directorate under the Railway Board. Subsequently a separate organisation called Central Organisation for Freight Operations, Information and Control Systems under the Executive Director (OIS) was established. After the submission of the DPD, a new organisation called CRIS was founded with the primary objective of implementing OIS and other computer related applications on IR. In the first two set-ups, other departments like Department of Electronics and Department of Telecommunications were not a part of the top management but their association was sought at various levels, through inter-ministerial meetings, committees and project teams. On the other hand CRIS has members from Department of Telecommunications, Department of Electronics and IR on it's governing council. Again, in the first two organisations only railway officials held executive positions, while CRIS was open to recruiting non-railway men.

3.4 Management of Turf Wars

Due to the inevitable resource shortages in a developing country, sharing of physical resources like a communication network with other organisations is in the overall national interest. However, the concern of an overseeing agency to plan for optimal usage of national resources has to be viewed in the context of the desire of the user organisations to provide a desired level

of service (especially in critical areas) and avoidance of dependence on other organisations for their operational functioning. Issues of ownership and control of the physical resource lead to unavoidable turf-wars between the various organisations. Other areas which may spark off turf wars is the availability of professional expertise (a scarce resource in many developing countries) in some organisations. The technology departments may view such projects as areas where their own expertise and achievements would be highly visible. This could give rise to situations where the technology issues per se could assume greater importance than aspects related to user acceptance and the managerial concerns of the user organisation. An explicit recognition of the inevitability of the turf- wars and a proactive management of these by the project leader, would result in lesser delays in such projects.

Most developing countries have established policies and procedures involving a multiplicity of actors in project contexts requiring new technology with high investments. While a certain level of involvement of other organizations is dictated by these policies and procedures, it is imperative that this involvement go far beyond the formally stated procedures. The involvement needs to be augmented both along professional and social dimensions. This is because, though these organisations may not be able to practically lobby for the project, they could effectively delay the project.

During the OIS project, there was protracted tussle between the Department of Telecommunications and IR over the ownership of the telecom lines. Though, initially IR was not even willing to consider the implementation of the OIS project without owning and managing the telecom lines, it subsequently agreed to evaluate the option of sharing the telecom lines with Department of Telecommunications. Besides Department of Telecommunications, Department of Electronics was also responsible for delays in this project. Even though, IR in consultation with Department of Electronics, had decided to opt for a centralised system connected to zonal systems fairly early, Department of Electronics went back on it's own decisions later and wanted CRIS to re-evaluate the option of a distributed system. Partly this may have been due to Department of Electronics's assessment that during the period of project delay, the indigenous hardware capability had substantially increased and adopting this approach would enable IR to choose totally indigenous systems. However, IR strongly felt that such an architecture did not reflect the organisational decision making processes especially with regard to wagon movements.

3.5 System Implementation Strategy

A top-down approach tempered with the bottom-up approach may yield dividends in a mega project. A top down approach is required to ensure that the system would provide data for managerial decision making while at the same time facilitating operational tasks. A bottom-up approach would catalyse acceptance at the user level.

Success of applications also depends to a large extent on the manner in which they are operated and maintained. The right kind of training can ensure smooth functioning of the application. Therefore, training programs for large applications need to be consciously designed keeping in mind the level of functionaries and their educational background.

Additionally, the method for conversion from the manual system to the computerised system may also be a determinant of the success of implementation. Careful planning of the conversion process needs to be done. The pilot project approach coupled with the phase-in method may work well in the introduction of new systems in large organisations [5]. Planning for post-implementation review would facilitate acceptance of the current system and provide feedback for further modification.

The OIS system has been largely accepted by the field level. The operational staff could understand the benefits of computerisation by working with applications developed by CRIS even though some of these applications were not related to OIS per se.

In the OIS project, user training has been an ongoing concern. CRIS has been conducting computer awareness and training programs for different levels of railway functionaries even before the implementation of OIS. In addition, specific training in using OIS is planned to be imparted as a part of it's implementation strategy. Comprehensive training schedules have been drawn up to ensure that all users of OIS receive training.

The field trial approach to system implementation will ensure that live testing and the experience gained from it can be used to improve the system performance and acceptance. The phasing of the implementation will allow some users to take advantage of the system early. Additionally, this implies only a gradual introduction of training and resources by IR.

4. CONCLUSIONS

Implementations of large IT projects in a developing country, like other large projects, is fraught with problems. The general lack of experience in implementing complex technology projects is compounded by the non-availability of models or guidelines for implementing such projects. The experiences of the developed countries are generally inappropriate due to differences in social, cultural and economic backgrounds. Further, demands on resources from various sectors and political interferences add to the problems. Often the systems which are set up to provide checks and balance to the various pressures involve a multiplicity of actors whetting the projects. While from the perspective of the use of large amounts of public funds, this seems essential, usually the processes tend to delay the completion of the project.

For smooth project implementation, awareness of the above scenario as well as of problems likely to arise in project formulation, appraisal and implementation, at the highest decision making level is essential. A preemptive strategy by a proactive management, anticipating the requirements of the various actors is necessary. A project manager with political acumen and missionary zeal almost becomes a necessity to ensure successful completion of the project. Projects which have high visibility and afford political mileage to their proponents are more likely to succeed.

Projects entering new areas of technology have a greater chance of success if they can be phased out into smaller components since resource allocators have a chance of observing the benefits as they accrue. The risks and accountability involved are also lesser. The case in point for the Indian Railways was the success of the Passenger Reservation System while the

OIS has not yet begun. This is inspite of the fact that initially the Passenger Reservation System was justified only as an addition to the OIS.

Projects involving computer-communication networks are primarily viewed as computer based projects in spite of the fact that the communication costs typically constitute 60% - 70% of the total project cost. As seen in this case, there was relatively little contention on the communication technology which later on became a significant spoke in the wheel causing delays to the project. The example also has a bearing on the management of consultants, wherein due to a lack of clarity from the users, a dramatic increase in project cost was presented based on the consultants' recommendations.

Being a crucial application with a significant impact on the economy, the technology management should be aimed at building local expertise capable of managing the system on their own, even though the project is begun with foreign assistance.

For an application which spreads across the entire organisation, the computer network configuration should blend with the organisational systems and processes. Organisational structure for implementation should be such so as to facilitate building up of requisite expertise for implementation. Turf wars though unavoidable are best mitigated by proactive management on the part of user department. Regarding system implementation strategy, a judicious combination of top-down and bottom-up approach coupled with appropriate training, pilot implementation and phase-in strategy will ensure smooth project implementation.

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Figure 1 *Organisation Chart: Indian Railways*

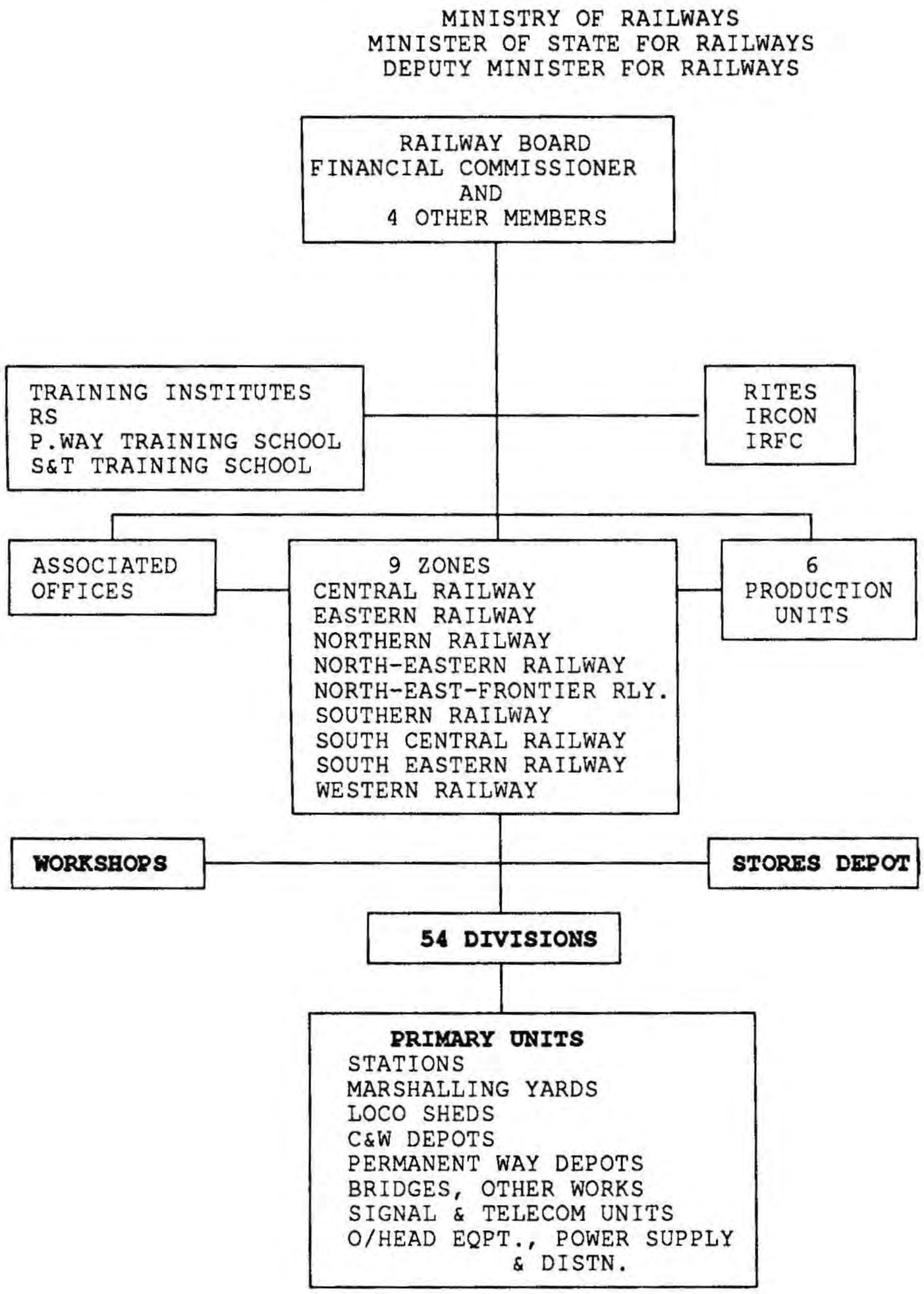

Figure 2 *Details of the OIS Configuration*

The OIS was to be implemented as a two tier system consisting of a central system computer and 7 smaller computers in the zonal railways. There would be functional division of work between the central and the zonal system. Locations for data entry terminals [known as Area Reporting Centres (ARC)] were identified. Each ARC would be responsible for the data reported to it from a nominated geographical area known as its Responsibility Area.

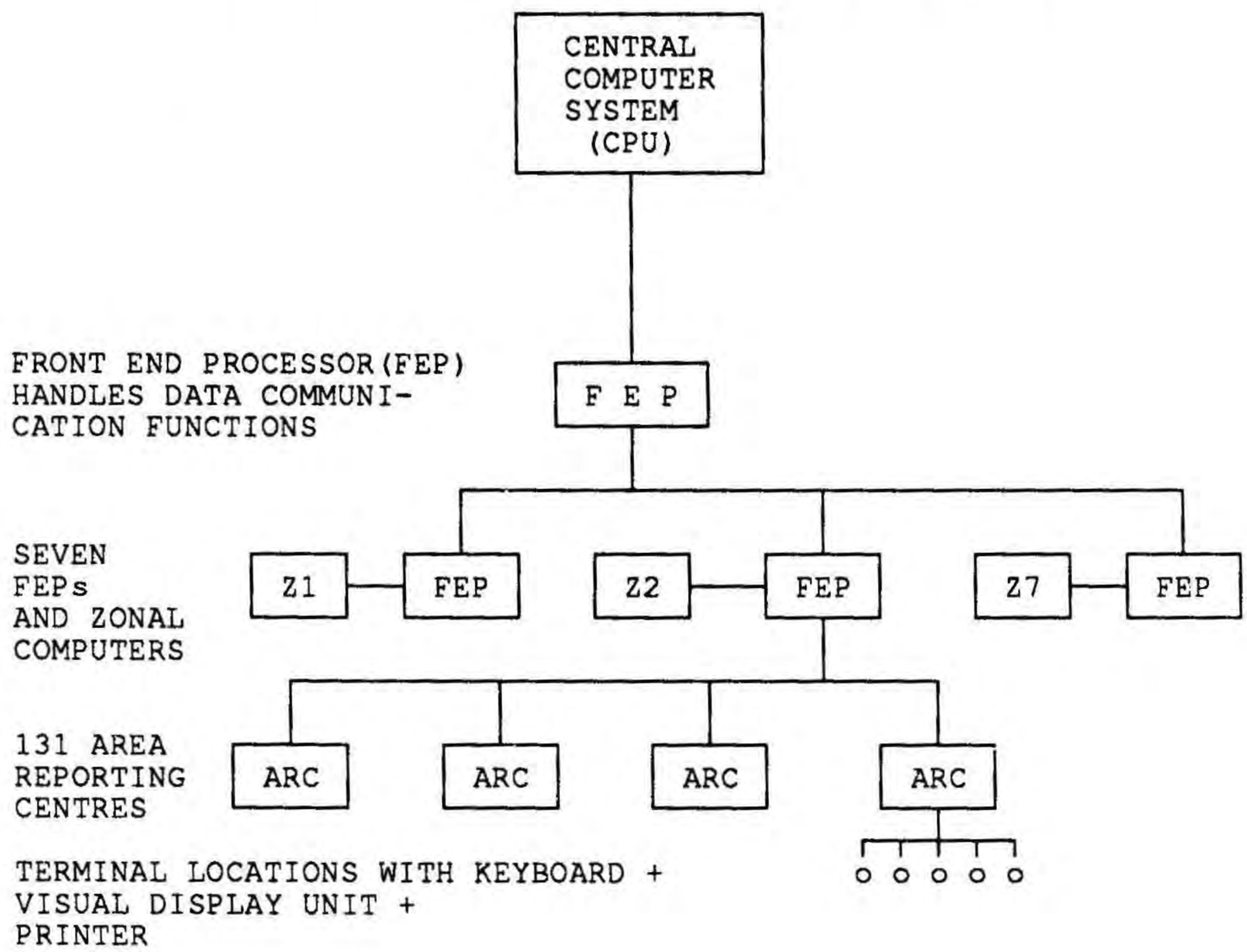

Table 3 *Centre for Railway Information Systems*

The Centre for Railway Information Systems (CRIS), is a Government Society formed by the Ministry of Railways under the Chairmanship of the Minister of State for Railways. The Governing Council of CRIS is constituted as follows:

Minister of State For Railways	Member & Chairman
Chairman, Electronics Commission	Member
Cabinet Secretary	Member
Chairman, Railway Board	Member
Financial Commissioner, Railways	Member
Secretary, Communications	Member
Secretary, Department of Electronics	Member
Additional Secretary to P.M.	Member
Executive Director/CRIS and upto 3 other Directors of CRIS	Members

In addition there is provision for nomination of upto 5 other specialists on the council.

CRIS is an autonomous organisation, set up with the objective of taking up computer related activities on the Indian Railways, for the following reasons:

a. To avoid duplications of staff by individual railways.

b. To ensure standardisation of computer hardware and software on the railways.

c. To undertake design and development of major applications on railways requiring higher levels of expertise, continuity of personnel, sustained guidance, and system wide applicability.

d. To organise the combined effort of railway executives and computer specialists, considered essential for the development of computer application on railways.

e. To develop expertise in highly specialised fields like operations research, simulation, expert systems, CAD/CAM, process control etc.

Table 4 *Major Events, Time and Cost Estimates*

Year	Major Events	Estimated Time of Completion of the project	Cost (in Rs. millions)
1979	Study team constituted to study benefits of computerised OIS	5 years if TOPS based system was adapted. 8-10 years for a fresh implementation.	2100
May 1981	Setting up of the OIS directorate		
July 1981	Two study teams set up. One to evaluate the major computerized OIS in France, UK, Germany, Canada and US. The other, a pilot project team to evaluate alternative architecture		
1982-83	Result of study teams available	10 years	4780-5200
July 85 - Oct. 86	Working on and submission of Detailed Project Document (DPD)		17770
May 1986	Setting up of CRIS		
April 1987	DOE brings forth alternative proposals		5000
May 87-88	A series of reassessment of costs by CRIS required by Planning Commission	7-10 years	12160
	Removal of provision of diaster backup, reducing the number of applications and a mix of digital microwave and satellite communication	7-10 years	10980
Late 1988	Approval of revised proposal by Planning Commission		
Early 1989	Implementation of the project begins. Installation of the central system of software modifications		
Early 1990	Approval of revised OIS by IR		
July 1991	Start of field trials		

COMPUTER-BASED INFORMATION SYSTEMS IN THEIR SOCIAL CONTEXT: USE OF DIFFERENT PERSPECTIVES

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ABSTRACT

Computer-based information systems (CBIS) can be better understood if different perspectives are brought to bear in analyzing the systems and their relationships with the contexts in which they are embedded. In this paper, a number of perspectives are used to derive a greater understanding of how a University Admission System (UAS) copes with changes in its wider social context. A number of conclusions with regard to the utility of the various perspectives in understanding the UAS are drawn.

1. INTRODUCTION

Computer-based information systems have often been looked at from different perspectives. Each particular perspective represents a way of conceptualising these systems. In order to get a greater understanding of CBIS and their relationship to the complex social context in which they are adopted, developed and used, it is necessary to combine a number of perspectives. In this paper a number of perspectives are used to analyze the UAS and its relationship with a wider social context composed of many stakeholders.

2. ANALYTICAL FRAMEWORK

2.1 Perspectives of Computer-based Information Systems

Two perspectives of CBIS are described in this sub-section; the technical and political perspectives. The *technical perspective* has largely been based on positivist scientific philosophy and is allied to the mechanistic view of organizations and the rational model of decision-making. It assumes that organizations have formal goals which are agreed upon by all

organizational participants and there are publicly sanctioned means to achieve these goals.

With regard to CBIS, this perspective focuses largely on the technology's discrete features and capabilities. It perceives computer-based information systems as socially neutral tools and well-defined machines, best characterised by formal objectives, procedures, and administrative arrangements over which there is a consensus. The provision of computer systems is, for example, viewed as a set of clearly defined tasks which depend upon specific technologies and personal skills.

The technical perspective also perceives CBIS as loosely aggregated collections of equipment, people, procedures, and beliefs, which could easily be broken into separate elements, and costed and evaluated independently [3]. Problems in CBIS use, for example, are viewed as being relatively individual, and best solved by separation into independent, individually solved subproblems.

Further, the supporting infrastructure (or context), both technical and administrative, is viewed as neutral, objective and external. Finally, decisions or actions to adopt, develop and use computer-based information systems are perceived to be objective, rational and co-operative, largely based on the information processing capabilities of the underlying technology. It is, for example, assumed that CBIS are adopted, developed and used to produce routine transactions and reports faster as well as to support rational decision-making, such as to increase managerial efficiency and organizational effectiveness. Good CBIS technology is thus assumed to be that which is effective in meeting explicit goals, efficient, correct and easiest to use.

The above technicist perceptions have been criticized for their narrow view of CBIS, particularly for ignoring the complex and dynamic social context in which computer-based information systems are embedded [2,6,7]. The technical perspective has therefore been found inadequate to conceptualise computer-based information systems in general, and to explain CBIS in their social context in particular.

The *political perspective* overcomes some of the limitations of the technical perspective. It perceives organizations as a loose network of coalitions with diverse interests and demands, competing for organizational attention and resources, and resulting in conflicts [5]. An important concept in this perspective is power, which is the medium through which conflicts of interest are resolved [4] and at the same time shapes those interests [7].

Computer-based information systems, from a political perspective, are tools which can bring power pay-offs. This is largely because CBIS have significant impacts, largely through their effects on the quality and availability of information, on work and work roles, on issues such as centralization and decentralization of control, on the relationship between groups and departments and on aspects such as surveillance and individual freedom and action. Divergent interests and perspectives are normally present in such contexts and thus CBIS are arguably one of the key areas for political action in modern organizations [8]. Computer-based information systems can therefore be mobilised to achieve changes in power distribution and influence among different types of staff, and thus cannot be neutral.

Further, the social world or the context of CBIS cannot also be neutral. Powerful individual actors and groups can mobilise and exploit this context to influence and to legitimise preferred CBIS outcomes. These outcomes are largely geared towards providing leverage such as increasing control, speed, and discretion over work, or increasing bargaining capabilities.

Finally, the political perspective perceives decisions surrounding CBIS adoption, development and use as divergent, conflicting and evolving out of power mobilization attempted by all primary participants or coalitions in support of their self-interests. In cases of conflicts, consensus may be fostered by coalescing support, agreement and power behind one interest. Good computing technology is thus one which serves the interests of powerful actors and does not undermine legitimate power relations.

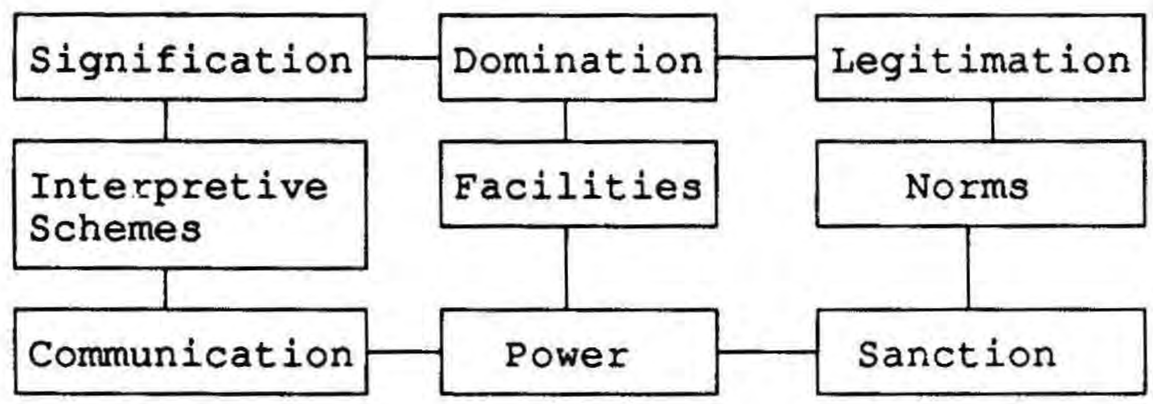
2.2 Relationships Between CBIS and Social Context

The two perspectives outlined above deal with the relationships between CBIS and their social context to some degree but are alone inadequate to fully understand how CBIS are linked to their social context. These perspectives can be complimented by Gidden's concept of duality of structure. This is the crucial concept in Giddens' Structuration theory. According to the notion of the duality of structure [1],

> "the structural properties of social systems are both the medium and outcome of the practices they recursively organise... structure is not to be equated with constraint but is always constraining and enabling... Structure has no existence independent of the knowledge that agents have about what they do in their day-to-day life. Human agents always know what they are doing on the level of discursive consciousness under some description. However, what they do may be quite unfamiliar under other descriptions and they may know little of the ramified consequences..."

Giddens identifies three structural properties of social systems or "modalities" that mediate between structures (of signification, domination and legitimation) and interactions (involving communication, power and sanction) (shown schematically in Figure 1).

Figure 1 *Giddens' Model of Structuration*



We can use this concept, which relates human interactions or actions and social structure or context, to further our understanding of how actions surrounding CBIS are related to the social context in which these actions take place.

The concept can be explained as follows: firstly, human communication involves the use of interpretive schemes which are stocks of knowledge that human actors draw upon in order to make sense of their actions and those of others. They thereby produce and reproduce structures of meaning which are termed structures of signification. Further, actors utilise power in interaction by drawing on facilities, such as the ability to allocate material and human resources. In so doing, they create, reinforce or change structures of domination. Lastly, actors sanction their actions by drawing on norms or standards of morality, and thus maintain or modify social structures of legitimation.

Two things are important to note with regard to Structuration theory. One is that the division of structure and interaction into three dimensions is only for analytical expediency, otherwise the three are inextricably interlinked. Two, by structure it is meant the social structure which is observed in action, not the physical structure. Physical structure, such as organizational structure, is implicated in action via modalities in the Structuration model and are only part of social structure if they are present in human minds and provide social context for action.

2.3 Data Collection and Analysis Methodology

Data was collected using two main methods. One was reading all relevant documents produced by the Public Universities pertaining to admissions. The second method was to interview the systems analyst/programmer in charge of the UAS and one of the key Academics in the Joint Admission Board (JAB). Thus the relevant information was obtained partly from a historical reconstruction of what happened and partly from the extensive documentation of the admission process. Data analysis, in accordance to the theoretical ideas outlined in sections 2.1 and 2.2, involved identifying the following:

- key actors or stakeholders of the UAS;
- the stakeholders' perceptions of the 8-4-4 UAS based on clusters;
- motivations for the identified perceptions;
- enabling and constraining influences of the wider social context on actions or decisions surrounding the 8-4-4 UAS;
- intended and unintended consequences of actions surrounding the UAS on the wider social context of this system and on future actions.

