INITIAL REPORT ON NETWORKING OF COMPUTERS AND TELECOMMUNICATIONS IN AUSTRALIAN UNIVERSITIES AND OTHER TERTIARY INSTITUTIONS

A report to the Australian Vice-Chancellors' Committee

by Emeritus Professor A S Carrington

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EXECUTIVE SUMMARY

This report sets out the preliminary results of enquiries into the significance for Australian universities and other tertiary institutions of developments in computer and telecommunications networking among institutions, with particular reference to the EDSAT and SPEARNET proposals. These envisage, respectively, a satellite-based telecommunications network among all Australian tertiary institutions, and a South Pacific, initially Australasian, university and research institution network.

After reviewing the functions available from the various types of electronic communication - voice, data, video and facsimile - and the means by which each can be provided in Australia, the report relates the range of potential network services to the needs of Australian tertiary educational institutions, on the basis of assumptions regarding the likely situation over the next seven to ten years in respect of institutional autonomy, real level of funding and scope for other funding of major developments. Needs are tentatively assessed in relation to possible administrative, academic (research and teaching) and library applications. A comprehensive survey of the needs of individual institutions for each of a representative range of potential network services is recommended as the only reliable basis for assessing effective demand, provided such a survey reflects the judgements of resource allocators as well as service users.

A subjective assessment based on available evidence suggests that apart from traffic such as voice, telex and video, considered likely to be more economically carried on Telecom or other public services, the most immediate demand for both administrative and academic purposes on an inter-institutional network would be electronic messaging, including mail, news, file transfer and possibly bulletin boards and facsimile. Other significant future possibilities identified as worthy of further investigation for use of the network include:

shared use of national or regional supercomputer centres, with decentralised user support services

information retrieval, including possible rationalisation of some library holdings of serials and specialised monographs

a co-ordinated and self-funding system of distance education, especially for continuing professional education

a centralised tertiary education administrative database and news service.

The intangible advantages for institutions in gaining experience with modern communications networks is also discussed.

In view of the range of variables and forecasts involved, a precise quantitative cost-benefit calculation is ruled out as inadequate to determine whether or not any network is justified, particularly as the choice is more between a single co-ordinated and planned network and the more haphazard growth of various smaller networks which may be mutually incompatible. Criteria are suggested for selecting among possible network solutions. These criteria are applied to the existing ACSnet and the EDSAT and SPEARNET proposals. ACSnet, although confined to messaging functions among UNIX-based computers and having limited robustness and reliability, is judged to serve a wide range of users very adequately. A recommendation is made for its continuation and progressive migration to international standards, with ultimate incorporation into a more comprehensive academic network.

EDSAT is considered to be a worthwhile research and development project with potential for encouraging co-operation and educational experimentation, but as unlikely to provide an immediate cost-effective basis for an inter-institutional network. Its comparative advantage in broadcast communication is less relevant to the probable priority uses of such a network, while the cost and complexity of management of a private satellite-based network, the high aggregate cost of multiple earth stations, and potential problems in flexibility and keeping the network technologically up-to-date, suggest a margin in favour of using public communication links.

SPEARNET, being primarily concerned with interconnection of diverse computer systems, is less technology-specific. By reason of the relatively low capital outlay, availability of incremental growth in scope and functions, and inherent technological flexibility, together with an advantage in meeting applications likely to be in high demand, SPEARNET is recommended as an appropriate foundation for a comprehensive tertiary education network. The recommendations of the AVCC Working Party on Networking Policy for registration of name and formation of an AVCC-owned management company are endorsed.

Issues raised for further consideration include the migration of SPEARNET from Coloured Books communications protocols (developed for the UK Joint Academic Network) to international (OSI) standards; the range of institutions appropriate for membership of the network; the organisational structure and staffing for policymaking, planning, standard-setting, technical development, network

management and operations; funding of capital outlays and both fixed and variable (traffic-related) operating costs; and relationships with other Australian and overseas networks. A range of legal questions is raised, on which professional advice should be sought, including copyright, defamatory material, regulatory requirements, responsibility for integrity of data, legal status of electronic mail and facsimile transmissions, and privacy requirements. A listing is given of more technical issues, which are not discussed in detail in the report because of their dependence on prior policy decisions.

Specific recommendations are given for limited financial support to EDSAT over the next two years to allow research and development of a pilot system to proceed, and for official sponsorship and support of SPEARNET as the basis for a comprehensive Australian academic network.

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PART 1. INTRODUCTION

1.1 This report sets out the preliminary results of enquiries made at the invitation of the Australian Vice-Chancellors' Committee (AVCC) into the significance for Australian universities of developments in the field of networking, including two specific proposals which had been put before the AVCC. These were, respectively, for the establishment of a satellite-based telecommunications network known as EDSAT and for a computer network known as SPEARNET.

1.2 The terms of reference were as follows:

1. What networking would mean for Australian higher education, particularly the universities, both nationally and internationally

2. Whether the two proposals (EDSAT and SPEARNET) could be brought together

3. The costs and likely future costs of such developments

4. Any other relevant matters relating to networking.

1.3 The enquiries undertaken have involved discussions and interviews with the parties primarily sponsoring the two specific proposals, EDSAT and SPEARNET, as well as a range of senior university administrators and specialists in computers and telecommunications. The public authorities providing telecommunications services within and beyond Australia have also been consulted. Discussions have also taken place with major computer manufacturers, the Commonwealth Departments of Communications and Education and the Commonwealth Scientific and Industrial Research Organisation (CSIRO). A listing of specific interviews and meetings is set out in Appendix A.

A review has also been made of recent literature in the field of networking, with particular reference