3. UNIVERSITY ADMISSION SYSTEM CASE STUDY

The essence of the case study described in this section is to concentrate more on the conceptual design based on principles and procedures of the UAS. It is the interpretation of these by the different stakeholders that was the source of contention. It was not the implementation of the computerised system in the first instance that created problems but the reversal of the salient principles of the design subsequent to the adverse reactions that necessitated revision of the implementation.

3.1 Principles and Procedures for 7-4-2-3 Admission System

The University 7-4-2-3 Admission System was based on the following principles:

- *Choice of four degree programmes* by applicants in order of preference;
- Satisfying the *requirements* (i.e. subject combinations or *clusters*) of the respective chosen degree programmes;
- *Ranking by merit* such applicants for a degree program.

The procedures involved carrying out steps b) and c) in sequence for the first degree choice for all candidates who had met the University Minimum Entry Requirement (UMER) of *two principal passes*, followed by the second degree choice for all candidates and so on until the fourth choice was completed. In addition, based on the capacities for each degree programme, the cut-off points were ascertained so that all candidates who met the cut-off points were selected for that programme ranked by descending order of cluster weight for their first, second, third and fourth choice respectively as appropriate.

Under the 7-4-2-3 system, entry into University was, therefore, primarily via admission into degree programmes and not vice versa. The underlying principle was crucial to ensure selection of relatively higher quality applicants into degree programmes, particularly in the general agriculture and science-based programmes which tend to be less competitive.

The 8-4-4 admission system was designed initially to conform to virtually the same principles and procedures as in the 7-4-2-3 admission system cited above.

3.2 The 1990/91 8-4-4 Admission System

As under the 7-4-2-3 educational system, the Public Universities continued to offer a variety of degree programmes from specialised programmes. The requirements for each degree programme under the 8-4-4 system had to be normalised so that all programmes specify a total of five clusters, with each cluster comprising one subject or more from which the subject with highest weight was counted towards the cluster weight. However, is to be noted that this normalization was not initially done and was actually carried out during the pre-processing stage of the 1990/91 admissions after the dangers of non-normalised clusters were sensed.

The actual stages for selecting candidates for 1990/91 admissions were:

- From the K.C.S.E. overall performance and the capacity of the Kenyan Public Universities, a Minimum Entry Weight (MEW) of at least 65 was determined and candidates meeting this weight were considered as eligible for consideration for admission to a Public University;
- The eligible pool defined above were then subjected to the cluster criteria of their respective Faculty choices by examining subject requirements for compliance and evaluating the corresponding cluster weights;
- The eligible pool were then sorted into their respective first choice degree programmes, in descending order of corresponding cluster weights;
- Given that each Faculty had a fixed capacity, given *apriori*, and subject requirements (clusters), the computerised UAS ascertained cut-off points that determined, via procedures stated in sub-section 3.1, who was to be selected to which course;
- All the candidates who could not be admitted to any one of their choices for one reason or

another but were admissible to other courses were then selected manually by the Admissions Board into programmes whose cut-off points were satisfied provided these were not already filled to capacity.

3.3 Problems Encountered by the 8-4-4 Admission System

The 8-4-4 educational system posed challenging problems for the UAS. The biggest one concerned those candidates who had Overall Weights (OWs) well above MEW of 65 but could not be admitted into any degree programme since they did not satisfy any Faculty cut-off points. It was these candidates with relatively *high overall scores* who were not selected that caught the attention of the public and the press. They cited that the admission system was unjust, perhaps notwithstanding the fact that the relatively high overall weight might have been achieved by good performance in a subject that did not count towards the cluster weight of any degree programme. Although the Admissions Board expected this situation, it did not, however, envisage the reaction from the public.

3.4 Reactions Following Announcement of 1990/91 Admissions

After the release of the 1990/91 8-4-4 admissions, schools, parents and candidates themselves brought to the attention of the Chairman of the JAB that some of the candidates with higher OWs had been left out while others with comparatively low OWs had been admitted. The perception of the public, particularly the candidates and parents, was therefore that either the cluster subject combinations were not comprehensive enough or that the Admission System based on clusters itself was unjust and that the emphasis should have been on the OWs as a primary admission criterion. As noted earlier, the Admission System had been changed after dangers of non-normalised clusters were foreseen at the pre-processing stage. The schools and the general public were therefore not made aware of these changes in advance.

Following this public outcry, the JAB decided to analyze the number of candidates with OWs greater or equal to 65 that had been left out. The perception of a sub-committee appointed to look into this matter was that the Admission System based on clusters had worked well in that "it had filtered into relevant degree programmes only those applicants who were clearly qualified for admission in accordance with their respective Arts or Science biases." Further, "none of the applicants who were screened out by the cluster system had performed any better in their respective cluster biases than those who were admitted."

Taking various factors into account, the sub-committee agreed that "the most acceptable criterion" under the circumstances for processing those left out was to "admit all applicants with an OW of 69 and above and all applicants qualified on the basis of the cut-off points determined by the cluster system". This meant that an additional 820 applicants qualified and these were admitted to the most appropriate degree programmes, with nearly 80% ending up in Bachelor of Arts (B.A.). The applicants were further distributed equally between the Public Universities, with each getting an additional 164 students. This procedure was implemented manually.

The experience of the 1990/91 8-4-4 admissions had a major impact on the next year's

admission procedures.

3.5 Changes in the 1991/92 8-4-4 UAS Principles

For the 1991/92 admissions, the JAB reversed the salient principles used in the 1990/91 admissions as articulated in the second last paragraph of sub-section 3.1 and in the admission stages of sub-section 3.2. As a consequence, entry into University was not via degree programmes and their respective cluster weights, but primarily by OW. The main consequence of this revision was that the relatively non-competitive degree programmes had to lower their cut-off points considerably to accommodate those already admitted into University and who could not get into the more competitive programmes. For example, in 1990/91, the cut-off points for B.A. and B.Sc. were 37 and 34 respectively, with the lowest cut-off point for any degree program being 33 in B.Ed. (Arts) in Fine Art. By comparison, the 1991/92 cut-off points for B.A. and B.Sc. were 32 and 29 respectively, with the lowest cut-off point being 25 for B.Sc. in Agriculture and Home Economics and B.Sc. in Natural Resources.

4. CASE STUDY ANALYSIS

4.1 Key Actors, their Perceptions and Motivations

One of the Kenya Government's broad policy aims in education, according to the 1989/93 Development Plan, is to have an educational system that produces individuals who are properly socialised and possess the necessary knowledge, skills, attitudes and values to enable them to effectively participate in national development. The Government's introduction of the 8-4-4 educational system was partly in cognizance of this broad objective and partly aimed at encouraging self-reliance in order to ease unemployment problems at lower education levels as well as enhancing capacity building in the Basic Sciences. The Government of Kenya, through the Ministry of Education, can thus be considered as one of the key stakeholders of the UAS as it was interested in ensuring that the new educational system, which had received a lot of public criticism, was successful, including admission of its school graduates into University.

A second group of key participants was the academic staff. This group comprised essentially of Deans of Faculties and the JAB. The perceptions of the Deans of Faculties were based on the requirement of specialised Faculty degree programmes and the need to maintain certain minimum academic standards. The initial subject clusters (non-normalised) were therefore based on individual Faculty perceptions of their requirements for admission into the constituent degree programmes rather than how the overall Admission System would work. This was largely because the Faculties were only interested in getting the best people into their degree programmes, in keeping with the basis of their perceptions stated above. The UAS design principles were thus developed to meet these academic interests.

The Joint Admissions Board, which was in a way attempting to satisfy the demands of the Faculties and the perceived political "demands" by the wider environment, had to have a wider perspective of the Admission System based on clusters. It rendered its support for normalised clusters when the need for normalization was pointed out by the technical people from their

overall systems point of view. The JAB perceived such an Admission System based on normalised clusters as "rational", "logical", "systematic" and "fair".

A further group of key actors was the technical people. This was largely the analyst/ programmer in charge of the UAS, and, to some extent, the Director of the ICS, who was also a member of the JAB. The main task of this group was to advise the JAB about the implementability of certain principles and how best to implement them. The modularity of the UAS and the thorough knowledge of the analyst/programmer of the system enabled changes suggested by the JAB to be implemented without many problems. The technical peoples' perception of the UAS was therefore shaped by that of the Academics and was limited, to a large extent, to the technical position, akin to the technical perspective of computer-based information systems.

The final group of key stakeholders in the UAS was the public. The main members of this group were the schools, candidates, parents, and other opinion leaders in education. A cross-section of this group had challenged the 8-4-4 educational system all the way through for different reasons, with most focusing allegedly on "... the haste with which the system was introduced without sufficient planning as well as the lack of their participation in evolving the system". It was realised, only during the pre-processing stage, that the non-normalised subject clusters were going to lead to a lot of problems and the JAB had to sort this out on the run. Even after normalising the number of clusters, there were problems and the general public still perceived the Admission System based on clusters as "unjust" or "unfair". This perception can largely be explained from a political perspective in that the system was not good because it did not serve the interests of the public.

It is argued that the main reason for the difference in the expectations of the public and the admission principles of the Faculties is that secondary school/University *interface* of the 8-4-4 educational system was not adequately thought through. This was because there was *mismatch* between the much broadened pre-university secondary school education, aimed at encouraging self-reliance, and the specialised degree programmes which the Universities continued to offer. This was in comparison with the previous educational system where specialization proceeded continually and narrowed in a pyramid-like manner. Indeed, neither did the Ministry of Education nor the Universities consider the implications of the much widened secondary education on University admissions when the 8-4-4 educational system was launched. The Admission System based on clusters devised by the JAB was an attempt to address this dilemma.

4.2 Action to Re-admit and Relationship with Context

Computer-based information systems have a complex relationship with the social context in which they are embedded. Action by both the Ministry of Education and the Universities not to consider the impact of the new 8-4-4 educational system on University admissions, although largely unintended, had the rather inevitable consequence of creating a constraining context for the computerised Admission System in that it could not cope the first 8-4-4 University admissions to the satisfaction of all the major parties involved. This turned the system into a centre of conflict because of the significant differences between the interests which coloured

the divergent perceptions of the Academics and those of the public with regard to how the Admission System implemented University admissions.

When some candidates who had high overall KCSE performance were not admitted into University, the public took the opportunity to challenge the basic principles and procedures of admission to University degree programmes. It mobilised the fact that some candidates with high Overall Weights were left out to justify their belief that the Admission System based on clusters was unjust. That is, they argued that the OW, given the changes in the educational system that broadened the school education, ought to be the important criterion determining admission into University programmes rather than subject cluster cut-off points. Despite their conviction that the UAS based on Faculty subject clusters had worked well and was "sound" as a basis for admission, the Universities were forced to compromise on this very conviction.

One possible explanation why the Academics could not offer any justification to counter the public's perceptions was because they were partly to blame for not communicating the basis of admission well in advance. A further possible explanation is that there were subtle influences on the Academics to comply with the public's views. For example, the sub-committee appointed to investigate the matter noted that the Admission System based on clusters had worked well but there were certain "anomalies" which "needed to be rationalised and/or explained".

The resort to manual methods to take care of the "exceptional" 820 cases was an indicator of the conditioning effect that the adverse public opinion context had on the system. In addition, this manual activity was carried out despite the fact that it was contrary to both strictly academic principles and the Government's objectives. The extra students were also admitted despite a context of already over-stretched University facilities and resources. One consequence of the decision to "bend the rules" and admit the students who had relatively high OWs but could not meet any Faculty cut-off points was that this action became a precedent to change the computerised Admission System procedures in future.

The Universities were accordingly forced to compromise and change the computerised UAS's design principles for the 1991/92 admissions to reflect the interests associated with the strong public opinion context. As Orlikowski [6] notes, once systems are developed, they are "maintained over their lifetimes and the frequency, manner and nature of such activity (or its lack thereof) too reflects current exigencies and political agendas." Thus taking a political perspective of CBIS, a system which becomes an instrument of conflict because it does not match the expectations of an important social context surrounding it will be changed to meet expectations of this context depending on the leverage participants in such a context can afford. Thus the prevailing of political motives over other considerations in the changes made on the Admission System in 1991/92 admissions displayed the importance of social context and of a political perspective in understanding computer-based information systems in their context.

4.3 Consequences of Changes in UAS's Design Principles

One notable consequence of changing UAS's design principles to be congruent with the

perceptions of the public was that this action acted to reinforce those perceptions. A second consequence is that the compromise on the Admission System helped stamp the authority of the public over the educational system, with the public re-emerging as important players in educational system decision-making, and at the same time weakened the Universities' abilities to influence policy affecting pre-university secondary education. The Universities subsequently found themselves in a weakened position whereby they could only adjust to cope with the implications of the changes made to the 8-4-4 pre-university education, on their Admission System.

A further consequence is that the debate that led to changes in the 1991/92 admissions, in turn, brought into sharp focus the secondary school/University interface of the 8-4-4 system; the apparent dichotomy between the much widened pre-university education and the obviously narrower specialised degree programmes. Compromising the Admission System and not adequately addressing this dilemma, in a way acted to legitimise and institutionalise the public's perception of the Admission System, and, with hindsight, might have been a soft option with cumulative adverse consequences.

A final consequence related to the above, which was initially not intended but subsequently became inevitable, was the lowering of cut-off points into some degree programmes thereby lowering the academic standards expected of those programmes. Admitting some candidates of a relatively lower calibre cluster-wise, particularly in the Basic Sciences, in turn negated, to a certain degree, Government's policy of enhancing the quality of science education.

5. CONCLUSIONS

A number of conclusions can be made from the work described in this paper. The first concerns the utility of the various perspectives in understanding CBIS in their context. It has been illustrated that the technical perspective was inadequate as a basis to conceptualise computer-based information systems in their context. We have described an information system that was highly conditioned by the wider social context in which it was embedded. The decision to change UAS's design principles in the second 8-4-4 admissions was, for example, done purely to meet the public's interests. We demonstrated in this case that the political perspective was a better tool to help us understand the interactions of the system and its social context compared to the technical perspective.

The concept of duality of structure was also demonstrated to be a valuable additional device to analyze the relationships between actions surrounding CBIS and the social contexts in which they take place. Prior lack of attention to the Secondary/University throughput or interface by the Ministry of Education and the Universities, following the introduction of the 8-4-4 educational system, forced the JAB to face this dilemma of the mismatch during the admission process. Even after changing the UAS to address its (the JAB) perception of the mismatch, the system had to further be modified not only to promote short-term self interests of the public, but also to negate standing Faculty admission principles. Furthermore, this had the consequence of lowering the quality of intake into the Basic Sciences, which in turn negated long-term Government policy on capacity building in this area, a policy which was part of the reason for introducing the 8-4-4 educational system in the first place.

A further conclusion concerns the ability of an information system to meet the challenges posed by changes in the immediate and wider social context. It was illustrated that a CBIS needs to have the flexibility to address itself to the specificity and the changing nature of both the technical and social context in which it is embedded. It was the Admission System's in-built technical flexibility that enabled its design principles to easily be modified to meet the changing demands imposed by both the Universities as well as the wider public.

Finally, specialised skills need to be available, such as the analyst/programmer in the case study, so as to modify existing systems to meet the changing *technical* and *social* (such as political) needs of the client organization and the wider context. The Admission System, for instance, had to be modified initially to be able to cater for the new educational system, and, subsequently, to meet pressure exerted by the public's perception of what they expected of a "fair" Admission System. The need to balance both *technical* and *social* aspects in maintaining, as well as developing, an application, implies that the CBIS personnel need to be sensitive to both technical and social issues surrounding CBIS. In the case study example, the social aspects were provided by the public and interpreted by the JAB with full cognizance of the implications for the UAS.

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ASYCUDA: A FRAMEWORK FOR AN INTEGRATED SOCIO-ECONOMIC DEVELOPMENT OF ECOWAS COUNTRIES

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ABSTRACT

This paper describes a low-cost multi-user system for Customs trade data capture and administration called ASYCUDA. It proposes a framework which attempts to show how its scope can be extended to serve as a platform for harnessing trade information as well as supporting a variety of Management Information Systems. The approach focuses on Management and Information hierarchies and their *matching* Information Systems needs. Examples of such hierarchies as they manifest in Customs Administration and the various levels of Planning & Control within the Economic Community Of West African States (ECOWAS) are used to illustrate this potential of ASYCUDA.

1. INTRODUCTION

In this Section, I will try and explain briefly, two keywords of this paper viz: ECOWAS and ASYCUDA. Together, these acronyms will persist not only as important aspects of the framework but as the main signposts of the discussion. My objective is to try and show ASYCUDA 's potential role for an integrated Information System (IS) delivery in ECOWAS.

In Section 2, an overview of the Customs Activity is given. The Framework is subsequently described in Section 3 showing the building blocks of the framework as a national and regional tool for MIS delivery by the ECOWAS COMPUTER CENTRE. The ECOWAS organisational goals, structures and processes form the basis for the discussion of its User-groups and their IS needs in section 3. There, the intention is to show how, based on the versatile ASYCUDA platform, the Computing Centre can proceed towards IS development for ECOWAS Planning and Control (P&C) within their matching end-user contexts.

1.1 ECOWAS

The Economic Community Of West African States (ECOWAS) is a sub-regional grouping of sixteen countries which was founded in 1975. Its overall mission is to promote economic integration in "all fields of economic activity, particularly industry, transport,

telecommunications, energy, agriculture, natural resources, commerce, monetary and financial questions and social and cultural matters..." [32].

Its policy organs (Fig. 1) comprise of a hierarchy of an Authority of Heads of State, a Council of Ministers and several Technical Commissions. The ECOWAS Secretariat and the fund for cooperation, compensation and development implement policies, pursue certain programmes and formulate new project.

The Community's COMPUTER CENTRE is a Department of the Secretariat located at the premises of the ECOWAS Fund ; it was first established in 1985. Its primary task is to work towards the full realisation of ASYCUDA's potential for socio-economic development. Hence, the role of the Centre in the continued development and use of ASYCUDA as well as other ISs is another important aspect of this paper.

1.2 ASYCUDA

The Automatic SYstem for CUstoms DAta (ASYCUDA) is a computer-based system that arose from the need to implement the ECOWAS Trade Liberalisation (TL) or free trade policy in the most effective way possible. It was first developed in 1981 by the United Nations Conference for Trade And Development (UNCTAD) on behalf of ECOWAS. Its initial purpose was to capture trade information at Community broder posts, airports, and seaports. Then, its main role from the ECOWAS viewpoint, was to facilitate the computation of revenue losses to Member States following the implementation of the free trade policy.

Over the last then years however, ASYCUDA has since outgrown this modest goal and become a more versatile tool for Customs work in many ACP countries. Hence today, Customs import/export procedures have been considerably rationalised and simplified in theses countries; ports management and control facilitated and trade data made readily accessible to other users But ASYCUDA's strongest point, is in cost-effectiveness as a socio-economic tool for developing countries. And as a measure of its impact, it has enjoyed considerable financial support from the UK, EEC, France and the UNDP.

2. CUSTOMS OVERVIEW

The Customs activity for most developing economies constitute a major source of revenue through import/export duties and taxes. This is truer still for those of our governments that depend on exports of agro-based products which, in these lean economic times, have tended to suffer from a steady decline in prices. Thus, it was in recognition of the significance of this activity that ECOWAS in the early 1980s sought help from UNCTAD in the design of a well articulated system of computer-based procedures governing dutiable and duty-free goods that enter and leave their ports.

The organisation for Customs work is generally structured in a three tier hierarchy of: local, regional and National/Headquarter offices as shown in columns A, B & C of Table 1 on the next page. At each level of the hierarchy a strong working relationship exists between Customs and two other important government agencies: the Treasury and the Department of Trade.

Other co-operating agencies include the National Statistical Office, Inaland Taxes Office and Police, Immigration and Health.

Table 1 Functional Hierarchy of the Customs Activity

A. NATIONAL HEADQUARTER FUNCTIONS	B. REGIONAL OFFICES FUNCTIONS	C. LOCAL OFFICES FUNCTIONS
1. PERSONNEL MGMT. 2. CUSTOMS STATISTICS COMPILATION 3. MANAGEMENT INFO. 4. VALUATION & FREIGHT 5. TARRIFS & REGIMES 6. DATA PROCESSING 7. ACCOUNTING 8. AUDIT & SECURITY 9. LICENCES 10 AUTHORISATIONS 11. COMMUNICATIONS	1. TAXES & DUTIES ASSESSMENT FROM: -direct imports -Warehouses -Distilleries -Manufacturers -Refineries & Ports -sales (VAT) 2. INWARD/OUTWARD CNTRL 3. FINANCIAL MANAGEMENT 4. CREDIT MANAGEMENT 5. TRADER VAT CONTROL 6. AS IN 3,7,8,11 OF HQ	1. DECLARATIO AND MANIFEST HANDLING 2. TAXES & DUTIES 3. TRANSITING 4. PORT BOATS CNTRL. 5. PASSENGER CNTRL. 6. DUTY-FREE CNTRL. 7. ARCHIVING 8. AS IN 3,7,8 & 11 OF HQ

At the highest level, the Customs activity extends into the realms of international co-operation with organisations like the Customs Co-operation Council (CCC) that, *inter alia*, sets international standards for data capture documents like Manifests and declarations; other important international agencies include the General Agreement on Trade and Tariffs (GATT), UNCTAD and UNDP. Also, because of its invaluable role as a resource generating agency, we find considerable interest shown in its activity by such global financial institutions as The World Bank and The International Monetary Fund (IMF) in countries with on-going Structural Adjustment Programmes (SAP).

It is however at the lowest level i.e Ports of Entry, that the Customs activity is most critical and hence more clearly defined. For instance, the policing and security issues that Customs are so well-known for worldwide is at most pressing here as drugs and other contrabands are checked for. Also, importers and exporters interact with this agency in a variety of ways depending on whether they are importing goods for: direct home consumption; warehousing or transiting; free-zone manufacturing; or pre-processing for re-export. Each of these modes of import are categorised into regimes for handling, clearing and tariffs; and some regimes are in turn governed by certain exemption or reduced rate clauses.

It is thus the complexity and magnitude of the processing and procedures governing the handling of goods and services into and from Member States, and the variety of actors and agencies connected in one way or the other with Customs activity, that brought about the need for an Automatic System for Customs Data (ASYCUDA) processing and MIS.

3. THE ASYCUDA FRAMEWORK

The ASYCUDA framework represents data flows through three layers. At the bottom is the regional gathering of data from points of imports and exports in ECOWAS. Trade data are classified here into banks of Economic, Financial and Customs types and fed upwards to a cluster of sub-systems: ECOTRADE; ECOSTARS and OFFICE SYSTEMS which can be considered as the second layer. ECOTRADE is the ECOWAS system for internal trade analysis and computation of revenue losses to Customs due to free trade. The others are the ECOWAS STatistical Analysis And Reporting System (ECOSTARS) and the Office Systems (OS) for the Operations and Studies, Finance and other Departments. The ECOWAS Trade Information NETwork (ETINET) can be considered as the top most layer as it manages information dissemination using Community products, industries and markets Data BASES as well as outputs from ECOTRADE and ECOSTARS.

The significance of the pyramid structure discussed is two-fold:

(a) it indicates how we must organise at the ECOWAS Computing Centre to support the three levels of both DP and MIS required for the Customs activity described in the structure shown in Table 1.

(b) it also fits the structure of the end-user categories within the ECOWAS Management structure wherein we must ensure steady upward flows of data whose information value increases with each sub-process and disseminated according to a hierarchy of information needs of the end-users.

This end-user hierarchy, as we shall see later in Section 3, fall into a similar pyramidal structure whose IS needs fits Anthony's [3] framework for Planning & Control(P&C) at each of three levels of Management. These are the operational at the lowest level, tactical at the middle level and strategic or policy formulation level. As this paper's thrust is on IS delivery for (P&C) within varying levels of management of the ECOWAS institutions, parcelling the cluster of sub-systems in this way affords us a perspective for a much clearer analysis form-context [31] analysis i.e matching ECOWAS user categories with their relevant IS delivery needs.

3.1 The Building Blocks of the Model

The Data Flow Diagram in Figure 2 gives a structure-process [8,30] view of the pyramid and assumes the SADM (Structured Analysis & Design Method) [4,5,6,20]. The primary data that drives the system is trade information captured at the National DP centres running either ASYCUDA or some other software. Presently three Member States operate locally developed Customs software; and for these, appropriate ASYCUDA file conversion interfaces are to be used.

3.1.1 National ASYCUDA Systems

Trade data arriving at Customs Computing headquarters, often come as goods declarations

obtained at the various ports of entry in a Member State. ASYCUDA thus operates either as stand-alone systems or as multi-user systems running under PROLOGUE in local Area Networks (LANs). It affects seven basic Customs activities. These are:

1. Manifest Control
2. Goods Declaration
3. Customs Accounting
4. Warehousing
5. Goods Movements
6. Licensing
7. Customs Statistics

Manifests contain entries of packages of goods shipped and have a control function. The software ensures that the quantities of goods exported from a given source equals that which is declared and is subsequently "written-off" by Customs at the port of entry intact. What we have here is thus a mechanism to check against importer/exporter collusion to avoid paying correct duties as well as a security measure against pilferage in general.

The Goods Declaration module captures data about a good as and when declared by the consignee. This function has numerous built-in control mechanisms that check for data inconsistencies in terms of data types and values alike. Thus on-line data verification takes place at the work station thereby ensuring that details of a declaration are, at the very least, self-consistent.

Warehousing is essentially a Stock Control function ; it monitors receipts and deliveries of goods in and out of Warehouses. Goods Movement is another mechanism to control imports through the use of transhipment registers whereas the Licensing procedure is invoked at the time of goods declaration to ensure that government regulation for restricted goods are not infringed.

With Customs Statistics, trade data are automatically compiled and stored into the Data Bases whilst Customs Accounting, assesses duties and taxes for each declaration. Daily journals of assessed duties are produced on demand. Some of the Customs procedures (Regimes) applied under ASYCUDA control include : *deferred duties* for some consignees; temporary imports and admissions; warehouse receipts and deliveries; transhipment and re-exports.

3.1.2 The Regional ASYCUDA System

ASYCUDA's foremost role from the Computing Centre's viewpoint is that of data capture. For at the Community level, we need a tool as far-reaching as this to harness and standardise foreign trade data. And, it is the need for standardisation that makes conversion interfaces for our non-ASYCUDA files imperative. Next, is ASYCUDA's statistics gathering feature. Here, the Customs Statistics function classifies and hence compiles sectoral data according to specific areas of analysis.

For instance, trade or Customs data is uniquely treated by ECOTRADE whilst all three types

of data are to be treated according to the type of analysis required under ECOSTRARS or the OSs. Thus for the Centre, the essence of ASYCUDA lies in its basic DP capability ; and its potential for filtering raw data upwards into other subsystems for value added processing and information dissemination.

3.1.3 ECOTRADE

ECOTRADE is the goal for which the ASYCUDA software was first conceived. It arose as a result of the TL policy which seeks to remove trade barriers between Member States and so its major role is to process compensation claims. As a first step towards reducing the impact of revenues losses from duty free imports of the Community's industrial products, Member States, on the presentation of suitable claims, are reimbursed for the amounts of money lost to the "common market". ECOTRADE also determines Member States annual contribution to a fund from which claims are paid. It has a statistical subsystem which obtains Products and Country flow statistics and computes Member States Trade Balances.

3.1.4 ECOSTARS

The ECOWAS STatistical Analysis And Reporting System is to come on stream by 1993. Its purpose is to compile and disseminate regional trade and other statistics within and outside the Community. ECOSTARS will thus analyse and tabulate statistics for external trade, transport, economic and finance among others. Trade statistics will of course be the primary focus with tabulations driven by commodities and their countries of origin for given periods; computed values will include CIF and FOD values (for imports & exports) weights, quantities and trade balances.

3.1.5 Office Systems

Although there are several Office System (OS) driven by packages such as Dbase & Lotus; only two of these necessarily fit into the framework described here viz : "Operations and Studies". Because the Fund's Operations Department mainly implements "loans guarantee" schemes, it requires macro-economic data about interest rate, sectoral profiles, Member States debt situations as well as their Structural Adjustment Programmes. Thus, the ASYCUDA economic sector Data Base tables clearly put this OS [26] within the scope of the framework.

The Studies function is however located in both establishments. Whereas in the Fund the emphasis is on the evaluation of sectoral project viability, in the Secretariat the focus is rather on providing and maintaining the macro-economic data used by various Departments. This need is thus integrated into the framework because ASYCUDA facilitates the capturing of the most current economic data from trade transactions.

3.1.6 ETINET

The ECOWAS Trade Information NETwork is also expected to come on stream by 1993. It will hold data about the Community's businesses, industries and priority goods whilst managing information retrieval from and integrate trade and Macro-economic Data Base. Its primary

role is to disseminate trade and other information within the Community. As a tool for Community trade promotion, ETINET will thus support the "mailing" of buyer-seller information across Member States using WANs. Wide Area Networking will indeed be low-cost in keeping with the design philosophy. For instance, we can draw from VITA's (Volunteers IN Technical Assistance) experience in using existing inexpensive and easy to use PC based communications software [31], such as Frontdoor, Fido or Seadog. So, we would be able to link not just with Member States, but readily communicate information directly to other end-users.

4. ECOWAS USER-CATEGORIES FOR IS DELIVERY

Several management factors including organisational goals, processes, structures, resources and constraints are important contextual [18] arguments for fitting [24,28] an IS into a given part of its hierarchy. Three of these will be discussed here : - ECOWAS goals, structures and processes. Structurally, Fig. 1 shows three distinct contexts at three levels : first, are the two institutions of the Fund and Secretariat for which there are OSs. Then there are the 16 Member States for which we must provide intra and extra-regional trade and economic information. Lastly, is the three tier supra-policy making sub-structure which needs strategic information for effective P&C [1,3,4,12,13,16].

Also, in Figure 1, we note that each of these depend for its IS support services on the Community's Computer Centre. Hence, the focus of the IS for each domain changes as we move from an integrated Office Information System [26] to a Community-wide MIS at the highest level. Thus, by examining the processes within each context separately, we can identify not only their P&C needs but also the differing quantities and quality of information support that will be needed to plan, control or manage the activities at each level. The discussion that follows will try to bring out where strategic, tactical and operational [3] types of information support are most needed based on managerial exigencies.

4.1 The ECOWAS Fund & Secretariat

In both institutions there is a similar hierarchy of Departments and their Divisions ; within Divisions there are Sections. Most automated systems such as Payroll, Project Management and Research are operated within departments or sections while the Computing Centre is expected to deliver ISs, run computer courses and give general support services. So, because the Centre has this all-pervading role for IS delivery we must try and relate the quality of its services to end-user attitudes [7,15] here. Table 2 on the next page shows that the effectiveness of a dynamic or lethargic Centre depends on the extent of users' responsiveness to IS delivery.

Clearly, a team of dynamic Change Agents [17,29] with keen user responses can seize most IT opportunities and better manage its risks. But because effective IS delivery for Operational P&C [3] tends here towards meeting sub-systemic [30] goals for departments, divisions or sections, the risks of incorrect, duplicated and inefficient data must be avoided. Again, the LAN-based data sharing proposed in the framework will effectively address this problem. The biggest drawback occurs when the Centre is either insensitive to users demands or merely reacts [10] to events. At such times, not only are opportunities lost, but delivered systems risks

being ineffective and not used [17,23]. Resources are thus wasted requiring re-definition of roles and methods.

Table 2 *Role-Response Matrix for IS delivery*

COMPUTING CENTRE (Role)

END-USER RESPONSE Attitude		Proactive	Reactive
	Keen	- IS delivery easier - IT better used - P&C improves - User needs in focus * Encourage dynamism	- Opportunities lost - Centre loses focus - P&C is weakened - Poor resource usage - Review Role & Focus
	Weak	- Cultural setbacks - Waste of resources - IT not beneficial - IS may not be used * Modify approach to IS delivery	HIGH RISK & WASTEFUL * Sensitize Users * Review Role & Focus

Tactical P&C [1,3,4] in these institutions is at its most evident in budgetary control. Resource acquisition such as loans and grants and their effective use thus calls for careful planning [11]. IS delivery here demands from us good P&C tools for financial MIS, resource control and project management. No doubt, the model has adequate scope for this role within the OSs. Through proaction [10], we can work out IS tools for forecasting socio-economic behaviour resulting from the TL policy for instance, and thus measure deviances from planned action [4].

Strategic IS needs [9,11,12,14] are differently defined in the two institutions in focus here. First, we note (Fig. 1) that the supervisory body for the Fund is a Board of Directors whose goals and strategies are devoid of the strong political constraints that impact on those of the Council of Ministers supervising the work of the Secretariat. Thus, whereas the Fund's Board needs data about profitable investment options and climate, the Secretariat's strategic concerns borders on macro-economic planning information that aids policy implementation and or modification.

One difficulty the Centre must recognise therefore is that any Strategic IS delivery is limited by the value judgement of these institutions. So, we cannot be too reliant on hard deterministic methods and data to support decision-making here. Further, the IS for supporting realworld systems that monitor and evaluate attitudes in Member States goes beyond querying persistent Data Bases that contain quantitative data about socio-economic behaviour.

For, even with the best for quantitative data and stochastic methods, only a limited set of strategic P&C needs can be met from the extended Data Bases implied in the model. The main reason being that whereas strategic planning is often tenable with historic data, Control which

is equally, if not more important, is restricted by the fact of two many external stakeholders influencing decision-making. Thus, both the model and the Centre suffer here no matter whether we are very proactive and enjoy the keenest of end-user commitment.

4.2 The Member States Category

To put the DP and MIS needs here into its correct perspective for analysis we must reflect on the functional hierarchy of the Customs activity shown in Table 1.

First, we note that Table 1 is structurally similar to the three ECOWAS "user categories" presently in focus here. That similarity thus permits us to correctly situate the DP and MIS needs of Member States in the IS pyramid. So, here, we can view the three levels A B & C in Table 1 first as the equivalent of Anthony's operational level from the point of view of the role and place of the Customs activity in a given national context. But because each level has its peculiar IS needs tied to its functions, we must first provide for the two upper levels - tactical and strategic - and, to a lesser extent, support ASYCUDA's role for effective Customs administration in Member States.

It is thus through this process that we can best see the Centre's role. For whilst serving as the bridge between UNCTAD - the ASYCUDA software developers - and Member States, the end-users, for problem identification and first level assistance, we are better placed to gather vital trade, economic and financial data for regional statistical analysis and reporting. Second, the IS pyramid offers through the upward flow of data into sub-processes like ECOTRADE and ECOSTARS information that are geared towards meeting Member States tactical and strategic P&C needs. ECOTRADE for instance, provides intra-Community trade flows and balance of payments reports based on internally manufactured exports - an instrument which clearly is useful for monitoring community-wide trade patterns and levels of imports.

Table 3 *The ASYCUDA Framework:Information Matrix for P&C*

ASYCUDA FRAMEWORK (Tier 2 & 3)

P&C LEVELS	ASYCUDA (Tier 1)	OTHERS (Tier 2)
TACTICAL P&C	- Trade Statistics - Customs Revenue - Economic Growth - Import Bill - Export Capacity - Consumer Patterns	- Projects Impact - Loans Utilisation - TL effect on Revenues - Trade Balances - Trade Biases - Industrial Growth
STRATEGIC P&C	UNDEFINED	- Import/Export Policy - Budgetary Policy - Industrial Policy - Community Initiatives - Stakeholding Control - Demand Management

Table 3 summarises the information types retrievable for supporting P&C at the tactical and strategic levels of Management in Member States. It also shows the two tiers of the IS pyramid most affected here. In all but one case, there is either direct or implied added value to source data captured from Customs declaration and filtered upward. Thus, data for strategic P&C cannot be defined at ASYCUDA's base level.

From the Table, all information types are merely quantitative pointers to both planning and Control issues. Decision-making will not doubt be affected by Member States internal social and welfare concerns. At the tactical level, information types and their socio-economic effects are listed for the first two tiers of the model. Strategic P&C sensitive areas are indicated for second tier processes as they might affect either planned policy measures or suggest the need for new control instruments. The value of the model here lies more in the ease of accessibility of critical planning and decision-support information as and when it will be needed by Community members.

4.3 Policy Institutions Category

Again we note that the ECOWAS policy institutions (Fig. 1) are also in a 3-tier hierarchy very much like the overall "user categories" of which it is as much a part. Thus, we have at the lowest level, Technical Commissions closely supervising the work of specific functional areas in the Secretariat and the Fund. Then there are the Ministerial Council and Board of Directors monitoring policy issues and taking decisions that are to be ratified by the Authority of Heads of State.

The essential point however, is that we have a management structure here that represents a collective on whose behalf decisions are taken that seek to "promote economic integration". Thus, our concern here is once again the goal argument and hence *what* IS that best fits [24,27] this user-category. Clearly, there is the need for both hard facts and figures here as well as the non-deterministic inputs which the model may be unable to provide. But the fact remains that the data types indicated in Table 3 above for SP&C [9,12,13] strongly applies here.

The process and data flows here are such that, for instance, the A&F Commission will consider budget estimates that would have been rigorously scrutinised at the divisional, departmental and institutional levels. Its recommendations and inputs to the BOD and or COM become highly aggregated data about which decisions must be taken and funding sought. Thus, it is on the advise of this body that the AOHS will ratify planned action and commit funds. Now, some of the planned action may require funds available from third parties such as donor agencies. This raises the issue of strategic and stochastic environmental [10,14,22] information about opportunities and risks for projects implementation and overall socio-economic goal attainment. In this context there is need for hard data for rigorous project appraisal and scanning [10] of the internal environment about the most competitive schemes for ease of attracting loans and or grants. Thus, the scope of the model all be it weak at providing qualitative data, is far reaching to the extent that its Data Bases can generate a variety of decision-making scenarios for which value judgements remain.

5. IMPLEMENTATION STATUS

5.1 National Projects

Presently ASYCUDA is installed in eight ECOWAS countries, namely: Benin, Mali, Burkina Faso, Mauritania, Cape Verde, Niger, Ghana, Togo.

Implementation processes are also quite advanced in the Gambia, Guinea (Conakry), and Guinea Bissau. Three of the remaining five member states i.e Cote D'Ivore, Nigeria and Senegal have locally developed systems. For these countries, we are now exploring the possibility of using ASYCUDA as a front-end data-capturing and goods-clearing system at remote sites. There are thus just two remaining countries of the Community - Liberia and Sierra Leone - which are yet to be brought into the ASYCUDA framework.

5.2 Management Information Systems (MIS)

It is thus against the above background that we must see the development and role of the Computer Centre and hence the model described for gathering trade and disseminating fiscal and economic information for the Planning and Control in Member States.

Although the interfacing mechanisms for data coming from the Ivory Coast, Nigeria and Senegal are still to be worked out at the base level of the model (where the Customs Declaration is the primary data source), we do not have any difficulty in using some segments of this same data for obtaining community external trade statistics for instance. It is thus expected that systems such as ECOTRADE for intra regional statistics, and that for community external trade statistics will be up and running in a year's time.

Secondly, we are in the process of installing national statistical systems based on an EEC donated software called EUROTRACE which we hope will serve as a useful statistical tool for member states external trade whilst affording us the opportunity of processed data collection that is also based on the Customs activity.

Thirdly, the Centre is actively pursuing the continued development of national implementations of ASYCUDA through carefully planned training programmes (of three months duration per session) for Customs personnel as well as the installation and maintenance of installed systems. In the past three years we have in collaboration with UNCTAD, brought on stream two new installations (Benin and Burkina Faso) and are currently developing three new ones - Guinea, Guinea Bisau, The Gambia.

There are however two major problems:

a) files transfer difficulties that hinder data gathering at the Centre especially as we depend on courier methods for sending diskettes to the Centre by Member States.

b) the need for compatibility or interfacing mechanisms to the three non-ASYCUDA systems whose data we must also capture and integrate into regional trade data banks.

In (a) above we experience considerable delays in the delivery of streamers containing national trade data. And such data when they arrive are stale. Hence, the difficulty of obtaining a total community picture.

The ECOWAS statistical analysis and reporting system is to be the kernel of all MIS as the Centre's IS delivery activities progress. Work in this area has only just begun with the determination of the various Macro-economic variables for which we must collect data. Detailed data and Functional Analysis are to be undertaken later this year; the development of this system is expected to continue through to 1993.

Perhaps the area where the Centre has been of greatest impact is in the delivery of Office System to the two ECOWAS institutions. For in the last three years we have put in place a variety of Text Processing and Financial Accounting Systems - using off-the-shelf software. We have also developed software for Payroll and Loans and Provident Fund Administration Systems.

5.3 Information Dissemination

Not unlike data collection, this is another area of considerable challenge especially as it affects Member States who must have ready access to Community data held centrally in our data banks. The approach to regional information dissemination is manifested in ETINET the top-end of the model which is also intended to be the gateway to the wider Community from its Computer Centre. Implementation here will start with CD-ROMS containing statistical and macro-economic information which is to be distributed to Member States for on-site access by development planners and monitors alike.

This phase is to last till 1994 when, in collaboration with the African Regional Centre for Technology, (ARCT) in Dakar, we hope to establish an *on-line* ECOWAS Trade Information Network. The Network will then facilitate data files transfer to and from the Centre as well as remote accesses to centrally held trade Data Banks.

6. CONCLUSIONS

The main message is that ASYCUDA's potential for harnessing data can be extended such that it becomes an effective platform for IS delivery. It has been shown that the continued socio-economic development of the ECOWAS Community can be significantly aided through the provision of a variety of information types for P&C based on the proposed systems configuration. The pyramid's limitations have nonetheless been indicated especially as it affects qualitative information for strategic P&C.

Second we have seen what a complex structure the Customs activity is and its significance for revenue generation in our depressed economies. Thus, the role of a system like ASYCUDA, first as a Customs administrative and Management Information tool and as an inexpensive method for automation - given its Micro based hardware environment - is crucial not just to revenue generation but to the notorious issue of debt management that is currently plaguing the sub-region's economies.

Third, it is clear that the role and capacity of the ECOWAS Computing Centre to deliver and maintain the Information Systems discussed here is crucial to the very existence and development of the community. For no Community can thrive without ready access to good quality information about first, its own internal activities, and, second, its external environment or stakeholders and competitors. Thus, the Centre must not only continue to research into new tools and methods for IS delivery but must be able to cope with the changing IS needs of its community.

Lastly, the question of IT's risks in the ECOWAS sub-region is one that is, no doubt, one that is still to be fully assessed. But opportunities there are no doubt - as the above case study attempts to illustrate. However, I think it is about time ECOWAS countries begun to fashion out clearcut policies towards the acquisition, use, maintenance and education in IT so as to contain waste. Indeed some developing countries within ECOWAS now assemble Personal Computer (PC) hardware even in situation of a "DO NOTHING" government policy. Besides, through the dumping of some unserviceable IBM clones in the sub-region, we now run risk of losing scarce foreign exchange. Considering therefore the sizeable investments which Member States public and private sector had made in the last two decades on Mainframes and Minis, the loss to our economies becomes a great deal more magnified as a result of today's rapid obsolescence of IT hardware.

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Figure 1 *ECOWAS Institutions and Information Flows*

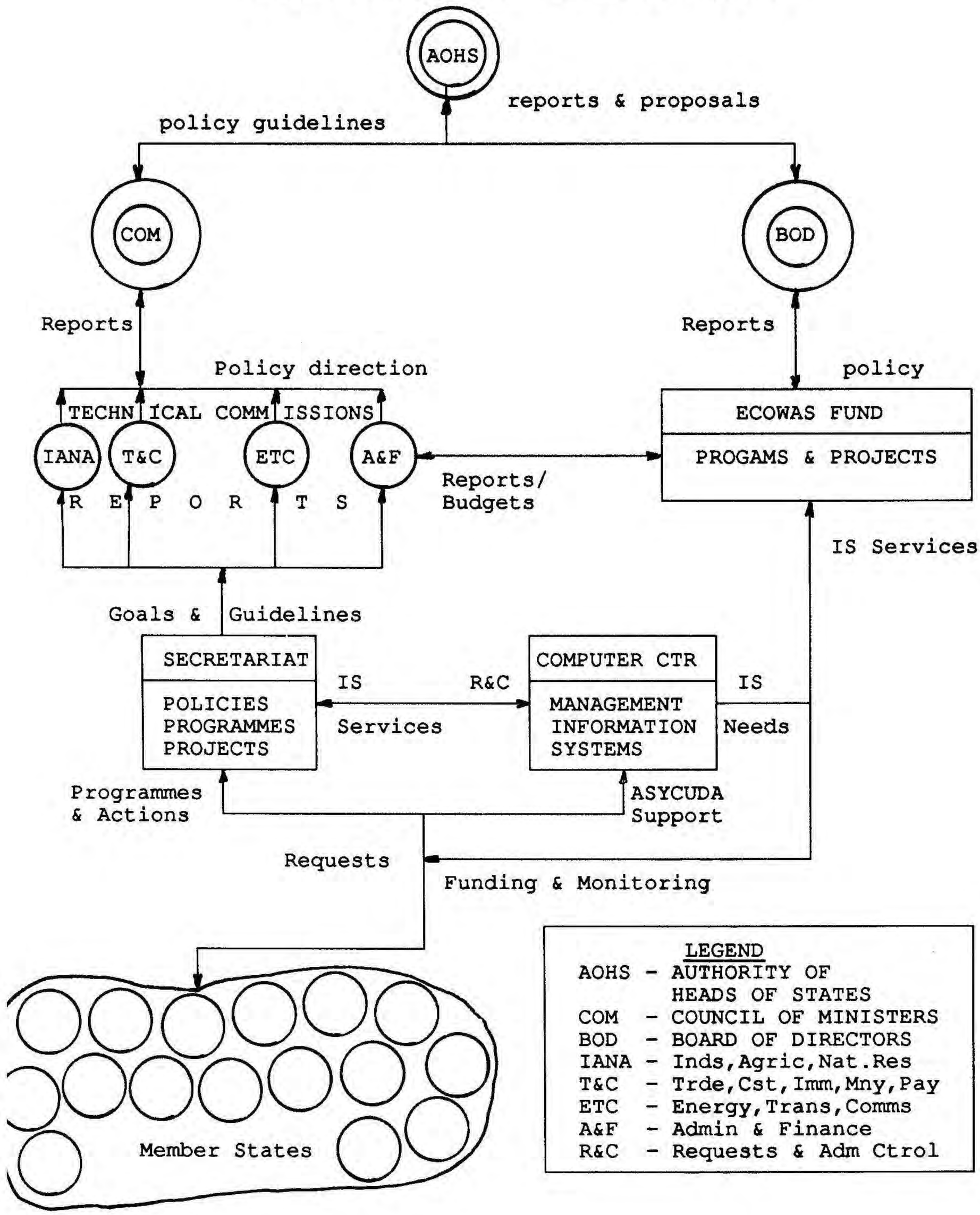
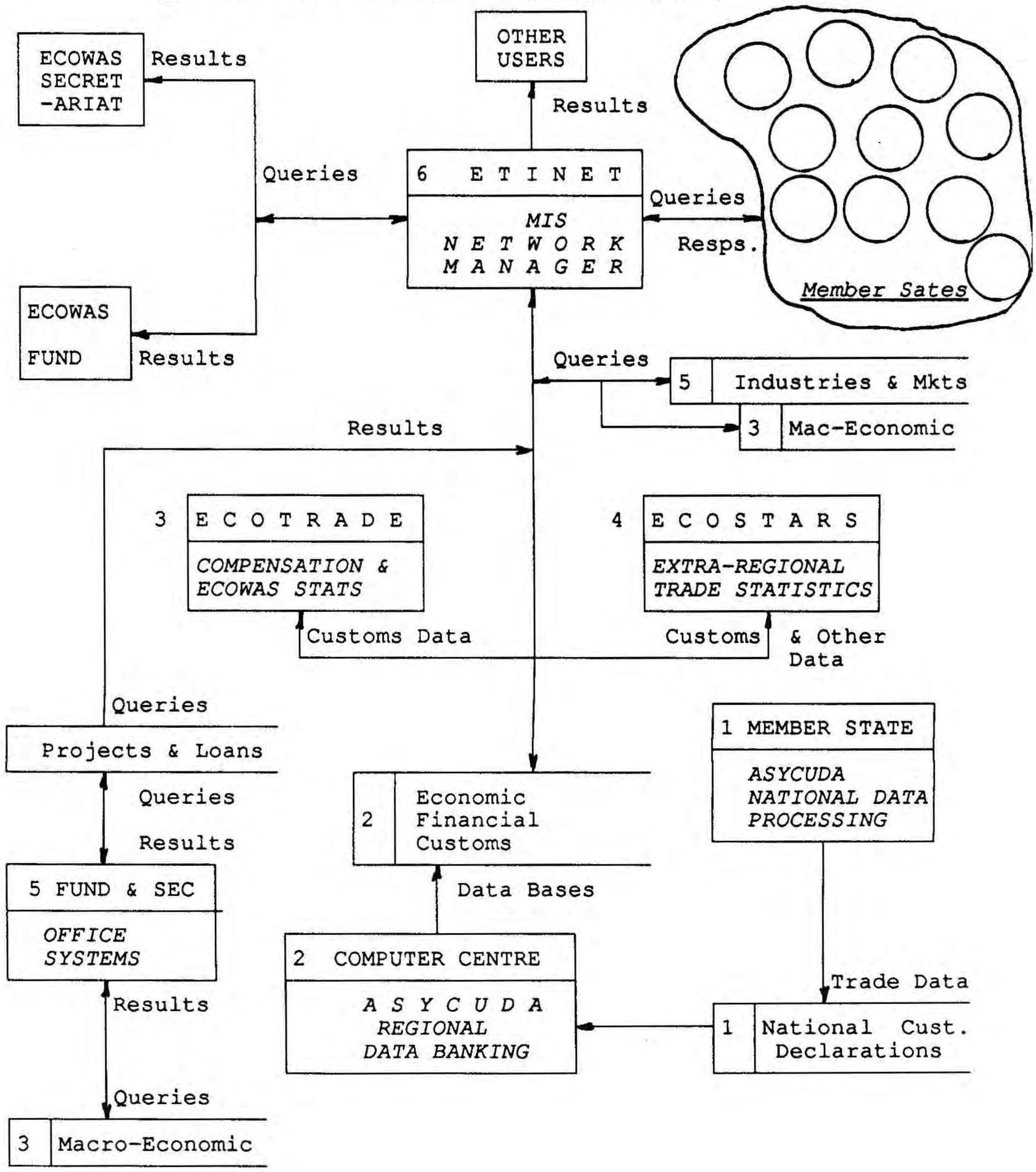


Figure 2 *The ASYCUDA Framework:Data Flow Diagram of the Pyramid*



ASPECTS OF COMPUTER SECURITY IN KENYAN BANKS AND FINANCIAL INSTITUTIONS

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ABSTRACT

The primary focus of the study was to find out the extent of management awareness of the potential risks facing computer based financial information systems and the preventive measures undertaken. The population of interest for the study comprised the 24 commercial banks and 54 financial institutions registered under the Banking Act and operating in Kenya as at 30th June 1988. A census study was carried out. The findings of the study suggested that most of the risks perceived by management were of a physical nature : fire, power surges and floods. The other more elusive and dangerous risks whose materialization would lead to unauthorized interruption, corruption, destruction, removal or disclosure of data and computer resources were not given sufficient consideration. The observations indicated apparent ignorance of the authorized user or the company's own employees as the major threat facing computerized systems. Huge losses were reported from frauds, spillage damage, magnetic media failure, etc. The preventive measures undertaken emphasized the traditional approach : access control, fire guards, power stabilizers, etc. This situation appeared to increase the potential for error, fraud, sabotage and unauthorized access to confidential information on many computer systems. Socio-cultural, organizational and economic issues which influence the current security situation were considered as the basis of the findings. Suggestions for strengthening the security of computer based financial information systems were made.

1. INTRODUCTION

The research reported here was done in 1989. It covers all the 24 commercial banks and 54 non-bank financial institutions registered and operating in Kenya. An exploratory research design was used. Data was collected using a structured questionnaire aimed at tapping information on the extent of computerization in these institutions, security awareness, control and breaches of security that may have been experienced. Most of the statements and/or questions were scaled in accordance with a likert type scale.

The study was stimulated by two developments that became evident in Kenya in the 1980s.

1.1 Unprecedented Computerization

Management appeared to have recognized the vital role computers play in their organizations.

It became fashionable for businesses to commit considerable resources to acquire the "wonder" machines that promised to instantly solve problems that had plagued their organizations over the years. Computerization appeared to signify growth, prosperity and modernization. The local mass media was becoming increasingly dominated with company features detailing the level of computerization and the competitive edge it was supposed to provide.

Banks and financial institutions specifically portrayed computerization as the ultimate strategy to customer service

1.2 Computer Related Crime

With computerization, criminals appeared to have developed unprecedented appetite towards stealing computer hardware, causing unauthorized interruption, corruption, destruction, removal or disclosure of computer based data.

International and local mass media and other pertinent literature reported increasing incidences and magnitudes of computer based crimes. For example; Hurford [1] in his survey stated: "It is becoming increasingly difficult to read a national newspaper or computer journal without some references to computer crime. While there seems no reluctance on the part of experts on this topic in claiming that the U.K. is in the grip of a multi - million technological crime wave, the true positions is less certain and hard evidence in less readily available".

Carter [2] revealed that, "Computer crime now poses such a significant threat to European business that spending on data security measures will treble to $ 1.7 billion per annum by 1992". Quoting "Data security in Europe" he stated that the potential for computer fraud will undergo a dramatic increase up to the mid-1990s.

According to Carter, "Many firms genuinely believe that they have adequate data protection systems, when in reality, their own staff are defrauding them everyday".

He reports that a survey of 386 companies, conducted by the American Bar Association, produced the surprising result that many firms continue to have faith in their security systems, even after instances of computer crime have come to light. He emphasizes that much of the computer crime is only discovered by accident.

Finlay [4] strongly warns that computer fraud and theft can put a company out of business and he suggests preventive steps that can be undertaken. Public accountants, among others, have also recognized computer security problems and have compiled and released comprehensive guidelines for members on the auditing of computer based information systems.

In Britain, "The Data protection Act 1984" is now part of the British legislation (Lane 1985) [6]. At the local level, many local and international auditing and management consultancy firms set up complete departments or sections to specifically address themselves to their clients' computer - related needs in general and specifically computer information systems application risks. Commercial advertisements by business firms in the computer based

industry are now on the increase - warning users of the threats to their computer systems and urging them to invest more in computer security.

Lane emphasizes that although the security of computer based information systems is fundamental to all systems, the need for security is most evident in financial systems. This is attributed to the basic commodity held in financial systems - money or its equivalent - and its undisputed universal attractiveness.

According to Norman, [7] a bank cannot take the security of its assets for granted: "And information (customer information) might be the most expensive and delicate asset a banking institution holds. Loss of such information might hurt an institution in a way that might never be regained. For, having happened once, people (customers - current and potential) would need to be doubly reassured that the danger has been decisively eliminated, and the only way to ensure that would be to invest in comprehensive disaster recovery facilities. Ironically, if the company had the foresight to embark on precisely the same plan of action before the disaster occurred, the market place would have been unaware of what had happened and the existence of the company would not have been threatened".

For the purpose of this study, security is used to refer to the protection of data from accidental or deliberate threats which might cause unauthorized interruptions, disclosure, corruption, removal and/or destruction of the data and protection to the information system from degradation or non-availability of services. A computer system is taken to comprise: "the hardware, software, application programs, communication facilities, computer and user personnel, the installation, methods and procedures, the data in the system and various supporting and ancillary services, for example, electric power and transport, without which the system cannot operate".

2. OBJECTIVES OF THE STUDY

The objectives of the study were two fold:
1. To find out the extent of management awareness of the potential risks facing computer based financial information systems.
2. To find out the preventive measures undertaken by management to contain the computer risks.

3. RESULTS AND DATA ANALYSIS

Seventy eight questionnaires were issued to the banks and financial institutions comprising the population of the study. Table 1 provides an initial analysis of the distributed questionnaires. As can be noted from the table, 58 questionnaires out of the total 78 distributed were successfully completed.

These were used as the basis for data analysis and the findings of the study. They represented 74% of the total questionnaires distributed and were considered sufficient to facilitate the completion of the study. The response rates for banks and financial institutions were 83.3% and 70.4% respectively. Regrets were received from respondents who considered

the information being sought as too sensitive and whose disclosure was considered injurious to their operations.

3.1 Perceived Security Risks in Computerized Systems

The responses measuring the extent of management awareness of the risks faced by computer systems were evaluated on a four point scale: 1) To a great extent, 2) To a moderate extent, 3) To a small extent 4) To no extent. A summary of the responses is provided in Table 2. It is evident from Table 2 that fire, power surges and floods were the only major risks perceived to face the computerized systems. Fire was considered an appreciable computer security risk by 79% of the respondents while power surges and floods were similarly perceived by 82% and 63% of the respondents respectively. These three threats may all be classified as physical risks. This observation was consistent with the findings of studies reviewed.

Only 42% of the respondents appreciated that operators could deliberately cause computers to malfunction. Over 60% of the respondents did not consider the various computer security issues to provide significant threats to their computer systems.

Finally, only 16% of the banks and 23% of financial institutions admitted having noticed lists of passwords cellotaped on the computer terminals, computer room walls or left in unlocked drawers. The cellotaping was seen as a measure to ensure that employees input the right passwords or codes. No risk was perceived.

3.2 Some Computer Security Related Problems Actually Experienced

The security related problems that respondents indicated they had experienced since computerization are summarized in Table 3.

The following observations were made from the responses summarized in table 3 above: The most commonly experienced computer security problems in decreasing order are the operator/clerical errors(42%), machine (hardware) failure (40%), power failure (36%), and magnetic media failure (33%). Huge losses were reported from incidents that were not as widespread as those listed above. These were fraud and spillage damage. No incidents of wire tapping were reported.

One respondent reported that collusion between an employee in a leading city branch and a computer criminal had led to a loss of kshs, 10.5 million. When the fraud was discovered, a cheque for Kshs. 8.5 million had just been deposited. Bank records (manual & computer) were removed upon the effecting of the transfer!

Another respondent reported that unauthorized use by a computer literate employee led to the organization losing over kshs. 40,000 in one incident. These cases was reported to the police but no prosecution was effected due to the fear of adverse publicity. The employees were quietly dismissed from the organizations!

Substantial losses were reported from an incident where an employee left a water tap running on Friday. By Monday morning, the computer room (downstairs) was flooded and the entire software had to be replaced. Cases of pins, tea or coffee spilling over the keyboards were also reported.

4. SOME SPECIFIC COMPUTER MEASURES CURRENTLY EMPLOYED

Table 4 represents some of the computer measures that the respondents reported they had instituted to control and manage risks that faced their computerized systems. The following observations were made from table 4.

About one-fifth (18%) of the respondents do not change their passwords at all. A majority of the respondents (58%) however change passwords on non fixed intervals.

Most of the respondents made back-ups at the end of the day. This might be linked to the observation made that most of the institutions used batch or combined batch and on-line processing approaches.

About one-quarter (24%) of the respondents stored the back-up files in the same location with the source programs/data.

Most of the respondents (67%) had separate units in the data processing department for system development, data preparation, computer operation, file library and data control. One-third of the respondents reported these duties being performed by the same unit or persons.

Almost all the respondents (96%) had a lock and key for computer room. About 80% of the respondents indicated that access to the computer room was restricted to the operators, data processing managers, programmers and management staff. One respondent reported that access was restricted strictly to operators and anybody else (management staff, programmers, etc.) was required to sign a visitor's book to be allowed access. Air conditioning, lock and key for media safe/cassettes and diskettes; and power stabilizers were instituted by over 80% of the respondents.

Other "non-physical" security measures were reported by fewer respondents e.g. on-line control total checks (49%).

5. COMPUTERIZED Vs. MANUAL SYSTEMS

A majority of the respondents indicated that computer based systems were not more risky than manual systems. Most of the respondents (69%) indicated satisfaction with their current security systems. These are illustrated in table 5.

The respondents who did not consider computerized systems to be more risky than manual systems (71%) gave two reasons for this view:

Most of the computer users were still computer-illiterate and would take long before enough courage and expertise to perpetrate computer crime was gathered. It was easier to implement controls in computerized systems than in manual systems.

The 29% who considered the computerized systems to be more risky than manual systems charged that it was easier to recognize change or mistakes done on paper than was the case with computer systems. A few respondents feared that a skilled computer operator could more easily perpetrate frauds than the skilled worker in a manual system.

Majority of the respondents not satisfied with their current computer security systems explained that no system was foolproof and any complacency could be exploited by computer criminals.

6. CONCLUSIONS

The study indicates that most of the risks perceived by the institutions were of a physical nature; Fire, power surges and floods. The other more elusive and dangerous risks whose materialization would lead, for example, to unauthorized interruption, corruption, destruction, removal or disclosure of data were only considered to be risks at most to a small extent. For example, only 36% of the respondents indicated that computer personnel/ users could perpetrate fraud or cause errors by making unauthorized changes to data files. A majority of the respondents (58%) did not consider significant the risk of operators deliberately causing a computer to malfunction. Sixteen percent of the banks and twenty three percent of the financial institutions which reported having noticed lists of passwords cellotaped on the computer terminals, computer room walls or left in un-locked drawers did not perceive this as a security risk. The cellotaping was a measure taken to ensure that personnel input the right passwords and codes. This action, while providing the users easy access to their passwords and codes, does increase risks as access to information is no longer confidential. This could be costly to the institutions as it becomes easier to perpetrate fraud. One-fifth (21%) of the banks and 16% of the financial institutions indicated that passwords have never been changed. This makes it easier for computer criminals, once they get hold of such passwords. They are also likely to misuse the passwords for a longer period. About one-fifth (19%) of the financial institutions obtained guidance on computer security considerations from their computer programmers and operators. such a system may not result in effective control measures. These employees may be only superficially knowledgeable in computer security and also too involved in the system to give objective advice on computer security. This observation indicates apparent ignorance of the major threat that face computer systems - the organization's employees.

The study also suggests that the measures to contain or prevent risks were mainly aimed at the "physical" threats. The emphasis appeared to be on the traditional approach - access control, fire guards, power stabilizers, etc. The study indicated that the most experienced computer security problems in decreasing order are the operator/clerical errors, machine (hardware) failure, power failure and magnetic media failure. Huge losses were also reported due to frauds and spillage damage. While the measures adopted might be effective in reducing incidents of power failure, the other more serious and frequent security problems

appear to be left unattended.

In addition, an appreciable proportion of respondents had instituted measures that appeared to be either ineffective or very risky. For example, 24% of the respondents stored both the back-up files and the source programs in the same physical location. Thus any physical catastrophe affecting the source programs/data would most likely affect the back-up files as well.

While most of the respondents indicated they reviewed their security arrangements, 42% of these did so on a fixed interval basis or not at all. Such procedures appear to be predictable and thus convenient for a computer criminal.

Most of the measures also appeared least appropriate to contain such "modern" crimes as computer viruses.

While most of the respondents (73%) had a written, formal computer security policy, only 44% made any annual budget allocations for the security of their computer systems. This confirms the view held in the literature that the issue of security is considered mainly after the other financial needs are satisfied.

Despite the aforesaid, 69% of the respondents indicated they were satisfied with their current systems. Most of the respondents(71%) did not consider the computer systems to be more risky than manual systems: The Two main reasons that were given were, first, that most of the computer users were by no means computer "wizards" and hence lack expertise to perpetrate computer crimes. Secondly, respondents felt that it was easier to implement controls in computerized systems than in manual systems.

These reasons however, appear to compound further the security problem. By the users being ignorant, it would imply that the better of them can always perpetrate fraud without the knowledge of the "illiterate" colleagues. It is a situation like this that led to the loss of ksh 40,000 by one of the respondents in the study.

The second reason suggests management ignorance of the fact that computerization provides more serious drawbacks in accounting controls than in manual systems. This is because it is much more difficult to segregate tasks and duties with computerization than with manual systems.

Only 29% of the respondents considered the computerized systems to be more risky than manual systems. As they indicated, it is easier to recognize changes or mistakes done on paper than is the case with computerized systems. A few of these respondents rightly pointed out that a skilled computer operator could more easily perpetrate frauds than a skilled worker in a manual system. A majority of the respondents who were not satisfied with their current security systems explained that no system was foolproof and complacency could be exploited by computer criminals. But only 31% of the respondents indicated they were not satisfied with their current computer security systems!

A fundamental conclusion from the above was that the findings of the study were consistent with the current theory on the security of computerized information systems. Management was largely found to be unaware of the major potential risks their computerized systems faced.

7. SOCIO-ECONOMIC IMPLICATIONS

The above findings should be understood within the following socio-cultural context of the computers in banking in Kenya:

Computers were introduced in Kenya as "wonder" machines specifically designed and tested to solve virtually all organizational problems. What was apparently needed was for an organization to invest in computers and then deploy (junior) employees capable of keying in the data. Solutions would be instantly found on the touch of a computer key! Top management therefore delegated the operations of the computer data processing (and security) to computer operators and programmers. The computer department was relegated to one of those other miscellaneous departments in the organization. A parallel manual system continued to operate along-side the computerized system as "safe-guard" against threats (physical) that were thought to affect computers. In general, management did not find it necessary to have "hands-on" experience on the computers to be exposed to the real risks that computerized systems faced. The fear to loose their jobs, undergo painful re- training or simply to display management ignorance of computers to the more conversant juniors (computer operators, etc.) might have contributed tremendously to management computer illiteracy and ignorance.

By over-relying on their employees for advice on computer security, top management fail to appreciate that the fundamental threat facing their computerized systems is the authorized user (the employee). Collusion with outsiders (criminals) is ruled out. The syndrome that potential computer risks "cannot happen in our organization" compound the security problem further. These creates an ideal environment for computer fraud. Besides, whenever a fraudulent employee is caught, he/she is quietly dismissed for fear of adverse publicity. The fraud might in the mean time have transformed the employee into an affluent member in the society!

Management appear not to appreciate the fundamental implication of computer insecurity - that it can put their organization out of business. The large banks and financial institutions can afford to hire the services of international auditing and management consultancy firms for advice on computer security. However, most of the small institutions have to rely on the capacity of local audit and management consultancy firms for advice and audit of their computerized systems. The local firms might be deficient in the requisite skills and might have problems with the influx of software used and tested elsewhere. The affordable professional backing might therefore not sufficiently cover the spectrum of computer security.

Customers look upon computerization for better and quicker services . These advantages might however be offset by the fear that their accounts might be more easily manipulated. Generally, it appears that there is a relationship between the technology of crime and the technology of the prevention of crime. It can only be hoped that the level and sophistication

of computer knowledge of employees keeps the pace.

Most banks and financial institutions appear to follow a "migration" path in the computerization process i.e. moving from less powerful to more powerful computers. This migration of technology might not give enough time for computer criminal activities.

8. RECOMMENDATIONS

The following measures could significantly reduce the risks and enhance the control over computer based financial information systems;

8.1 Increase Management Awareness of the Risks Facing Computerized Systems

Management should be more aware of the diverse nature of risks their computerized systems are exposed to. It should appreciate the reality that materialization of the risks could easily put them out of business. The following measures could increase the management awareness.

Auditors, dealers, manufacturers and suppliers of computer hardware and software could organize regular seminars for their clients. Using such forums the security features of the products could be highlighted and security considerations emphasized.

User organizations could subscribe to computer-related journals or publications to be kept informed on the various computer security issues, computer crime and controls worldwide. These could provide a basis for defining and revising computer security policies to be in line with the evolutionary nature of the computer crime.

Security of computerized systems could be given as much emphasis as finance, marketing, production etc. The computer security management should be responsible to the highest levels of management. For example, to the board of directors - this could make it execute its line and staff functions more objectively and effectively.

Auditors and other adequately knowledgeable computer security consultants should be involved in the security policy definition, implementation and evaluation to make it effective.

8.2 Increase Employee Awareness

Measures to raise the employees awareness of computer security are important because the major threat to computer security is from the authorized user. This is perhaps attributed to the fact that he/she is immune to the traditional controls that mainly emphasize access control. The following measures could however reduce the risks from the employees:

Penalties for breach of security measures should be defined and executed like in any other offence. Management should make it clear that an employee doing anything injurious to the security of computer based information will certainly be caught. This would reduce the temptation of employees committing such crimes on the assumption of the management

ignorance. Continuous staff education on security considerations. Making an employee accept the responsibility for the security of computer systems as one of the terms of employment. Rewards could be introduced for employees suggesting enhanced computer security measures.

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Table 1 *Summary of Questionnaire Returns*

Type of Institution	Questionnaire Returns		Regrets		No. Response		Total	
	No.	%	No.	%	No.	%	No.	%
Banks	20	83.3	3	12.5	1	4.2	24	100
Financial Institutions	38	70.4	7	13	9	16.6	54	100
Total	58	-	10	-	-	-	78	-

Table 2 *Extent to which various issues were considered security threats*

Computer Security Issue	A risk to atleast a moderate extent (percentage) (1&2)	A risk to atmost a small extent (percentage) (3&4)
1. Standing and/or transaction data may be:		
(a) read without proper authorization	31	69
(b) altered without proper authorization	38	62
(c) deleted without proper authorization	36	64
(d) retrieved without proper authorization	31	69
2. Computer personnel/users may perpetrate fraud or cause errors by making unauthorized changes data files	36	64
3. Programs or data files may be intentionally:		
(a) copied	36	64
(b) stolen	38	62
(c) disclosed	40	60
(d) destroyed	40	60
4. Computer resources may be used without proper authorization	38	62
5. Unauthorized persons may gain access to confidential data	36	62
6. Operators may deliberately cause a computer to malfunction	42	58
7. Data entered for processing may be:		
(a) inaccurate	40	60
(b) incomplete	40	60
(c) entered in the wrong accounting period	36	64
(d) entered twice	29	71
(e) omitted	27	73
8. The following may cause great damage to data:		
(a) fire	67	33
(b) power surges	69	31
(c) floods	53	47

Table 3 *Computer Security Related Problems Experienced*

Sr. No.	Nature of the Problem	Experienced to atleast a moderate extent		Experienced to at most a small extent	
		Number*	Percentage	Number*	Percentage
1	Operator/clerical error	19	42	26	58
2	Machine (hardware) failure	18	40	27	60
3	Magnetic media failure	15	33	30	67
4	Fire	2	4	43	96
5	Flood damage	7	16	38	84
6	Power failure	16	36	29	64
7	Malicious damage	5	11	40	89
8	Theft/fraud	6	13	39	87
9	Unauthorized use	7	16	38	84
10	Wire tapping	0	0	45	100
11	Diversion/loss of data in transit	1	2	44	98
12	Spillage damage	1	2	44	98
13	Air conditioning failure	5	11	40	89

(Note: *Number represents total number of respondents put under the classification)

Table 4 *Computer Security Measures Currently Employed*

Security Measure Employed	Banks		Financial Institutions		Combined	
	No.	%	No.	%	No.	%
1. Change of passwords:						
(a) Fixed intervals	6	32	4	15	10	22
(b) Non fixed intervals	8	42	18	69	26	58
(c) Not at all	4	21	4	16	8	18
(d) Combined (a) and (b)	1	5	-	-	1	2
2. Back-ups of file made:						
(a) Hourly	-	-	2	8	2	4
(b) End of day	13	68	20	77	33	73
(c) Convenient periods	3	16	2	8	5	11
(d) Others:						
-a,b,c,	2	11	-	-	2	5
-b,c	1	5	2	7	3	7
3. Storage of back-up files with respect to source programs/data:						
- same location	4	21	7	27	11	24
- different location	15	79	19	73	34	76
4. Separation of duties in the data processing department:						
YES	13	68	17	65	30	67
NO	6	32	9	35	15	33
5. Lock and key for computer room	17	90	26	100	43	96
6. Use of temperature controlled media safe/air-conditioning in computer room	17	90	25	96	42	93
7. Lock and key for media safe/cassettes and diskettes	18	95	23	89	4	91
8. Power stabilizers	15	95	23	89	38	84
9. Insurance policies to cover computer related losses	14	74	20	77	34	76
10. Data verification checks	15	79	19	73	34	76
11. Data validation checks	15	79	18	69	33	73

Security Measure Employed	Banks		Financial Institutions		Combined	
	No.	%	No.	%	No.	%
12. Continuous staff education on security considerations	13	68	20	77	33	73
13. Inclusion of any responsibilities with regard to security	13	68	19	73	32	71
14. Rejection controls (e.g. coding errors, mispostings)	15	79	17	65	32	71
15. On-line controls total checks (read off the screen)	10	53	12	46	22	49
16. Locks and key PCs or terminals	10	53	10	39	20	44

Table 5 *General Computer Security Evaluation*

	Banks		Financial Institutions		Combined	
	No.	%	No.	%	No	%
1. Computerized systems more risky than manual systems*						
YES	6(1)	30	11(5)	29	17	29
NO	14	70	27(7)	71	41	71
2. Satisfied with current security systems?*						
YES	13	68	18	69	31	69
NO	6	32	8	31	14	31

*Responses include those of non-computerized respondents (in brackets)

COMPUTERIZATION AND THE EFFICIENCY OF THE NAIROBI STOCK EXCHANGE

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ABSTRACT

The Nairobi Stock Exchange (NSE) is one of the oldest in Africa having been started in 1954. This paper argues that the introduction of modern information technology may confer immediate benefits to investors on the NSE. Many studies and reports on the modernization of The Nairobi Stock Exchange, for example, deal with improvements on the trading systems, particularly, volume levels. None has studied or reported on the need for and the means of improving stock exchange communications. Any modernization of communications on a stock exchange today will of necessity involve the introduction of computers and computer technology; and for the developing countries, the costs of such a transfer of technology from the undeniably technology- dominant First World will be enormous. One other area that has not been adequately explored, however, is the effect of modern computerized communication systems on the efficiency of stock markets particularly in developing countries.

1. INTRODUCTION

Many studies and reports on the modernization of The Nairobi Stock Exchange, for example, deal with improvements on the trading systems, particularly, volume levels. None has studied or reported on the need for and the means of improving stock exchange communications. Any modernization of communications on a stock exchange today will of necessity involve the introduction of computers and computer technology; and for the developing countries, the costs of such a transfer of technology from the undeniably technology-dominant First World will be enormous. For example, the London Stock Exchange alone spent over 25 million pounds Sterling in computerizing its operations in 1986, not counting the costs incurred by individual analysts, investors and other in bringing their own systems into par with the Exchange's.

Since the inception of the theory of market efficiency, a lot has been said both in favour of and in opposition to it. The spread of information is a key element in determining the financial efficiency of a market, and it is thus of some importance that the means of distributing information - communication - also be looked at as part of the study of market efficiency. One area that has not been adequately explored, however, is the effect of modern computerized communication systems on the efficiency of a market and on research based on information

from such markets.

This paper intends to show that:

- computerized communication technology can and does play a major role in the development of an efficient stock exchange
- the key to developing a viable and efficient stock exchange in developing countries lies in the use of computerized communications

Modern, high-speed computerized communication systems of stock exchanges ensure that information from around the country, and the World, will be much more readily available to investors and other interested parties. This increased availability of information will help investors remain more informed and so therefore indirectly assist them reduce the risks they face in investing on the stock exchange. Before examining the contributions of computerized information system, it is important to first examine the issues of market efficiency.

2. MARKET EFFICIENCY: DEFINITION

The word efficiency in economics and finance has been assigned different meanings depending on what is emphasized. It is important to understand what definition of efficiency one is dealing with in order to develop a rationale for empirical tests. This paper adopts Stiglitz [16] definition of Information efficiency, viz:

- the market must provide the correct incentives for gathering the right amount and kind of information,
- the market price must reflect all the information available to the various traders
- firms must be able to convey efficiently information about their prospects to potential investors.

Foster [7], argues that market efficiency may be attained, among other factors, because of Quality, quantity and timeliness of information made publicly available. This is taken to be that adequate disclosure of information minimizes ignorance in the market and causes the market price to reflect the true value of the security.

Efficiency in this paper is concerned with how qualitative and quantitative information is made publicly available in successful stock exchanges.

2.1 The Importance of Efficiency of the Stock Exchange

The key importance of information in the stock exchange is that its availability is the determining factor in evaluating the exchange's financial efficiency. This in turn, however, only serves to raise the real issue; why is the concept of an efficient exchange so important? According to Keane [10] "... the potential implications of market efficiency are far reaching for all those concerned with the market". In other words, the concept of an efficient market is one whose importance extends beyond the realm of finance alone; in fact, an efficient capital market will more often than not affect the operations of the entire economy in which it is

located. The potentia implications of an efficient stock market are therefore quite numerous and wide-ranging.

Thus, the first major result of an efficient securities market is that it tends to lead to an optimal allocation of available investment capital. This is achieved through the market's accurate portrayal of a security's potential risks and returns in its market price, a factor that will lead investors to place their funds in the most optimal areas [10].

Arising from the above will be the implied result of an optimal allocation of the economy's total resources. Capital is but one of the key resources in economic production, but if it is optimally distributed, then so by implication will be the other resources such as land, labour and entrepreneurship - assuming of course that these resources are combined in the correct or optimal proportions. Thus, in order to achieve an optimal distribution of resources in an economy (and hence maximum operating efficiency) it is important - even essential - that the economy's available capital be optimally distributed. In other words, an efficient securities market will act as a stimulus for the bringing into active production of otherwise dormant resources, thereby serving to boost the economy as a whole.

Another major importance of market efficiency is that an investor in an efficient market will usually be better off simply holding on to a stable portfolio rather than continuously shopping around for bargains (as there will be few if any). This will not only minimize the investor's transaction costs, but it will also ensure him a relatively steady and continuous return on his investment [10]. In fact, such a situation will also mean a fundamental change in current investment practice from a "buy-hold-sell" policy aimed at consistently beating the market to a "buy and hold" policy designed more to provide one a steady if not spectacular return on one's investment.

In the area of corporate finance, the main implications of an efficient market will be that there will be one form of security (e.g. common share or debenture) that will be likely to constitute a more efficient vehicle of finance, and that there will no longer be any more "most opportune" times of issuing the securities (e.g. during a bull market) [10]. Published or publicly available corporate accounts will also be much less valued by individual investors as a means of evaluating share prices because prices set by the all-knowing information efficient market will be much more readily acceptable to such investors in general [10]). The overall effect will therefore be that the costs of floating new issues (i.e. raising new capital) will be significantly reduced as companies will no longer have to incur interest charges or other opportunity costs as they await favourable conditions for their issues as is currently the case.

A further implication of efficient security markets is that the role of the securities analysts and advisors will diminish greatly. The average investor will no longer look to the analysts and advisors as the ultimate source of information on where to invest, but will now regard them merely as someone to fall back upon should one's own communication-information system temporarily fail. In other words, the role of the investment expert will be reduced to being a supplementary source of information rather than a key one [10]).

3. COMPUTERIZED COMMUNICATIONS AND EFFICIENCY OF STOCK EXCHANGES

3.1 The Development of Viable Securities Markets

Reilly [13] suggests that the development of a viable and efficient securities market depends, among others, on:

(1) Timely and accurate information on the price and volume of past transactions and similar information on prevailing supply and demand.
(2) Low transaction cost. This 'internal' efficiency means that all aspects of the transaction entail low costs. This includes cost of reaching the market, the actual brokerage cost involved in the transaction, as well as the cost of transferring the asset.
(3) Rapid adjustment of prices to new information. This efficiency ensures that the prevailing price reflects all available information regarding the asset.

The key drawback thus faced in developing viable securities markets in developing countries is that of lack of efficient, low cost, reliable, high-speed information technologies to provide instantaneous information to investors. It is precisely this strong advantage of information technologies that has led the sophisticated stock exchanges of New York, Tokyo and London to their position as the most efficient markets today [11]. There is evidence that the Newly Industrialized Countries' financial market have greatly benefited from the new information technologies [8]). Can the developing world benefit from these experiences? Currently, the NSE is void of what would be seen as an efficient information monitoring system. What are the social implications of the introduction of such a computerized system?

3.2 The Role of Computerized Communication

Computerized communication will provide primary information to investors and should be developed for the exchanges for the following reasons:

(i) With modern high-speed computerized communication system, information from around the country, and the world, will be much more readily available to investors and other interested parties [17]. Thus, whereas, for example, Kenyan investors must wait for their copy of the daily newspapers to get the previous day's closing prices on the Nairobi Stock Exchange's, computerized communication network will get them an instant view of the prevailing stock prices at that moment. This increased availability of information will help investors remain more informed and therefore assist them reduce the risks faced in investing on the stock exchange.

(ii) The increased availability of information and the subsequent reduction in investment risks will tend to attract many previously apprehensive investors to the exchange for the first time. This will in turn serve to eliminate two of the key problems often seen to be the key causes of inefficiency on the stock exchange; viz poor information flow and inadequate numbers of investors on the market. Thus, the overall effect of this move towards more market investors will be an increased tendency toward semi-strong form efficiency [11].

(iii) The vast flow of information and the increased number of participating investors will greatly diminish the chances of a minority of investors making abnormal profits at the expense of the others through previously successful techniques such as stock or company analysis. This is because with more people having better access to all available information, the probability of one person finding an undervalued security will be greatly reduced.

(iv) The prospective benefits to be gained from the practice of insider-trading will be greatly reduced on a large stock exchange with many investors and efficient communications [17]. This factor too will tend to attract new investors to the stock exchange. Past experience has shown that reports of insider trading sometimes tend to put off prospective investors from dealing on stock exchange [11].

(v) The easy availability of information and consequent growth of the stock exchange will force the authorities in the developing stock exchanges to formulate and impose adequate rules for the regulation of the increasingly sophisticated market. This in turn will serve to increase investor protection [17] and make the market even more attractive as a vehicle of investment, thereby further fuelling its growth and drive toward efficiency.

(vi) As the market grows, more companies will be attracted to it as a source of funds. Consequently, the number and variety of quoted public companies will grow and hence affording investors opportunities to build optimal portfolios.

3.3 Problems in the Computerization of the Stock Exchange in Developing Countries

Like all issues, the modernization of stock exchange communications has both its strong and its weak points. Among the most serious hindrances to the development of communications on the stock exchange is the prohibitive cost of such an exercise. Any modernization of communications on a stock exchange today will of necessity involve the introduction of computers and computer technology. For the developing countries, the costs of such a transfer of technology from the undeniably technology-dominant First World will be enormous, in some cases possibly even beyond the budgets of some countries. For example, as noted earlier, the London Stock Exchange alone spent over Sterling Pounds 25 million in computerizing its operations. There will also be costs incurred by individual analysts, investors and other in bringing their own systems into par with the Exchange's [17].

The second problem that may arise from the modernization of the exchange communication system is that introduction of the new technology may create a need for a specially trained operating staff to run the system. As a result, there may be possible clashes between the more established stock-brokers and the new generation of computerized brokers entering the exchange, leading to a disruption of services to the investor. In reality, however, the prospect of such a clash remains quite distant, the main reason being that the incorporation of the new brokers into the exchange will be more gradual than sudden, thereby allowing the old generation plenty of time to learn and adjust to the new environment.

Finally, a third problem that may afflict a computerized stock exchange is computer fraud. This is currently a major drawback of computerized systems in various fields, but with the growing sophistication of computer security systems, it too becomes a problem whose solution lies in the not too distant future. Any attempted fraud on the exchange will not be likely to go unnoticed for long due to the high level of communication efficiency brought about by large numbers of investors who will be having instant access to trading information. Nevertheless, computer fraud is not an issue to be taken lightly by the authorities in developing the stock exchanges of the future.

Notwithstanding these problems, the role of communications in the attainment of market efficiency is one whose importance cannot be overstated. It is evident that the computerization of information technology has a lot more to offer the stock exchange, especially a developing one, than was previously thought possible.

4. THE SOCIAL ECONOMIC ROLE OF STOCK EXCHANGES

Given the relative scarcity of capital and the small volume of savings in most developing countries, the question may be asked whether there is any need for the establishment of stock markets in the first place, leave alone the issue of computerizing its communication systems. Drake [6] says that:

"There are different opinions about how beneficial securities markets are likely to be in practice. Some writers have been inclined to take a rather optimistic view of the role which securities markets might play in expediting economic development. Others have been more pessimistic. There are those, for example, who conclude that a securities market may seriously jeopardize the growth and stability of a country's financial structure, may introduce factors which tend to aggregate, if not originate economic fluctuations, and may adversely affect the allocation of savings, reallocation of existing real wealth, redistribution of income and the conduct of monetary policy". He concludes: "The question of benefit to economic development is an open one, subject to empirical investigation of past performance and judgment of future prospects in each specific case."

As the level of income, savings and monetization increases and the structures of the economies change in developing countries, securities markets have started to gain a significant role. In Kenya, for example, the development of a capital market was conditioned by the need for funds in the private sector and the structure of the economy rather than the government need to borrow locally [3].

The role of the securities market is that of financial intermediation and capital formation. The market deals with financial assets which are necessary to facilitate the process of wealth and capital accumulation. The most fundamental financial asset is money which is necessary for the development of any form of advanced economic system because it is necessary to facilitate the exchange of economic goods. Other financial assets, such as shares, bonds and debentures are used to aggregate the small pools of savings and channel them into real investment. This channelling is accomplished by financial intermediation. Financial intermediaries are firms whose assets consists almost of financial claims against others. Examples of such financial

intermediaries are Banks, Life Insurance Companies, Pension and Provident funds. In financial intermediation savings are gathered from households and the intermediaries invest them in financial assets. The primary securities market plays a key role in this process of financial intermediation.

In summary, a securities market may play the role of:

(a) Providing liquidity to investors by enhancing the marketability of securities through the operation of the exchange. The existence of a market facilitates the purchase and sale of debt instruments and equity securities, particularly through dealings on a stock exchange. A stock exchange not only permits dealings in existing securities (increasing the liquidity of such securities) but also facilitates the issue of new securities to the public [3]. This occurs because the exchange provides a continuous market for individual securities issues. A continuous market is predicated on a large volume of sales, a narrow price range between the bid and the asked price and between the previous sale and the sale taking place at the moment. It also depend on the rapid execution of orders. There are also sufficient number of buyers and sellers of the shares of stock of each company traded and a sufficient number of brokers and other members of the exchange transacting orders to assure a broad and active market. The effect of these factors is to improve the liquidity and marketability of the securities that are traded.

(b) The mobilization of savings to finance new investment. The markets for capital acts as a link between borrowers and savers in the economy. A continuous market for competitively priced securities provides a favourable climate for raising capital. The existence of a ready market to trade in the newly issued securities makes them acceptable to investors.

(c) Facilitating wide spread ownership of financial assets thereby reducing the concentration of economic power, income and wealth in the hands of a few. This occurs, for example, where the shares are distributed nationwide ensuring equal participation by all those who desire in the ownership of corporations. The distribution of new issues in Kenya and Nigeria provides good examples [18,19].

(d) Moving business into professional management as well as acting as a stimulus to entrepreneurial capacity. Calamanti states that besides making better use of latent entrepreneurial capacity, the market would also lead to improved accounting practices, greater profit orientation and more disclosure of information, thus also yielding social benefits. The above is probably made on the assumption that the pressures from the securities markets are able to act effectively on corporate management to make them aware of the need for full information disclosure.

(e) Indigenisation and/or privatization of productive activities. The securities market will be used as a vehicle by which foreign capital can be channelled to the locals without disruption of economic activity since ownership certificates shares can be floated in the primary (new issues) market or existing securities can be disposed-off in the secondary market. Similarly, withdrawal of any one foreign investor may not be readily noticeable.

(f) Increasing the volume of foreign investment. It has been identified that one of problems of developing countries is the shortage of capital [1]. The possibility of using the securities market as a magnet to attract foreign capital and therefore close the capital shortage gap is an important one. Currently, with the debt burden of developing countries becoming unmanageable, a deliberate system of replacing foreign inflows with investment capital rather than debt would be most ideal. The impact of foreign capital flows and the benefits it confers cannot be underestimated [1]. Investing in securities markets other than in one's own country reduces the level of risk because of holding an internationally diversified portfolio [14]. For example, van Agtmael and Errunza [2] show that investing in markets of developing countries may offer attractive opportunities for high returns and diversification to investors of developed countries. Investments by foreigners may also be desired because a key problem in developing countries is the inadequacy of foreign reserves. The reserves are necessary to purchase the capital good essential for industrialization. The foreign funds attracted by the securities market may be used for this purpose.

In order to facilitate their role in social and economic development, the securities markets should be efficient. The level of efficiency will be enhanced through providing relevant, reliable and timely information. Computerization plays this role perfectly.

5. SUMMARY AND CONCLUSION

Information is the key issue in efficient markets. How much information is publicly available and how quickly it is reflected in security prices determines a market's degree of efficiency. From the preceding discussion and evidence, it becomes quite clear that one way of strengthening a fledgling stock exchange and moving it into a modern, semi-strong form efficient one is through the use of modern computerized communication systems. In London, New York and Tokyo, it was essentially the introduction of modern high-tech communication systems that put these stock exchanges at levels of efficiency beyond any other in the world. If Nairobi, Singapore, Bombay, Mexico and the rest of the developing world's stock exchanges are to achieve similar levels of success, high-tech communication is the key to their progress.

The enactment of security laws is one way of strengthening exchanges. In Kenya, the Government published the Capital Markets Authority Act, 1989 with the view of setting up a capital market in the country. According to the Act, the Authority is charged with the responsibility of "promoting and maintaining an effective and efficient securities market". Whatever the outcome, the aim of the Authority should be to build on the telephone market operated by the Nairobi Stock Exchange and add on a computer network to form the basis of the new exchange. This will save the Authority and the country the burden of building a physical stock exchange with a trading floor, offices and so on, together with the added advantage of increased efficiency. In fact, the concept of a trading floor is slowly but surely becoming obsolete as computers take over the world of stock exchanges; on the London Stock Exchange, for example, the trading floor is slowly losing both its importance and its utility to the computerized SEAQ system [17].

The theory of efficient market support the idea of improved communications to boost stock market efficiency. This states that a market's efficiency is largely determined by its ability to

react instantaneously to new information [10,15]. Thus, a modern quick communication system will enable new information to reach the market sooner rather than later, and, the same system will also enable investors to place their orders instantly once information is received. Thus, the speed of communication both to and from the investor will be greatly boosted, and the efficiency of the market will improve dramatically.

The above implies that both the theoretical and empirical support for the modernization of communications in the stock exchanges is quite strong. As a result, the inevitable conclusion of this discussion is that there is a real need for the developing stock exchanges to invest in modern communication systems if they are to progress to the level of semi-strong form efficiency. This need arises not only in order to upgrade the exchanges themselves, but in order to boost the economies of the developing countries. Last but not least, the diffusion of technology will possibly also lead to a close in the gap between the developed and developing worlds during the next century.

In conclusion therefore, it must be reiterated that the developing world has a lot to gain from the modernization of communications in its stock exchanges and all other financial markets. It should nevertheless be emphasized that like in all other investment projects, the investment in modern security market communication systems is worthwhile in the long run only if cost benefit analysis indicate so. The issue to be addressed to next should be on the nature of the databases to be set-up to serve investors, researchers, stock brokers, security analysts and all other interested parties.

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IV

HEALTH INFORMATICS IN AFRICA: ETHICS AND APPROPRIATENESS

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ABSTRACT

People working on the field level of information technology in developing countries are probably convinced by day-to-day experience that computers can have a positive development impact, if only due concern is given to proper use. In the industrialized countries, to the contrary, many if not most people suspect that computers in developing countries are mere white elephants. This paper tries to give answers to the latter kind of people. First, the issue is discussed on a general ethical level. It is shown that the real issue is that of practical fit to concrete requirements. The preconditions, benefits and trade-offs of computer use in African health care are then discussed, and a practical case of a Nigerian teaching hospital presented.

1. INTRODUCTION

To many Western people, computers in Africa are an absurd idea, even more so in the health care. Africa is yet the continent where most of the Least Developed Countries reside, and where many children die in simple diseases like measles. Is it not unethical then to spend money in computers in health care in Africa?

The question is paternalistic, but needs to be taken seriously. This discussion paper points out that similar ethical questions should be asked about the usage of computers (or other technology) in health care in any country. Yet, instead of sweeping generalizations, one should look at concrete cases, ways of use, preconditions, benefits, and trade-offs. The bulk of the paper deals with the pragmatic issues of "appropriate health informatics" in Africa. The theoretical elaborations are illustrated by a practical case from Nigeria.

2. THE ETHICS OF COMPUTERS IN AFRICAN HEALTH CARE

When discussing the ethics of computers, even seasoned development agencies easily resort to simplistic emotions, not to speak about the layman. Instead of *ad hoc* prejudices, the ethical stand must be formulated in a general way. If one maintains that it is unethical to spend in computers in Africa while children die in measles, then one should regard spending

in computers unethical *anywhere* as long as preventable diseases prevail in some part of the world. There cannot be double standards, one for Africans and another for Europeans.

So if somebody from the industrialized world tells us to forget about computers when there are more high-priority things to do, then we should reply: "Alright, then ***you just stop spending in computers*** and ***do*** direct the funds into immunization and essential drugs! It is ***you*** who is spending in computers, after all. Very well, we have nothing against it if you think investments should be directed according to human needs and not according to money and power. Just start to do like that, and start from yourself."

If, to the contrary, one regards that computers are beneficiary tools in promoting people's health in the industrialized countries, then people in Africa have the same right to benefit from these useful things. So, if computers are considered useful instead of vanity, then the global community should work together in making computers benefit *those who need them the most*. Who are the most needy in the world: the sick and the children in the Third World.

We thus come to the conclusion that if computers can be used to benefit African health care, then that is precisely *the most ethical* form of informatics.

This way or that way, a global ethical view points out that the use of computers, whether in Europe or in Africa, should be directed by human needs, not by payable demand. And this way or that way, it appears the industrialized countries should take a very critical look indeed at their own use of computers (is it ethical that these countries spend in automatic cash dispensers, multimedia, electronic warfare etc. when people die in measles and diarrhoea?), while Africa in general and African health care in special get a good mark in computer ethics.

Although Africa needs computers more than Manhattan or London City, everybody knows that in practice the former has less computers than the latter. Why? Again everybody knows: because Africa has less purchasing power and less political influence. If ethics is not just nice words, then, the global community should find ways of putting the human needs in control in practice. But that is another story.

3. PRAGMATIC ISSUES: PRECONDITIONS

From the discussion above it should be evident that there is no question *in principle* about the justification of computers in African health care. However, not every use of computers is justified, in any country. The use is justified ***if*** it benefits human needs. Thus several more specific questions can be asked: What *kind of* informatics would be the most useful in African health care? On which *preconditions* is it feasible? Applied, developed, and operated *in which way*? What are the potential *benefits*, what are the *trade-offs and risks*?

To my mind, these questions are much more interesting and useful than sweeping moralism on a general level. A similar approach is taken by King [1] in discussing the appropriateness of Artificial Intelligence technology in developing countries: Theoretical on/off arguments on a general level are not useful, the appropriate uses should be induced from rich empirical case material.

Avgerou and Land [2] have discussed profoundly how information technology fits to different definitions of appropriate technology. For my purposes the following definition is the most applicable one:

> *"a technology is considered appropriate, when its introduction into a community creates a self-enforcing process, internal to the same community, which supports the growth of the local activities and the development of indigenous capabilities as decided by the community itself"* (Pellegrino, cited by Shires [3]).

The definition does not say anything predetermined about a given piece of technology — a hoe can be appropriate in some time and context, a tractor in some other. The definition also applies equally well to any community, be it in Africa or Europe. What matters is that the introduction of the technology should empower a community to achieve increased self-governance and well-being through an endogenous process.

Returning to computers in Africa in general, it is obvious that the need for *hardware imports* reduces the self-dependence of African countries. However, the same applies to most industrialized countries as well — the development of microelectronics is directed by a couple of transnational companies only. The best alternative left to most countries in Europe as well as in Africa is to assemble clones, not to dream of indigenous development of integrated chips or new computer architectures.

Computers, however, are useless without some applications software. Actually, the reason why computers are "the stone axes of today" or "the electric motors of today" — the most universally applicable technology of our age — is precisely in the fact that they are flexible, programmable to any use. Some types of use, like text processing, are fairly universal, but in general the flexibility means that some amount of programming, or adjustment, must be done *locally*, in the very context where the computer is used. Even a text processing package cannot be really used without some kind of setting of parameters and designing of the modes of use.

Local software skills are thus a *prerequisite* to making the most of computers. These skills are not proprietary to any transnational companies, any country can develop them. In the same time, emerging software skills enable a country to apply the universality of computer technology to her own needs, as decided by herself. Applying Pellegrino's criteria we can notice that while computer hardware technology has a bias towards decreased self-sustainability, the computer applications technology has a strong potential towards the opposite. So software skills are quite *empowering*, appropriate technology to African countries.

Friedman [4] has identified three major phases in systems development in the industrialized countries. The first one, until mid-1960s, was characterized by hardware constraints, the second from mid-1960s till early 1980s by software constraints, and the latest phase by user constraints. The early constraints seem to re-emerge every time new computer technology is introduced or new applications domains are entered — so the early years of minicomputers were dominated by hardware constraints again, and the same happened during the early

years of micros, and today in new domains like Electronic Data Interchange (EDI). In Africa the *hardware problems*, the most fundamental ones, are now in the foreground and it will take some time before lasting standard solutions will emerge for cheap multi-user configurations, protected electricity supply, and hardware maintenance arrangements.

However, when the hardware problems will be relieved a bit, people will find out that hardware alone does nothing. It is possible that the high availability of applications packages nowadays will take Africa directly *from the first phase to the third one* in Friedman's framework. That is, Africa may need not so much software engineers — experts in efficient mass production of software — but applications developers, people who are experts in assisting end-users in identifying their requirements, obtaining suitable applications packages and high-level tools, and developing adjusted systems from these elements.

Consequently, I would suggest that a practical-social view, emphasizing *the uses, applications, and users*, should be encouraged in African Computer Science curricula, decreasing the focus on nuts-and-bolts technology. It should be noticed as well that expatriate experts, however technically qualified they may be, are always less advantaged as "phase three systems developers" than their indigenous colleagues. Sustainable, appropriate uses of computers in Africa can only be generated by African systems developers in cooperation with the users. This is even more true in health care than in standard business.

Wisner [5] [6] has pointed out the need for a *total* transfer of technology; i.e., that a piece of technology cannot be successfully transferred unless the maintenance, organizational etc. aspects are transferred as well. He puts forward the difference between the industrialized and the developing countries in a proverbial way:

> "*A breakdown which could be repaired in a day in Paris or New York will require 2 or 3 days in a small town in France or in the USA, 2 or 3 weeks in Algiers or Manila, 2 or 3 months in Africa below the Sahara ..., and this simply because of the differences in industrial density.*" ([6], p. 87)

Wisner speaks about the transfer of technology, but the same applies when considering the preconditions of an endogenous development of computer use. A large network of supporting activities needs to be identified or established in order to make health informatics sustainable [7]. The supporting activities need to be concretely analyzed in each case. The most important of them, as has been pointed out already, are hardware maintenance and systems development.

In conclusion, appropriate health informatics is possible, but only if some preconditions are met. First, the focus must be on cooperative systems development for priority needs, not just on hardware imports. Secondly, a network of supporting activities is needed. Both of these preconditions are equally true in Europe and in Africa, only the needs and the present state of the infrastructure vary.

Sometimes people with little experience with Africa assume that the biggest problems would be due to incapable users. Actually, this assumption comes dangerously close to implicit

racism. My own experience suggests that this is not a major issue at all. Of course people who have not dealt excessively with technical devices can be cautious in the beginning and need time to develop typing skills, but nurses in Finland often have the same starting point and also perform quite well after some time.

Conceptual and hands-on training is important, starting from the existing expertise of the users. Maybe the most important precondition for success is that the would-be users know that the system will be for them and they have a say on its design and use. With motivation to learn, everybody will learn. People are not the problem, the infrastructure is.

4. PRAGMATIC ISSUES: BENEFITS AND TRADE-OFFS

People are often quite impatient about the benefits of computers in health care: if computers cannot cure diseases, they are useless. However, the role of computers should be compared with that of cars in this context. Neither ambulances nor medical records systems are medical instruments *per se*, but both of them can have a big *indirect* effect. It would be more labour-intensive, cheaper, and less import-dependent to substitute ambulances by porters, but that would mean unnecessary pain and delay. In the information activities, many health care institutions still "carry the load by foot" although more cost-effective methods are available.

What are computers used for in European and North American health care? A bit clinical decision-support, embedded systems in radiology, clinical laboratories and intensive care, almost no expert systems in practice. Although these kinds of *medical* uses are fashionable and get much space in conferences, they do not represent the bulk of computer use. The bread and butter of *health care* informatics in a broader sense are statistics on the one hand and operational systems on the other. The former are processing-intensive, high-volume applications, while the latter mostly have to do with archiving and communication. As Forster [8] notes, in Africa medical informatics is in general less useful than health informatics in the administrative and operational domains.

From the use point of view, computer systems in a health care institution can serve the immediate patient care, the auxiliary services, local coordination and planning within the institution, or external coordination and planning amongst institutions.

Statistics is a straightforward case for computerization in Africa, too. The WHO and national authorities lament that lack of reliable information is a major obstacle to planning. It is a time consuming task indeed to compile monthly statistics in a district administration or a major hospital by pen and paper only. It also requires major management skills. Yet the results come too late to assist operational management. "User friendly" microcomputer packages can help in all these aspects.

Unlike statistical applications, *operational systems* in hospitals are multi-user by nature. The very objective of the latter is to support cooperation in time and space amongst the health care staff. For instance, an appointment scheduling system or a drug inventory control system take in information from many users over time (appointment bookings, sales and consignments of drugs) and provide other users with accumulated information which directs

their work (appointment lists, alarms on low stock of a drug). A single-user computer can still be used if the activities are centralized and not very voluminous.

However, some of the most useful operational applications are decentralized by nature. A laboratory order entry/results reporting system is actually a communications system between the wards or clinics and the clinical laboratory. The whole system is based on having a terminal (or workstation) at each end, sharing a common data base. From an African point of view, no cheap and straightforward standard technology has emerged yet for "few-user" systems. Both local area networks and minicomputer architectures (including Unix micros) are technically complicated, environmentally sensitive and relatively expensive.

Computer-based communications is probably going to be one of the biggest benefits in Africa. These technologies have rapidly gained popularity world-wide recently. The penetration of wide-area networks in Africa is still very low, but there are some quite attractive features in them especially for those parts of Africa where all kinds of telecommunications infrastructure are weak. Electronic mail can make use the telephone lines during the less busy deep night hours, computers are patient enough to dial the number one hundred times in sequence if needed (and sometimes it is), and error-correcting protocols contribute in making electronic mail *the cheapest means* of transferring information if "snail mail" is excluded. Relatively cheap packet radio and satellite techniques are extremely important to the continent where distances are long and copper cables expensive.

This far speaking about the world as a global village has been widely exaggerated from an African viewpoint. Computer-based communications technologies are, without exaggeration, finally promising a way for even relatively remote African communities to gradually get a two-way communications medium within their reach. In the more near future, African academia can reach their colleagues in other countries and the scientific literature through computer-based communications. This is a great improvement as well, because health research is an essential prerequisite for endogenous, self-supporting development in health care, and research without a contact to the global scientific community is next to impossible [9].

From the point of view of the *levels of the health care delivery system*, most African countries are recommendably focusing on the Primary Health Care. This does not mean, however, that the other levels of the system could be ignored — to the contrary, to speak about the *focus* means that the secondary and tertiary levels are needed in order to serve and facilitate the primary one [10]. The secondary and tertiary levels should provide the primary care with information processing services. It is not reasonable to try to take computers to the field level of primary care except in research purposes. Again, too impatient an attempt to use computers directly in the front line of health care can cause more trouble than benefits.

Wilson [11] has comprehensively discussed the role of microcomputers in support of Primary Health Care management in developing countries. He has since been involved in putting the ideas in practice in the form of special applications packages. From today's point of view the only aspects one needs to add to his treatise are the new potentials of computer-based communications and text processing (production of educational materials or the like).

Quite often too high expectations are put on solving management problems by specifying "the right" *information contents* of a system, or in formal information in general. People tend to hope that if the right information is collected and processed using the right algorithm, then the right decisions will be automatically produced. We don't expect a typewriter, card box, calculator and telephone to produce good decisions, so why should a computer system which is basically not much more than these traditional devices put together? Computers are *instruments* for human work, they do not replace work.

In the same vain, health care managers cannot find a statistical machinery which would distill the right decisions automatically to them — statistics is needed, but communications is even more important. Traditional ways of visiting, meeting, talking and reporting are the most important "information systems", but computers can serve too.

Comparing a text processing package with a typewriter, a data base package with a card box, a spreadsheet package with a calculator, and a multi-user system with a telephone network, we can conclude that computers can really be of enormous help in many burdensome day-to-day operations. They can make health care staff more efficient but not more wise.

5. A CASE IN POINT: O.A.U.T.H.C., ILE-IFE, NIGERIA

The theoretical propositions above are based on a practical case [10] [12]. In 1987, one of the two dozen teaching and specialist hospitals in Nigeria, the Obafemi Awolowo University Teaching Hospitals Complex (OAUTHC), Ile-Ife, decided to commence an Hospital Information System Project. By occasion this author spent the next year as a Visiting Research Fellow at the OAU Computer Science Department, and after all a basic Medical Records system was developed as a joint Nigerian-Finnish undertaking.

In the beginning we learnt about the hardware problems in the hard way. We also faced the dilemma of identifying a reliable and reasonably priced multi-user technology. Relying on experience from Finland and the USA we decided to use a relatively less well-known software technology based on the M (MUMPS) programming language, a standard "Personal" Computer, and terminals. The entire four-user system cost about the same as two family cars in Nigeria.

The system has been in daily operational use since January 1991. The technology has proved reliable, cost-efficient and easy to use. The Medical Records staff of the hospital take care of the daily operations, including back-ups and ad hoc data retrieval, independently. The staff of the Computer Science Department, OAU, assist in technical problems and take care of further development. University of Kuopio, Finland, provides second-line assistance.

The most tangible benefits are in routine statistics. It used to take two weeks of full time work of a Medical Records Officer, or about six weeks of calendar time, to produce the Monthly Statistics of Morbidity and Mortality to the Federal Ministry of Health. Now it can be printed within one hour after entering the last discharge summary. That does not bring about unemployment, as is sometimes feared — instead, the Medical Records Officer now has more time to serve the administration and the Residents with *ad hoc* information searches.

The data base management system even makes the searches much easier and timely than the old card box system. Thus research and management are also amongst the beneficiaries.

The terminals at the Consultant Out-Patient Department and at the Radiology Department facilitate direct entry of patient information and easy retrieval of the patient's medical record from the 100,000 patient folders in the archive. However, more substantial direct benefits to the actual patient care can be realized only after extending the information contents of the system by including laboratory and pharmacy information.

First-year experiences have been very positive, and raised interest in the other teaching hospitals in the country. There are now many interesting alternatives for further development, notably in the Primary Care activities of the OAUTHC, and in the Pharmacy Department. Recently an international electronic mail link, to our knowledge the second one in Nigeria, was established between the hospital and University of Kuopio. Extending the link to OAU campus and other sites in Nigeria provide exciting prospects. The participants of the Joint Project also want to share experiences with others, and are organizing a National Workshop this year and the first ever International Working Conference on Health Informatics in Africa (HELINA'93) in April 1993, under the auspices of the International Medical Informatics Association (IMIA).

By evaluating the developments in Ile-Ife using the criteria put forward in Section 4 above, one can say that the Joint Project is performing well in harvesting the benefits and avoiding the pitfalls of health informatics, after the initial hardware problems. However, the sustainability of the systems development activity still raises some concern.

The economic hardship in Nigeria, as in many African countries, has tried especially severely the universities. There is a high demand for Computer Scientists in the private sector, and salaries that are many times what one can get in a university. Those who stay in the universities are overloaded by lectures and administrative tasks, without much possibilities for state-of-the-art research, not to speak about systems development. One might thus wonder why the OAU Computer Science Department is in charge of the systems support — would it not be easier to hire a private enterprise to do the job? In the Joint Project it is argued, however, that it is exactly through this kind of practically oriented projects that universities can, first, directly contribute in the development of their countries, and secondly, provide their staff with some extra revenue and professionally attractive work, not to speak about the international contacts.

This far the Joint Project has performed the worst in facilitating the Computer Science Department and its staff, due to the hardware problems and the lack of external funding. In order to ensure the long-term sustainability of the preconditions discussed in Section 3 above, this drawback has to be solved.

6. CONCLUSIONS

Computer systems must not be outright excluded from African health care, but careful consideration is needed in each concrete case of putting them in use. If the prerequisites for

their sustainability exist or can be established, then tangible benefits can be expected in day-to-day applications like text processing, "card boxes" and statistics, which are the most fundamental uses of computers in any country.

More ambitious gains can be achieved in research and in computer-based communications. Specialized operational systems and the support for Primary Health Care both require even more indigenous systems development capabilities. However, these more ambitious uses are where African people can benefit the most from computers.

Every time a computer investment is considered by African health administrators, they have many very concrete alternatives for their money: whether to obtain essential drugs, build a new clinic, hire more staff, or develop an information system — and it may even turn out that there is no money to any of these. I would ask them to be very considerate, not to believe any computer hype but not to be stuck in old stereotypes either, this way outperforming their colleagues in the industrialized countries. Meanwhile, carefully evaluated experiments are needed in order to investigate the potential.

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ARTIFICIAL INTELLIGENCE FOR DEVELOPING COUNTRIES: PROMISES AND POSSIBILITIES

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ABSTRACT

Artificial Intelligence as a discipline has the unfortunate image of being high-tech and mysterious. In fact many of its aims are essentially practical and potentially it provides a means of disseminating expertise and effecting technology transfer to ordinary people, not just a computing intelligentsia. Many of its tools and techniques are ideally suited to developing country applications. We examine what AI has to offer developing countries in terms of tools, techniques and appropriate areas of application. We assess AI's potential applications, its use as an 'appropriate technology' and its potential for technology transfer and skills distribution. We examine some of the reasons for success and failure of 'AID' projects in terms of their appropriateness and offer some guidelines for appropriate projects. Lastly, we outline the activities, aims and projects of an international 'AI for Development' group which has been set up recently.

1. INTRODUCTION

The words 'Artificial Intelligence' tend to conjure up an esoteric, futuristic and essentially impracticable enterprise, perhaps the vision of the android in 'Star Trek' who is composed of "heuristics and neural networks", but certainly nothing of practical value to ordinary earth-bound folk. This is unfortunate as in fact AI is not necessarily alien and esoteric in its applications. One of the major aims of AI is to produce systems that can behave in a more 'human' manner and thus be understandable and maintainable by ordinary people rather than a computing intelligentsia. In contrast, many 'ordinary' computer programs require a heavy investment of training for the eventual users.

AI also has an expensive image, as the sort of enterprise which can only be undertaken with immense computing resources and highly trained personnel. It need not be expensive, either in terms of machine power or person power. Projects can now be implemented quickly with rapid prototyping tools which allow 'non-programmers' to design, specify and implement systems, potentially without ever touching raw code. Although the tools themselves may seem an expensive initial outlay, software and hardware prices are falling rapidly. Many large AI toolkits, previously only available for powerful workstations, are now written for PCs and the cost to power ratio for small computers is becoming more favourable every year.

Unlike many other branches of computer science, AI tends to treat a computer as a tool for doing a job, not an end in itself, and as such it should be a discipline whose aims and applications are ideally suited to implementation in developing countries.

2. WHAT CAN AI OFFER DEVELOPING COUNTRIES?

We feel that the promise of AI for developing countries lies in its practical applications for the solution of everyday problems in a way that can be useful to ordinary people. Four characteristic AI techniques (expert systems, planning and scheduling, natural language processing and modelling) and three types of AI tools (rule-based tools, knowledge engineering environments and knowledge acquisition tools) are here briefly mentioned with reference to practical development problems, but these are only a sample of the techniques and tools available.

2.1 Techniques and Tools

2.1.1 Techniques

The most obvious AI techniques to be of use in developing countries are those associated with expert systems. The attempt to encapsulate the knowledge and skill of one or more 'experts' in a specific domain means that the expertise thus entrapped can be repeatedly used in areas where no such experts are available, but the demand for their skills is high. Many of the problems faced by developing countries can be characterised in this way; expertise and skills being scarce and often localised in urban areas whilst a large rural population has little access to the facilities that such expertise could offer in domains like health care. As will be seen from the Applications this is indeed where many appropriate applications are envisaged. Scheduling is an area of AI which looks at ways of dealing with large organisational problems. In particular, scheduling is concerned with efficient allocation of resources, be these physical, mechanical or human. In areas where such resources are scarce and/or expensive such an approach could prove invaluable. Effective planning and scheduling are particularly important in manufacturing, even on a small scale, to improve efficiency of production.

A large number of AI researchers are involved in investigating the possibilities of natural language communication with computers, automatic translation and other linguistic aspects of computing. The possibility of interfacing with a computer in one's native tongue removes a significant barrier for many potential 'ordinary' users. If one's native language is not English (or perhaps even Japanese), dealing with computing manuals and instructions can prohibit the use of an otherwise simple system. Speaking the same 'human' language will still not guarantee easy communication with a computing system which employs its own esoteric command language. Automatic translation holds out hope for surmounting these problems.

Modelling is a generic AI technique applied in many domains. The attempt to 'model' some human process like diagnosis helps the resulting system to behave in a predictable and familiar manner. Modelling a domain (e.g. a factory's operations, a country's economy) allows statements and inferences to be made about objects in that domain (Tuesday's output, last

year's export income). Modelling the user of a system ensures that the system's behaviour can be tailored to that user's needs and abilities.

2.1.2 Tools

Great advances have been made in recent years in the development of tools for building AI systems. Most AI tools are geared towards being very 'usable' so that you no longer need to be a highly trained computer programmer to develop an AI system. Many tools are now available for PCs which tend to be more environmentally robust and, because they are also often cheaper and standardised, are often the machine of choice in developing countries.

Rule based tools (such as Expertech's XI-plus, Texas Instruments' Personal Consultant) offer a framework for building expert systems using if-then rules, often organised into 'rule-sets' acting as knowledge bases. Although such systems are limited in that their knowledge representation must be restricted to this type of rule they are widely available, quite robust, have good user interfaces, run on PCs and are relatively inexpensive.

In using knowledge engineering environments such as (IntelliCorp's KEE, Inference's ART, GoldHill's GOLDWORKS), the system builder is not restricted to a rule representation. Graphical interfaces with mouse and menu selection allow easy construction of knowledge bases and low-level structures are supplied as basic building blocks. All three systems mentioned are available for PCs. Their interfaces are very usable with little or no training.

Another interesting development has been the emergence of Knowledge Acquisition Tools, knowledge acquisition being that stage in the life cycle of an AI system where the information about the domain of application is formulated into an appropriate representation. Knowledge Acquisition Tools such as rule induction systems, decision tree builders and model building tools (Radian's Rule-Master, Neuron Data's NEXTRA, Intellicorp's KLUE) aim to make the construction of AI systems even more direct, some even promising that the 'expert' in the application domain can build the system directly themselves.

2.2 Application Areas for Developing Countries

Education: Rapid development means a big burden on educational resources not only because more children receive basic schooling, but also because adults are trained in specific areas of skill. As a health service expands to serve more of its people, health workers must be trained. As industry expands, more training is needed for industrial workers and technicians. Techniques in intelligent tutoring can offer training programs for all levels of education, including distance learning. User modelling ensures that a program's level of difficulty is geared to the student's individual needs and abilities.

Manufacturing: AI applications in industry include factory scheduling, ensuring efficient utilisation of machinery, human resources and stock control and robotic control of assembly lines.

Resource planning and management: Public resources need to be managed effectively, and the

building of new facilities needs careful planning. Planning skills can be distributed, for example, for designing energy plants or water and sanitation resources.

Medicine: Where there are not enough doctors, computerised decision support systems can potentially alleviate the immense diagnostic workload of rural health workers. Such systems can also assist with routine therapy decisions. Other medical applications include modelling very specific expertise and spreading it around the country, analysis of epidemiological data, predicting patterns of disease and modelling drug distribution services. (See [1] for a review summary of some of the extant diagnostic systems.)

Agriculture: Knowledge about the best methods of soil utilisation, how to manage crop rotation and planning of complex plantings are all areas where a simple AI system could be used to disseminate expertise. Animal medicine is often very similar to human medicine and the same types of systems can be implemented with veterinary knowledge. Improving the health of animals incidentally improves the health (and wealth!) of people, as many diseases and parasites can be transmitted from domesticated animals and animals are in many places a valuable food resource.

3. AI AS APPROPRIATE TECHNOLOGY

One of the main reasons for the relative lack of a significant general infrastructure of AI in developing countries and a dearth of AI for Development projects and products is again an 'image' problem. AI is considered to be 'inappropriate technology'. This view is widespread in the academic community, amongst potential funders and also in government departments responsible for sanctioning research projects. It is understandable, and commendable, that aid agencies are unwilling to fund enterprises which seem inappropriate for the country of application. It is rational that governments of developing countries are unwilling to become involved in projects which, although largely aid-funded, could use up scarce local expertise resources if the projects turn out not to be supportable. The academic community, more familiar with very esoteric applications of AI, such as in specialist areas of medicine like cardiology, find it difficult to visualise their use in less 'technological' environments.

3.1 Criteria for Appropriate Technology

In an earlier paper [1] we reviewed the notion of appropriate technology, looking to various sources for principled definitions. From these we produced a general list of criteria for appropriate technology which can be applied to computing systems, with special applicability to Artificial Intelligence. For a technology such as AI we feel that the greatest emphasis should be placed on the idiosyncratic requirements of local application and maintenance, i.e. satisfying the criteria of adaptability, relevance of form and relevance of content.

Effectiveness: it should function adequately and measurably in the environment for which it is designed, so don't put something in place unless it works and is robust.

Usefulness: it should answer an existing need, not a researcher's whim.

Usability: it should be 'easy to use', design adhering to good HCI principles, and should make the process it is designed to assist less complex or time consuming. The system should not place an excess learning or usage burden on the user but be assimilable into normal practice.

Supportability: it should be supportable within the existing infrastructure and economy. Local computing guidelines should be followed and software maintenance should be locally managed (see also 'adaptability').

Adaptability: it should be adaptable to changing requirements and circumstances, meaning that knowledge bases can be easily maintained and altered by local experts.

Cost effectiveness: the cost of the system should be offset by measurable improvements in the area of application (e.g. better health care, improved production).

Relevance of content: the knowledge base should be locally relevant and rooted in familiar facts (e.g. regional disease profiles).

Relevance of form: the interface and inference mechanisms should be similarly related to familiar things (e.g. local training manuals). If a skill is taught and performed in a certain way (e.g. troubleshooting diagnosis of machinery, planning crop rotation) the behaviour of the system should reflect that.

Minimal training: it should be as 'obvious' as possible and such training as is required should fit in with existing skills training. Again, there should be no great learning overhead or the creation of a specialised skill in simply using the system.

3.2 Why AID Projects Fail

Given that some AID (AI for Development) systems have been developed and trialed, what is the track record for this technology? Does it really have the potential to boost knowledge and expertise in rural areas where there are shortages of skilled personnel? Are the promises of section 2.2 in applications areas met? Unfortunately, the record is not universally good. Some projects for developing countries have in the past been abandoned at an early stage simply because the 'knowledge' embodied in the system is inaccurate or irrelevant to the application area and the representation is too rigid to allow easy alteration. The underlying database often proves to be inappropriate for the users or the inference strategy itself is similarly unfamiliar.

In a thorough evaluation of a medical decision support system that was not a success [2] points to many areas where the system's performance was inappropriate. For example, the knowledge base did not cover the symptoms encountered (violating the 'Relevance of Content' criterion), use of the system made the consultation longer than necessary (violating the 'Usability' criterion). She gives an excellent account of the problems with field trials of this archetypal primitive rule-based system based on a well known set of clinical algorithms (paper-based diagnostic flowcharts) used in developing countries [3]. A lot of the problems with the system arose because of the content of the underlying flowcharts which, although drawn up for use in developing countries, are not geared specifically to the locale in which this system was

tested.

We can characterise most of such failures as emanating from several sources. The related appropriateness criteria which are probably being violated are noted in parentheses.

- problems with the content of the domain databases (relevance of content)
- problems with the structuring of domain databases (relevance of form)
- problems with inference procedures (relevance of form) resulting in
- problems with apparent behaviour (usability), and
- inability to recover from these problems due to rigidity or lack of maintenance facilities (adaptability, supportability)

Two AI for development systems that have succeeded in that they are still in use, one for medicine and one for micro-hydro design, [4] and [5] are remarkable for the emphasis placed on employing knowledge relevant to the locale. We can see that great care has been taken to ensure that they are not alien systems designed in one environment and thrust into another. Briggs' system, a medical diagnostic support system being used by pharmacists and rural health workers, was designed and built in the country it is being used in; South Africa. Anderson's system, a portable expert system to assist in the design of micro-hydro schemes in rural areas, was only constructed after extensive field studies and consultation with local experts in Nepal. '...the system also embodies some of the 'rules of thumb' developed by practitioners with many years of experience in the field, and it can allow for subjective assessments of situations. For example, in the case of a small hydro, a villager saying that in a particular year the rainfall was 'a bit heavier than last year'...' ([6] p.9)

3.3 How to Make AID Projects Appropriate

In planning a project of this type, perhaps the major effort should go into ensuring the appropriateness of the proposed system by tailoring to local requirements. A preliminary investigation should attempt to uncover existing practices in the area of application, nature and methods of training, attitudes to computers and so on. The results of this survey should feed into the construction of the knowledge base and the design of the interface. There may well be locally published documents (like generic drug lists for a medical project) which can also feed directly into knowledge base design. Attention should be paid to existing practices in the practical setting so that, for example, the system does not ask for data which is not available or beyond the scope of extant facilities.

At a practical design level, we feel that the provision of a maintenance and update facility is crucial to ensure that the content (at the very least) remains appropriate to the setting. An out-of-date system is useless. The maintenance facility is crucial both in the early stages of a system's installation and once it is completed and in use. During the period when the system is being built and trialed a mechanism for altering the knowledge base(s) is invaluable. Often the problems with the underlying information or inference strategy only become apparent once the system has been developed and is undergoing field trials. The system's designer cannot anticipate all possible behaviours, and an evaluation phase is generally regarded as the point at which problems can be identified and rectified. Once the system has been designed, built,

piloted and installed, it will need to be flexible enough to respond to many changes. Expert knowledge in most areas, especially in developing countries, is surprisingly fluid.

The traditional method of building and maintaining expert systems with a heavy involvement of first-world knowledge engineers is costly and time consuming, and also likely to result in an inappropriate and rigid product. This expense can be minimised if local experts can build the systems themselves with the help of AI tools such as knowledge acquisition tools. The intimate involvement of the local expert in building the system contributes to the resultant product being appropriate in both form and content. The local expert should be able to control both factual knowledge, such as what diseases must be covered in a medical diagnostic system, and also the more procedural knowledge, such as the local conventions for history-taking or how a diagnosis proceeds.

4. THE WORK OF THE AID GROUP

The AI for Development group was set up in 1990 based in the department of Artificial Intelligence at the University of Edinburgh. It has created an international interest and now has a global mailing list and an occasional news group. We here outline some of its principles and practice.

4.1 Activities

An international newsgroup on computing for development was initiated and has been running for some months. A small library of publications from throughout the world is accumulating. We concentrate on articles concerned with practical projects as well as those outlining general principles of design and issues to do with implementing projects in developing countries. A software library of applications is held and demonstration applications are available for dissemination. Two major practical projects are currently under way.

4.2 Aims

One of the main aims of this group is to set up a 'skills resource' in AI for development. This involves setting up a database of all known past and present AI projects in or for developing countries, finding out what the demand for such projects is and matching an appropriate AI technique to them. A more pragmatic skill, perhaps, is knowing how to fund such a project, and we also regard this as part of the 'skills resource'.

Advice should be available on appropriate design methodologies, how to conduct a feasibility study, frameworks for evaluation, setting up a communications network for collaborative projects, and of course, tools and techniques.

Of course, AI is not appropriate for every application everywhere. Another aim is to try to outline just what the minimal requirements are for an AID project.

In planning an AID project it is vital to be able to learn from the successes and failures of the past. As has been previously mentioned, one of our main 'themes' is that of AI as Appropriate

Technology. We feel that adequate planning of a project to adhere to criteria like those outlined in section 3.1. We are constantly reassessing these criteria.

4.3 Projects

Two AI for Development projects are currently ongoing. A project to develop a knowledge acquisition tool for medical diagnosis in developing countries emphasises the need for local experts to have control over the design, building and maintenance of AI products. A project on indigenous knowledge in agroforestry emphasises enabling the capture of local knowledge and the transfer of AI techniques.

A model based toolkit for building medical diagnostic supports for use in developing countries. There have been various attempts to bypass the knowledge engineer in the transfer of information between expert and expert system with the use of automated or semi-automated knowledge acquisition tools. These have limited applicability for a development context, partly because they lack the knowledge structuring facilities that a knowledge engineer can bring to bear when analysing a domain. Tools which do offer these structuring facilities tend to be geared towards use by knowledge engineers. However, we don't want to make our local experts retrain as knowledge engineers. This would make the medical skills shortage even more acute.

What is needed for our purposes is a tool that provides knowledge structuring facilities that can be used by local experts in developing countries and does not require them to become knowledge engineers. This tool is for them, to build and maintain medical diagnostic support systems easily which are locally appropriate in both form and content. The system is in the form of a toolkit which is used to construct medical diagnostic support systems with appropriate domain and task knowledge. The emphasis is on providing the local expert with facilities which will enable them to enter their knowledge in a familiar form, rather than forcing them to learn a new and alien methodology.

The representation of indigenous ecological knowledge about agroforestry. Local people possess a great deal of knowledge about their environment and about suitable land management practices. This knowledge can complement external scientific knowledge. However, there are considerable problems in disseminating this indigenous knowledge to others who could benefit from it, there are difficulties of integrating it with external scientific knowledge, and there is a real danger that much of this knowledge will be lost through social changes and the imposition of external solutions.

The aim of this research is to develop computer-based methods for eliciting, testing and representing indigenous ecological knowledge, so that it can be used for supporting sustainable agroforestry practices.

The work involves collaboration between 6 institutions: The School of Agricultural and Forest Sciences, University of Wales, Bangor, is responsible for overall co-ordination and management of the project. The Department of Artificial Intelligence, and the Institute of Ecology and Resource Management at the University of Edinburgh are developing the formal methods for knowledge representation and the software for eliciting and reasoning with the indigenous

knowledge. Each of the following four institutions is providing a Study Fellow who will spend most of his or her time in the home country, obtaining and structuring knowledge about a particular aspect of agroforestry practice, and some time in the UK for training in knowledge-based methods: Department of Biology, University of Chiang Mai, Thailand (mixed farming) Faculty of Agriculture, University of Perdeniya, Sri Lanka (home gardens) Division of Forestry and Beekeeping, Tanzania (trees in rangelands) Pakribas Agricultural Centre, Nepal (production of browse for cattle). The project is funded by the UK Overseas Development Administration.

5. CONCLUSION

In conclusion, AI, far from being an outlandish discipline to be confined to the ivory towers of academia, offers hope of essentially practical solutions to many of the problems faced by people in developing countries.

AI tools and methods have become increasingly 'usable' in recent years and the possible areas of application for these methods are many and diverse. AI can be characterised as an 'Appropriate Technology', and we have here emphasised that in designing such projects the criteria for 'appropriateness' suggested herein should be adhered to. The introduction of an AI program has implications both at the national and the individual level, and several countries are now progressing towards a firm AI infrastructure. We feel that more countries should be encouraged to follow, and hope that the creation of international resources like the AI for Development group can help further their progress.

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EVALUATION OF HEALTH INFORMATION SYSTEMS: ISSUES, MODELS AND CASE STUDIES

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ABSTRACT

Multiple experimental and developmental applications of information technology to health and medicine in developing countries have been reported. Many of these otherwise interesting studies are flawed by an inconsistent, weak or non-existent evaluation. This is regrettable since it is only through what is learned through evaluation of such endeavour that a creative and sustainable role for health informatics in developing countries can be established.

This paper presents the case for structured evaluation of information systems, and provides a framework within which this complex task can be approached. This framework explores in some detail both the functional characteristics and the systems properties of innovations in information systems. The proposed methodology has been used in two health informatics case studies in sub-Saharan Africa.

1. INTRODUCTION

There is worldwide consensus that health should be a priority in national development strategies. This has resulted in a reorientation of policy to place a particular importance on the strengthening of health services in developing countries, where only a minority of the population has access to a high level of health care. The World Health Organisation's (WHO) Health For All strategy, for example, states that social development can no longer be regarded as distinct from economic development. This is because the progressive improvements attained by the development process can only be achieved and enjoyed by a healthy population [1]. This view has been supported by other authors on development. In defining development for all, Harrison asserts that development must aim for an eradication of absolute poverty, hunger and want [2]. Streeten advocates a change from traditional economic viewpoints of development, towards regarding health as a basic need which should be viewed as a national priority [3].

A large difference exists between the standards of health provision, and the capabilities to provide the required services, in the industrialised countries and those of the developing world. This is reflected in regional statistics on basic health indicators and in the amount of resources available for health. In the poorest countries, life expectancy at birth is on average 22 years lower, and the infant mortality rate is 10 times higher, than that in industrialised countries. An average of one nursing person to 3,130 people in developing countries is contrasted with 1 to 130 people in industrialised countries; expenditure on health as a percentage of total public spending is also low (3.4% compared with 12.5%), and decreasing [4]. Nonetheless, there is wide agreement that major improvements are possible, even within the constraints that exist, if resources are better targeted and managed [5]. Information technology (IT), in particular, is increasingly seen as a valuable tool for better resource management in health [6,7].

It must however be recognised that advocating IT in developing countries can be a contentious position, and some do not view it as an appropriate option for developing countries in general. To identify in the abstract the possible role for information technology in health care in developing countries is easy compared to considering the problems of implementing real, sustainable and beneficial information systems in the domain. Various classes of issues are influential in assessing the true sustainability and utility of health informatics applications in the longer term, including those that apply to the use of information technology itself and those that relate to the context and imperatives of improved health care. The basis of this paper is that only through careful, comprehensive and comparable evaluations of systems and studies that are made will it be possible to refine and develop appropriate understanding.

The use of advanced technology in developing countries in the past is often seen as having created a dependency relationship, characterised by an increasing reliance on outside sources for machines, equipment, inputs and both managerial and technical personnel without corresponding development gains [8]. Stewart attributes this to the historical development of inappropriate technologies [9]. It is also the case that the infrastructural deficiencies of developing countries will determine the viability of a computer-based information system implementation. In the developing world, much of the basic physical infrastructure that is taken for granted in developed countries is either non-existent or poor [10,11,12,13]. Other aspects of support infrastructure are also relevant. Another significant resource problem for developing countries in both health and in information systems is the lack of skilled and trained personnel. Training facilities are generally poor, requiring staff, software, literature, equipment and other facilities that are not easily available locally. In health systems this is often most manifest in the regional and community level, exactly where information systems projects might be seen as able to make their greatest impact. Reliance on outside expertise and specially funded project level work can in the short term alleviate this, but in the longer term can only contribute if skills are effectively transferred [14].

Finally, any information technology based system must take local ways of thinking and behaving into account; it must try to cause 'soft' cultural changes which can easily be absorbed by the local community [15]. For example, notions of rationality and efficiency may differ, affecting the ways in which skills are accepted, modified and embedded in a society [14]. Language, attitudes towards time, and the meaning of authority may also differ [16]. In

addition to national cultural traits, organisational culture has also been distinguished as a separate issue and a growing number of researchers have pointed out that organisational and social aspects can damp out the intended effect of a technical innovation [17]. If, for example, people are used to working with informal, non-standardised methods of data processing, IT implementation becomes more difficult [12]. A computer-based information system cannot be divorced from its social environment, and as Walsham *et al.* state, an information system should always be regarded as embedded in a social system [18].

With these issues as background this paper is concerned to develop a broad and general framework for evaluating health information systems projects and case studies. In this way it is intended that evaluation can contribute to finding the appropriate path for a creative involvement of information technology with the problems of health care delivery.

1.1 Evaluation Models

In building any information system, the developer not only has to develop the system in a competent and professional manner, but also needs to know that it is the right system that is being developed. This is particularly vital in developing countries where there is both a greater risk of resource wastage if the system implementation is unsuccessful, and, for any given project, a greater opportunity cost. Evaluation of prior systems development work and of other projects in the domain is thus vital to inform the developer and to permit enhanced planning and management functions.

Evaluation is widely acknowledged to be an important and useful stage of information systems development, generally considered to come at the end of the development life cycle alongside the operations and maintenance phases [19]. In this way it provides a means of judging a system's true worth or value against initial requirements, and also serves as the basic mechanism of a learning process that informs future developments in similar environments. Furthermore, in the attempt to assess whether performance is satisfactory, weaknesses in the system under study and requiring further development can also be identified.

While there is general agreement on the importance of evaluation in information systems projects, various authors disagree on the detailed role and scope of the activity, and various alternative terms have been used to distinguish between different types of evaluation. For most authors, evaluation has meant a concentration on the technical aspects of an information system and its immediate environment, but it has also at times been used as an umbrella term covering a broader process of investigation into social, technical, organisational and other aspects that might affect the operation and outcomes of an information system innovation.

Hirschheim and Smithson classify a continuum of approaches to the evaluation of information systems: ranging from what they call objective/rational to subjective/political approaches [20]. The zones in the continuum are as follows:

- *efficiency* which they define as "performing a particular task well in relation to given criteria" and includes hardware and software performance, correctness of programs, and software reliability;

- *effectiveness* "deciding what tasks should be done", is more difficult to evaluate. One reason for this is the lack, in most cases, of an adequate initial definition of success or failure; another reason is that assessment at this level is a subjective task, dependent on individual judgements of such things as the value of new information resources. Evaluations of this aspect have therefore tended to measure what is easy to measure rather than what is most important;
- *understanding* is an appreciation of the functions and nature of evaluation, and the limitations and problems in the process of evaluation. This arises because of a need to view evaluation as a social activity which evokes political and social issues.

In terms of this continuum, the methods for conducting such assessments vary from the soft or informal (understanding) to the structured and formal (efficiency). The understanding aspect of the above classification is, in particular, less oriented to quantitative approaches, while effectiveness can be measured in a semi-formal fashion, and efficiency may be measured quite formally. Hirschheim and Smithson point to the need to redress the quantitative and efficiency bias of the evaluation process. Thus evaluation should involve an appreciation of the functions and nature of a system, and the limitations and problems in the process of the system's assimilation into an environment. The World Health Organization (WHO) have suggested, from the health perspective, that the purpose of evaluation is to improve services and guide planning, and suggest a process that includes the following components [21].

- verify *relevance* or rationale for adopting the system within the general health policy;
- assess *adequacy*, whether sufficient attention has been paid to all the details involved in implementation;
- review whether *progress* is made by comparing actual activities with scheduled activities;
- assess *efficiency*, whether the results obtained have been maximised in relation to resources used;
- assess *effectiveness* at improving an unsatisfactory health situation, where feasible this should be quantified;
- assess *impact*, the overall effect of the programme on health and related socio-economic development.

The WHO use some of the same terms as Hirschheim and Smithson, but order the components differently. In a sense, their approach embodies the understanding concept, emphasising the need to specify what is being evaluated, and then to assess the impact of a programme on the overall level of health. However, their main suggestion for aiding the evaluation process is in the use of indicators and criteria to measure change, thus implying a quantitative appraisal.

2. A PROPOSED GENERALISED EVALUATION APPROACH

Health information systems need to be evaluated to include both the information systems and the health perspective. One general approach to the evaluation of a health information system has been proposed by Donabedian and was later used by Vallbona [22,23]. The framework allows the impact of an information system on the health care system to be evaluated at three levels: the *structure*, the *process*, and the *outcome*. It is also assessed from different stakeholder viewpoints: that of the *planners*, *providers* and *consumers*.

Based on the work described above the following structure has been developed for evaluating the efficiency, utility and overall impact of health information systems. The proposed evaluation approach is based initially on the three concepts of structure, process and outcome (SPO). These need careful definition:

- The *structure* of a system is the manner in which it is constructed, or the whole of its essential parts. Put another way, the structure is 'the fixed and designed components'.
- The *process* it performs is a series of operations by which a task is accomplished, and information transformed. This can be described more simply as 'the way things are done'.
- The *outcome* of the system is the impact or visible effect. This can be rewritten as the 'general result of the system in operation'.

Conventional IT evaluation has concentrated on structure, whereas health evaluation has focused on outcome. The process is then the link between the two. To restate the flow between the three components, one wants to evaluate how the design of the structure has created or modified a process and achieved a set of outcomes.

This three-part analysis can then be applied at three main levels: that of the system's functioning, human perspectives of those involved, and the overall impact on the health care system. One can observe a natural diagonal between the SPO components and these levels (Figure 1). System's functioning falls most directly under structure, human perspectives under process, and the health care system under outcome, but by developing this model more fully, and extending it into a full matrix, the approach used here sets out to capture a broader and more comprehensive view of the effects of a system. For example, when the structure of a system is considered in terms of its overall impact on the health system, one can appreciate the opportunities and problems that arise in implementing IT in developing countries. Considering each of these matrix items (levels and components) in turn:

Level 1. The system's functioning. This has been referred to as the raw efficiency of the system itself by Rossi-Mori and Ricci in their consideration of medical expert systems [24]. Broken down into the evaluation procedure, the following aspects may be considered:

Structure - what are the hardware requirements and is the software structure understandable? Does the full set of system components work together in a technical sense?
Process - is the method by which the system transforms its data, the information processing, correct and valid?
Outcome - are the results relevant, applicable and reliable? Does it meet the requirement specifications?

Level 2. Human perspectives. This includes the acceptability of the system by the various stakeholders, and considers how the system's functions affect them. Rossi-Mori and Ricci include human perspectives in their outline, but only that of the immediate system's user. Our framework recognises at least three roles under human perspectives, which are sufficient for the case studies reported. In other situations, there may be more roles worthy of consideration, in which case, the number of stakeholders has to be increased. Assessing human perspectives of information systems is not easy and these aspects are not easily

measurable. Researchers must allow themselves both the freedom to identify sufficient stakeholders and the freedom of using qualitative judgements in their analyses when quantitative measures cannot be obtained. The three stakeholders identified here are:

The User. This is the primary agent in the system implementation, who is indispensable for its proper functioning. Within the SPO dimension, this poses questions such as:

Structure - what are the changes to working conditions, in terms of the physical environment, skill requirements etc.?
Process - how is the user's mode of operation changed? Are these changes seen as desirable to the user as an individual, and to the user's organisational role?
Outcome - is the overall effectiveness of the user within the health care system enhanced?

The Recipient. This is the person who the system is expected to benefit, and who is often directly or indirectly affected by its implementation. This person will, in general, also be the source of the information processed. In a classic medical informatics application, this would strictly be the patient. Within a health informatics application, this may be more generally the population served.

Structure - are recipients required to modify their behaviour in any way?
Process - how is the recipient's experience of health care altered at the point of contact with the system?
Outcome - does the use of the system result in changes in the quality of service and better health for the recipient?

The Administrator. This is the person responsible for the general management of the health unit. Note that, since this is under the human perspective heading, assessment at this level is focused on the person responsible for the management of the individual health unit rather than the whole health system. Thus, it is limited to the administrator's immediate concerns.

Structure - is the system a reasonable, cost-effective and efficient alternative to existing structures?
Process - does the system imply change in the health care delivery activities for which the administrator is responsible? Does it change the character of the administrator's job?
Outcome - does the system improve specific health provision on a reasonable metric?

Level 3. Health care system. This involves a consideration of the impact of a system's use on the health care system as a whole, and on health itself. It concerns the national developmental level in its widest possible sense. In Rossi-Mori and Ricci's approach, this is the effectiveness at the "health problem" level of assessment [24].

Structure - does it change the balance between the functions of the different health care providers?
Process - does it affect practice and delivered quality of health provision?
Outcome - does it improve the health status and development potential of the population it serves?

The justification for the approach described here can be made from two main angles. Firstly, it provides a procedure that assesses the technical and the social aspects of a system, as well as the long-term impact on improving health care. Secondly, it is a standardised procedure for reporting evaluation results that can be widely applied. It incorporates all the points mentioned in Rossi-Mori and Ricci's outline for the evaluation of medical decision-aid systems. The Hirschheim and Smithson approach to information systems evaluation, and the WHO approach to health programme evaluation can also be accommodated within it. In summary, the evaluation framework proposed here permits a structured view of health informatics projects which recognises both the need to link an information technology grounded perspective with one that includes an understanding of the broader concept of health.

3. THE CASE STUDIES

The evaluation framework described above was developed as part of a research project that implemented and conducted field trials for two health informatics systems [25]. The first of these was a computerised field data collection system for health surveys, named the Field Data Collection System (FDCS) [26,27]. The second study was of a medical decision aid designed for use in primary health care clinics, ESTROPID [28]. Both these systems are described in detail elsewhere and only a brief description is given here [25]. In each case the evaluation was based on a careful experimental design, and extensive statistics were collected on relevant aspects.

3.1 Field Data Collection System

FDCS, Field Data Collection System, was piloted for 8 weeks during a malaria morbidity survey in Bakau, The Gambia. The system provided a facility to design and administer a structured questionnaire in the field with a small, battery powered hand held computer, the Psion Organiser II XP. The system was intended to enable a moderately complex questionnaire to be administered by field workers, and the collected data to be transferred to a Toshiba portable microcomputer for analysis. The aim of the system was to improve data quality and to speed up the survey cycle. The experimental design was thus particularly concerned with evaluating such data quality.

3.2 Expert System for Tropical Diseases

ESTROPID, an Expert System for TROPIcal Diseases, was developed as a self-sufficient system that could be used by trained nurses or other similarly qualified health personnel such as clinical officers (COs) during routine consultations. It was intended for primary health care clinics in tropical Africa. The knowledge used in ESTROPID was solely extracted from the Essex flowcharts [29]. These appear to offer a handy, concise and compact collection of knowledge essential for the basic practice of tropical medicine and health care. Their development was supported by the World Health Organisation. The set of 64 flowcharts each comprise of a chart heading, a series of decision boxes with signs or symptoms to ask for, with two arrows (one for positive answers, and the other for negative ones) leading to either another decision box or a diagnosis box. This seemed an ideal source of knowledge for a computer-based system, and indeed ESTROPID is not the first medical decision-aid system to exploit

Essex's work [30].

The system was designed to deal with the spectrum of diseases that can be treated at the out-patient level, and that require a minimum amount of clinical skills to understand the medical procedures and investigations it requests. The aim of the development was to provide diagnostic support and management advice, to help improve service to patients, and encourage better resource usage and management at the primary health care level. The system was evaluated at a primary health care clinic in Kenya, and the primary focus of the evaluation of this system was to assess its potential for clinical benefit. The experimental design was thus targeted at evaluating the diagnostic ability and value of the system, and was based on patients seeing a Clinical Officer using either the ESTROPID system or a Clinical Officer using the established procedures. A doctor then saw each patient. The results of the two consultations were then analyzed for concordance.

4. EVALUATION OF THE CASES

This section summarises the evaluation of the two case studies within the framework described above. It is not possible to give the full evaluation here, but it is hoped that the flavour is conveyed.

4.1 The System's Functioning

Structure. In the case of the FDCS system the hand held computers functioned well and proved robust in spite of a few falls and being left in the charge of the interviewers for the duration of the study (8 weeks). Battery life in the tropical environment proved to be a problem, as did the data transfer ports on occasions. The duration of the batteries directly influenced the amount of data that could be collected at a time.

In the ESTROPID study the Toshiba portable used worked well with a stabiliser, but the software was less than adequate. The interface was not flexible enough to handle the range of symptoms it was presented with. The knowledge base and the underlying flowcharts were overambitious in attempting to cover more diseases than could be treated at the out-patient level, sacrificing more useful detail for treatable diseases. The flowchart structure resulted in an interface that was repetitive and cumbersome. It also did not include many important relationships between symptoms that help to reinforce or reject diagnoses.

Process. In the case of FDCS interviewers, despite minimal prior computer knowledge, found it easy to conduct interviews with short prompts, and found the compactness of the machine a bonus for carrying around. Data transfer needed some care, but was generally done without much difficulty within half an hour. With a few exceptions, the data was successfully transferred onto a microcomputer after being returned to the base.

ESTROPID was slow in all interactions, in accepting entries and displaying questions. The interface was very basic, and it could not deal with contradictory information, handle extra information during the consultation, or allow any backtracking. Its reasoning mechanism was very opaque, not demonstrating in any sense human-like intelligence in its line or method of

questioning. The richness and complexity of the real diagnostic task left ESTROPID looking very amateurish indeed.

Outcome. The comparison of ESTROPID's output with a doctor's diagnoses showed that they were worse, but not much worse, than those of a Clinical Officer in normal consultations. On the other hand, the expected benefits of the FDCS system proved real in practice, in reducing the number of errors in the data collected as well as the time taken to conduct interviews. The improved survey cycle time cut out the week's work required for data entry and checking.

4.2 The User's Perspective

Structure. In each case training was offered to the systems' users. In the case of FDCS this was assessed as adequate and FDCS proved easy to learn. In a more established study, the interviewers would need further training after they had mastered the basics, for example, to learn to replace batteries and use other outer level menu functions. The menu-based software proved easy to learn and use for those with no previous computing experience.

ESTROPID made some demands on the Clinical Officer's normal working conditions. The computer needed to be kept in a secure place as it could not be left safely in an unlocked room. This meant taking the computer and stabiliser each day from the store room, to the consultation room. Under normal conditions in a rural health clinic, this might be an important consideration if the computer equipment cannot be transported easily.

Process. A change in the attitudes of the FDCS users was observed during the study. Although their initial expectations were highly individualistic ranging from pessimistic to optimistic, they all tended to express opinions more in favour of FDCS at the end of the study. Some of the things that were disliked by the interviewers were related more to trial management than intrinsic characteristics of the system. The various things listed as positive by interviewers covered all the expected benefits - automatic question skipping, error checking, automatic recording of time and date, as well as unexpected by-products, the interviewer only needed to carry one instrument considerably lighter than paper questionnaires and easier to handle when interviewing. Some of them found the system initially difficult, and these were the most resistant to its use at the start. At the end of the survey, all of them could mention how some aspect of the software could help their work, and none expressed an opinion against the use of FDCS. When using the system, the focus of work shifted completely to the field, no additional checking by the interviewers was necessary before the data was 'handed in'.

In the case of ESTROPID the use of the computer did not change the initial detail gathering stage of a consultation. The patient was still asked what was wrong with them in the usual manner. Probing, in taking the rest of the history, did change as the clinical officer used ESTROPID to guide his interrogation. Routine physical examination was relegated to a less conspicuous role, and the clinical officer only examined the patient when ESTROPID requested it. The system's structure however was not a good model of actual practice and patient symptoms need to be verified by physical examination as often as possible and not just when a system suggests it.

Outcome. Overall, it would seem, from the point of view of the FDCS interviewers, that once they had become familiar and confident with the system, it resulted in few negative changes in their jobs and improved their efficiency. As their work output, interviewers could return data on a chip instead of a pile of heavy papers, which most mentioned as a bonus.

The ESTROPID diagnoses, although not acted upon, did not significantly improve the clinical officer's concordance with the doctor. The clinical officer felt he disagreed with ESTROPID's diagnoses 4 out of 10 times, indicating that if he were meant to implement ESTROPID's diagnoses, he might have chosen not to. The consultations also took longer, and were related to the clinical officer's typing and reading abilities.

4.3 The Recipient's Perspective

Structure. In the case of ESTROPID it was the trial design itself that presented most inconvenience to the patient rather than the use of ESTROPID. They had to see two clinicians, instead of one, and were subjected to some delay. In the case of the FDCS there was little change in the structure.

Process. ESTROPID consultations took longer and were less personal since they excluded many of the additional functions a Clinical Officer does very quickly, for example, in passing information to reassure patients, or advise on nutrition. Survey respondents in the FDCS trial did not object to the use of the computer and became noticeably more enthusiastic when its use was explained to them.

Outcome. Although the ESTROPID system had certain systematic errors, these did not result in significantly worse diagnoses overall. However, ESTROPID nowhere reached the speed and competence with which the CO normally performed his job. The outcome of the FDCS trial can be more positively assessed in that the length of the weekly interviews were reduced somewhat.

4.4 Expected Viewpoint of Administrator

In neither case did the field work include a detailed investigation of the opinions or attitudes of the management of the health units involved. This is a clear weakness of the studies, but the evaluation framework at least highlights this deficiency. Overall it was seen that administrators would need to be satisfied that either system was cost-effective and an efficient alternative to existing practice. In neither case is this clearly demonstrable though the FDCS system has clear potential.

4.5 Expected Impact on Health System

In the case of ESTROPID the overall evaluation of the application seems to make it a non-starter for a number of reasons. Current technology remains too expensive for ordinary health centres. Software design still falls far short of delivering the required level of expertise. In this study, employing a skilled clinical officer, there was a likelihood of challenging the system on disputable cases. In other situations, his experience may not be the overall norm, and may

result in the transfer of accountability from a health worker to a machine that has not proved its worth.

Most medical diagnostic-aid systems for developing countries attempt to improve or support the diagnostic ability of nurses or other paramedical staff. None have met their stated aim of increasing the quality of routine decisions made at the primary health care delivery level. It is doubtful that such systems could have an impact if the health personnel were not trained well enough to question its decisions, yet well-trained staff can do without a computerised aid, and perform better, and faster, delivering care with a more personalised approach than any computer-assisted system could provide. Any value added is thus hard to identify. This analysis is not intended to conclude that health personnel do not need any help. It argues instead that their need of computerised decision-aid technology is questionable.

Computer aided data collection such as FDCS could result in a significant improvement in the process of data collection and management in developing countries. It could encourage more sophisticated sample design, allowing more adaptability in questionnaire design, testing and modification and producing better quality data in less lead time. The computer-readable data in ASCII format feeds naturally into analysis software. FDCS offers a quick start-to-end way of conducting surveys in rural areas of developing countries, helping to make the survey process more easily managed. It also has some implications for more general health monitoring activities in the long-term. The use of the system could reduce the data collection load on paramedical staff if it encouraged the demand and use of specific items of data for management purposes. It could also enhance the role of data processing personnel. By improving the accuracy and timeliness of data, problem-oriented policies could be based on the information produced. Data might be produced to assess the extent of a problem, but also to evaluate the effectiveness of any interventions proposed and implemented. FDCS could ultimately improve the overall health status of a population if the cycle of demanding data, using that data to design and implement policies, which in turn produce more data, were maintained by decision-makers.

5. CONCLUSIONS

A major difficulty with ESTROPID was that observed clinical practice did not correspond well with its structural assumptions. The performance of ESTROPID was dependent on its structure, design and logic mechanism as well as the basis of its knowledge - but there proved to be inherent problems with the design. Not surprisingly therefore, it did not result in a significant improvement of performance. The use of the evaluation framework described in this paper made it relatively easy to assemble the evidence to arrive at this conclusion.

In contrast, the malaria morbidity investigation used in the FDCS study was a relatively straightforward situation. That the system proved to reduce errors and speed up the data cycle in this type of survey is an achievement. In other situations with more potential for error (for example, longer questionnaires with more skips, or those that are administered over a short survey period), its impact might be more dramatic. Furthermore the technology used in the study worked quite successfully within a developing country context.

The use of the evaluation framework to summarise the results of these two studies illustrates its power to highlight the main findings and insights from health information systems. We hope that it can also provide a basis for comparison of the results of these studies with others.

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Figure 1 *Full Evaluation Framework - The Broader View*

SYSTEMS PERSPECTIVE

FUNCTIONAL PERSPECTIVES	(Technical system) System's functioning	(Human activity system) Human perspectives	(Health care system) Health provision
Structure (Information Technology)	Technical detail	Work conditions and imposed requirements	Balance of care provision, management and training requirements
Process (IT in achieving health task)	Altered use of information in health care delivery	Organisational setting and social interaction	Altered delivery and practice in health care system
Outcome (Health)	Meet requirement specifications in health terms	Change in perception of health service quality	Health status of target population

SHARING AND ADAPTING EDUCATIONAL COMPUTER SOFTWARE

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ABSTRACT

The explosion of information technology that is occurring in more-developed countries and being rapidly assimilated into their educational and training settings is bringing particular challenges to less-developed countries. Strategies for predicting the adaptability and potential relevance of computer-related instructional resources for less-developed countries when those resources originated in more-developed countries are important. Research at the University of Twente in The Netherlands with regard to educational software portability includes a number of projects in less-developed countries. In this paper we use one of these studies--a project in Mexico--to stimulate reflections on questions about the portability of educational software from the perspective of less-developed countries.

1. INTRODUCTION: EDUCATIONAL SOFTWARE PORTABILITY

We define portability as the capacity of an item to be useful in environments different from those for which it was originally developed. There are many reasons to study the portability of educational software, particularly in the context of less-wealthy or less-developed countries.

1.1 Economic Motivations

Educational software development is a labour-intensive, time-consuming, costly process. From a perspective of improving the attractiveness of a commercial educational software market, it is desirable to extend the applicability of a software package outside of its original distribution radius. Also, a larger volume in distribution can lower costs, clearly important to a market development for educational software [1].

These economic arguments intensify in the context of small and/or less-developed countries. "Small countries simply cannot fund the major cost of their own educational software development" [20]. Less-developed countries are not only limited in financial means, but also experience a shortage of qualified software production teams, a scarcity of up-to-date

development tools, and limited access to information about technological advances [3,4]. "Reinventing the wheel" with respect to educational software already available elsewhere may often be too costly for less-developed countries [5,6,7]. In his analysis of computer use in third-world schools, Hawkridge [8] notes that "developing and marketing suitable educational software is so costly that few countries attempt it" (p. 324).

1.2 Educational and Scientific Motivations

There are also strong educational and scientific reasons for the sharing of educational software. From an educational perspective, we still have much to learn about effective software design, implementation, and support. As much as possible, we need to disseminate examples of good practice so that they can be more systematically evaluated in a variety of different settings. From this perspective, the wealthier countries have much to learn from the ingenuity of poorer countries with respect to creative use of limited resources. For example, Zhang and De Diana [9,10] describe a system developed in China where up to 64 learners can be served with one relatively inexpensive computer, using hardware and software strategies that could well be used in even the wealthiest countries.

From the scientific perspective, there are also other important motivations for the study of the portability of educational software. Insights from software engineering need to be adapted to the new discipline of "courseware engineering", [11,12]; to do this, examples must be systematically analyzed. Thus the goal of optimizing adaptability in educational software is essential to the maturing of the field, from both scientific and educational perspectives.

1.3 Social Motivations

There are also powerful social motivations for the portability of educational software. There is a desperate need for instructional resources in many developing countries [15]; for wealthier countries to acquiesce to the rapidly increasing gap between the educational resources and opportunities available in the richer and poorer nations of the world is humanly insensitive and politically dangerous [16].

2. FACTORS THAT LIMIT THE PORTABILITY OF EDUCATIONAL SOFTWARE

Despite the compelling reasons for improving the portability of educational software, there are many barriers to this portability and also many situations in which portability is not desirable. In this section, we briefly outline some of these factors and some strategies for minimizing their impact.

2.1 Categorization and Interrelationship of Factors

There is an extensive amount of literature and experience in the area of educational resource portability, and in particular a growing body of experience with respect to computer-related resources. The synthesis of this experience is one of the focuses of a four-year research project at the Department of Educational Science and Technology at the

University of Twente in The Netherlands [17,18]. With regard to factors that influence the portability of educational software, there are many categorizations possible. The categorization used in the University of Twente research [17] is as follows:

- *Technical factors*, relating to the:
- Physical input of data and mechanisms for human computer interactions;
- Program architecture and algorithms, particularly with respect to language handling;
- Authoring languages and tools used in developing the software;
- Operating system level;
- Hardware characteristics;
- Network level (i.e., related to connecting the software with other objects, such as peripherals or other computers).

- *Educational factors*, relating to:
- Educational need and relevance;
- Curriculum content, globally and in detail;
- Instructional approach, at the micro-level and at the macro-level;
- "Tone and style" of educational interactions;
- Social and physical settings of the learning environment in which the software is planned to be used; and
- Teacher considerations, related to experience and attitude.

- *Social/cultural factors*, relating to:
- Language in which the learner interacts with the software;
- Tone and style of communication;
- Cultural identity;
- Political sensitivities;
- Cultural perception of the roles of the teacher and learner; and
- Local references and assumptions.

- *Organizational factors*, relating to:
- Instructional procedures affecting software-related decision-making and implementation;
- Copyright and ownership;
- Cost-related issues, including pricing, development costs, and cost-effectiveness;
- Marketing and distribution issues;
- Maintenance; and
- Management of the design, development, and distribution processes.

2.2 Context-specific Interrelationships

These factors interrelate in different ways given different educational contexts. For example, in less-developed countries an additional technical problem frequently arises because of the often-lower memory and storage capacities of available equipment compared to the environments in the more-advantaged countries where the software products were

originally made. Murray-Lasso [19], for example, describes typical school computers in Mexico: 8-bit machines, the majority of which have memories between 16 and 64K, no disk drives or printer ports, and unreliable cassette memories. Software producing countries do not any more produce educational software for such limiting hardwares. Planning for this sort of technical problem is an example of what Bengtsson [20] calls "backward portability", in distinction to forward portability, which involves anticipating future advances in technical environments and conditions.

Portability barriers related to social and cultural constraints also have particular importance when considering less-developed countries and their acceptance of software originally developed elsewhere. Hawkridge observes in his analysis of educational computer use in third-world countries that "many (of those countries) import software but are unhappy with what they get, for educational and cultural reasons" [8]. Murray-Lasso (the past president of the Mexican Society for Computers in Education) states emphatically that "The first (portability) constraint is cultural. Mexico will not accept culture-dependent computerized educational materials that were developed for other cultures [6] because it cannot feel that it is being "colonized" or a "satellite" of somewhere else [21]. Wombi [22] comments even more strongly: "Technology is like genetic material--it is encoded with the characteristics of the society which developed it, and it tries to reproduce that society". Thus the reaction of a less-developed or poorer country to educational software offered to it from a more-developed country may be heavily influenced by its feeling about this identity issue, even if it can see benefits from economic and educational perspectives for acceptance of the software.

2.3 Strategies for dealing with Problems Associated with Educational Software Portability

Our research not only involves the better identification of problems that influence the portability of educational software but also the improvement of strategies to lessen the problems (or to decide when the problems indicate that a portability situation will not have a cost-effective solution). We are studying such strategies by applying them in projects in a number of countries, including China, Bulgaria, and Mexico.

It is of particular interest to us to study the factors and strategies in the context of less-developed and less-wealthy countries. A project recently completed in Mexico [23] richly illustrates many of the portability factors as well as the outcomes of various strategies for dealing with the factors when attempting to adapt software made elsewhere for use in a country with less experience and resources available in schools with regard to educational software. We will next describe this study in more detail.

3. A PORTABILITY PROJECT: EDUCATIONAL SOFTWARE FOR MEXICAN SCHOOLS

A question of considerable interest in Mexico is if some of the extensive amount of educational software available in other countries could also be useful in Mexico, given various national constraints. Miss E. Mols, a graduate student at the University of Twente,

took on the assignment working on a portability-investigation project relative to this question. She related her experiences to the overall model of educational software portability of Collis and De Diana [17] and in particular to their five-phase software life-cycle approach [24].

3.1 Initial Decision Phase

Mols then met with a Mexican expert in educational computing and from a collection of existing educational software programs chose with him a set that appeared to be promising candidates for the portability research. Mathematics programs were chosen, to avoid culturally-referenced curriculum areas as much as possible. Nine-to-ten year olds were chosen as a target group, because children of this age are still in school and still dealing with mathematics as a common curriculum but are old enough to deal with computers without too many conceptual problems. Also, the software would have to run on hardware already in Mexican schools so technical complexity had to be considered. Programs would haven to be of low cost or free, and not offer copyright problems in terms of adaptation. Social and cultural aspects also influenced the team during the selection of a final set of four software programs.

However, the software selected had been originally written for a model of computer not available in The Netherlands and considerable effort had to take place to adapt the computer and find a suitable monitor in order to examine the programs.

3.2 Global Redesign Phase

For this phase, Mols went to Mexico. She first spent some time studying the educational system, visiting the school in which she would try out the adapted programs, and finding out as much as she could about the level of experience with computer use in Mexican schools as well as about the mathematics curriculum and how it is usually taught [25]. She also had to become familiar with the software authoring environments available to her in Mexico and gain experience with them.

During this time, Mols made an extensive curriculum analysis relative to the content in the software and decided where content adaptations would have to occur. Visits with local specialists--mathematics, computer education, software developers--occurred.

3.3 Product Adaption Phase

During this phase the programs had to be recoded because of different authoring systems and hardware platforms. Many technical difficulties arose, such as lack of appropriate characters for the Spanish language in the graphics mode of the authoring environment used, and the use of appropriate error-trapping procedures. Continual testing took place, with frequent comments from teachers, which resulted in many adaptations to the software to better fit with Mexican instructional practice. More conceptually, the fact that Mexican students would always be working with a program in pairs or a small group meant many changes in program design had to occur. Many adaptations relative to culture and social

aspects also had to occur, ranging from aspects of the graphics in the software and expressions and local references to the tone and style of instruction. A teacher's manual had to be developed, as local teachers had little or no prior experience with using computers.

3.4 Distribution and Maintenance

The experience Mols had with the headmaster of the school in which she worked van be seen as representing some of the cultural and organizational issues that can frustrate software exchange and distribution. Despite the fact that he had originally agreed to the project (in the context of a hardware donation to the school) the headmaster apparently was not inclined to value the idea of a female researcher, from outside of Mexico, interfering with his school and its routine. The time that Mols needed to observe students interacting with the program was severely limited, so little on-site revision could occur. Timing and scheduling problems, plus the fact that only part of each class using the software could work in the computer room at any one time, complicated systematic study of the software or the opportunity to improve it and try it again. Despite these problems there was some evidence that students using the adapted programs performed better than students using similar but unadapted programs.

3.5 Further Implementation

The likelihood of use of the adapted packages continuing to be used outside the framework of Mols' research activities is not easy to predict, although IBM Mexico was impressed with her work and has indicated interest in supporting broadscale distribution of the software. However, given the problems generally confronting computer use in Mexican schools [25], it is unlikely any software, no matter how portable, has yet much chance of large-scale "success" in terms of implementation--at least until fundamental issues relating to resource provision, teacher training, and teacher reward and support are addressed [26].

3.6 Reflections on the Experience

Virtually all the factors listed in section 2.1 were relevant to the Mexican portability project. Software architecture proved to be a crucial issue in program conversion, as the programs that were converted were not originally done in a modular style, nor did they have a clear separation between logic and data. Thus everything had to be rewritten for the new hardware situation. Questions with respect to the effects of Mexican teachers' preferred instructional approaches proved to be hard to settle early enough in the porting process, as the teachers and students who were to use the programs did not have much computer experience. Teacher training again proved to be a paramount issue. The teachers had little experience with computers and thus it was hard for them to involve their students in computer use. Cultural assumptions had to be accommodated during the entire process of program conversion. Difficulties resulting from institutional decision making were manifested in timing and scheduling problems, resulting among others, in a limitation of opportunities for students to work with the computers. Thus the Mexican experience has strengthened our understanding of the factors that influence the portability

of educational software, and has reconfirmed our awareness of the complicated nature of the portability problem.

4. CONCLUSIONS

How well does the Mexican project relate to some of the major recommendations emerging out of our overall work [26] for improving educational software portability?

4.1 Suggestions for Improvement of the Portability Potential of a Software Product

These include:

- Continued improvements in strategies for software design and architecture, with more standardization of approach and technique
- More portability-appropriate authoring tools; that is, tools that actually support adaptation agents in adapting courseware to local and cultural conditions of use
- Continued examination of instructional approaches most effective for educational software
- More and better teacher involvement within each step of the software life cycle particularly teacher training
- A greater sensitivity to the pervasiveness of cultural assumptions and other aspects of cultural identity in any educational product
- Increasing attention to the development of distribution networks and better strategies for the dissemination and sharing of computer-related educational resources

It appears that each of these recommendations is pertinent to the Mexico project and is directly applicable. The sixth recommendation is more abstract, but still important to the overall development of the use of computers in education in Mexico. Mols notes in her case study [25] that various problems related to economics, such as poorly paid teachers with limited access to computer-related information or training, make it very difficult to expect computer implementation to take place in Mexican public schools. This is particularly the case in rural areas, where support for even basic delivery of education is difficult to maintain. The yearly Symposium about Computation in Infant and Youth Education attracts many teachers, but most have little or no opportunity for training or for computer access. Thus strategies for sharing of ideas and low-cost computer activities between Mexico and other countries are of great importance [6].

4.2 Suggestions for Policy Areas

In addition, to the above solution areas, we have indicated areas related to policy and organization that we believe are likely to lead to more portable, and more available, educational software [26]. Such areas include:

- Better strategies for the sharing and distribution of computer-related educational resources, including electronic networks and human networks (such as those nurtured

within international professional societies such as IFIP)

- More attention to copyright and ownership issues, moving toward some sort of international standardization and a better understanding of the needs and perspectives of both producers and acquirers of software
- More attention to strategies for estimating the cost and the cost-effectiveness of different types of educational software and different types of development and acquisitions processes. Cost-effectiveness of educational software products can be improved considerably if products are developed for a world market and not for specific cultural conditions of use

We believe that these policy-level recommendations are relevant to the situation in Mexico with respect to computer-related resources in education, but also to developing countries in general.

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CONCLUSIONS

Since the last international conference organised by the working group in New Delhi, more than three years ago, some progress has been made in our understanding of "information technology (IT) in developing countries (DCs)". Many of the discussion and debate themes have changed over the years and there is now more insight (although not sufficient) into the application, and problem area, of IT in DCs. Some relevant research has been done in the area and many publications highlight experience of various countries in their efforts to use IT. Professionals with interest in the area have moved away from the debate of the late 1980s of whether "any IT is really needed in the developing countries or not", to "what kind of IT is appropriate for DCs".

The need for IT, for economic growth and social development in DCs, is well accepted by all those concerned (professionals, politicians, users, donors, etc). However significant areas of social concern, such as education, family planning, and poverty alleviation, are not major users of IT in most DC's. As very few DCs have succeeded in fully exploiting this developmental potential so far, and as many projects are failing, there is general agreement that there is a need to assess whether specific types of IT are appropriate for specific socio-economic and organisational circumstances or not.

It was felt that the perceived need, available resources, and cost-effectiveness of any technology make the technology appropriate or inappropriate. Therefore, applications of technology must be driven by a need that is felt locally rather than forced by external agents. There are wide variations amongst developing countries in terms of access to technology. The technology of some of the applications in developing countries may well be very sophisticated. Each country must make its own decisions about the kind of uses to which IT can be put, rather than blindly borrowing ideas from developed countries.

Effective utilisation of IT would require careful consideration of social and organisational aspects at both national and organisational levels. Yet, our understanding of what social and organisational changes are necessary and feasible is still very poor [Avgerou and Land]. Even more so is our understanding of what impact IT has on the socio-cultural environment of the country.

As the title of the book and the theme of the conference suggests, the focus of this conference was more on the "socio-cultural implications of computers in developing countries", in a broad sense. Information technology, which is largely developed and produced in the industrialised world, is introduced in a totally different social, cultural, economic and organisational environment which often influences the outcome of IT appliance, as highlighted by some of the case studies presented. However, much more work is required in this area, as was apparent from the presentations on various topics; many presentations did not touch on the socio-cultural issues at all. This is largely because there is very little knowledge abut what exactly are the social and cultural implications of this new technology on DCs.

There was general agreement amongst those present that quite often, systems fail in DCs because of the way they are designed and developed rather than due to environmental (telecommunications or electricity) or human resource constraints. Walsham argued that "systems may fail when the initiative for such systems, and their design and development processes, often reflect top-down approach, with those at the centre of the government department or the senior levels of a private company deciding on the scope and detail of the systems. [Hence, the] systems developed often do not support the work activities of people at lower hierarchical levels in the organisation." He suggests an alternative approach to systems design and development: a "bottom-up" approach, "aiming to provide systems which assist and complement the human capabilities of people at lower organizational levels, with data for central control being regarded as an important issue, but not the only one considered in system design".

A number of cases presented highlighted the importance of "non-technical" issues on the success of a project. Madon, in the CRISP case she presented, argues that "the major objective of improving the effectiveness of development planning, through introduction of microcomputers, remains unfulfilled. [This is because] inadequate attention is paid to the social context within which the technology is implemented. The crucial influence of contextual variable on the process of information systems adoption need to be addressed. [Moreover, that] effective management of the process of change brought about by computerisation is needed. Management requires a broad vision of the purpose of computerisation and an understanding of the organisational and human factors involved in achieving this goal".

It was evident that very simplistic approaches can hardly be useful for situations involving complexities of human behaviour and unpredictable performance of the physical components of the system. On the other hand, complex methodologies will be shunned by designers because of the large overheads involved and the low perceived utility. The practitioners felt that in difficult environments in developing countries, where realities can change quickly, it is difficult to do extensive planning. Every opportunity must be grabbed to move the implementation forward. Even the merit of a decentralized approach cannot be blindly recommended for every situation. Perhaps a balanced approach where an application serves the information needs of a central authority as well as local operatives must be taken. Local operatives must be involved in the system design.

Rodrigues and Waema argued that "technical perspectives are inadequate as a basis to conceptualise computer-based information (CBIS) systems in their context". The case they presented demonstrated that political perspective, especially in DCs, was a better tool to help understand the interactions of the system and its social context compared to the technical perspective. It was further suggested that a CBIS needs to have the flexibility to address itself to the specificity and the changing nature of both the technical and social context in which it is embedded.

It was suggested by Ojo, and widely acknowledged by most, that there is a desperate need of IT experts appropriate knowledge and skills to deal with the different social, cultural, economic and organisational context in DCs. In other words, there is a need of better trained cadre of indigenous IT professionals who have a clear understanding of these different

conditions in their countries.. These conditions are crucial factors in determining IT application requirements and potential utility. The requirements for this kind of IT professionals call for improved IT manpower development programmes, which do not exist in many countries, and a general increase in computer literacy and awareness. Woherem suggests that "for nations to benefit from this technology they need to develop a "culture of IT", i.e. a culture that is aware of the technology and its different functionalities/uses and that utilises it in different governmental, industrial and services sectors".

No forum where the application of information technology in DCs is being discussed can end without reference to national IT policies and strategies. A lot of importance is given to this topic by governments and politicians in DCs, and by those discussing a particular country. We saw from Chile's case presented by Fuller that the country had made some progress in the area of IT application and the export of software without a national IT policy so far, but if the country is to make further progress, there is a need for a policy and government investment in human resource development. There is no doubt that the formulation of appropriate and well-articulated IT policy for a country can be helpful. The only major problem in DCs is that many policies are formulated but never implemented because there is no mechanism for implementation built into the policy. For a policy to have any impact on a nation, there must be a total commitment by relevant authorities in terms of funding and human resource development in order to adopt and implement the policy.

There was some discussion of the role of information in creating an open society. In countries in which corruption has become a way of life, it was argued that IT can help in creating a culture of open information. Citizens, media, and public agencies must have easy access to information (particularly large amounts of information collected by the government) unless it invades the privacy of citizens. IT can facilitate such access. Analysis of information on the quality of social services and inequity in access to services must be made public through media. Such exposure will counterbalance the almost unlimited power that most public bureaucracies exercise.

One does not need emphasise the need for further research in the area to improve our understanding of IT in DCs: its economic and socio-cultural impact, appropriateness of the choice of applications, the process of applications development, etc. Much of this research needs to be done in DCs.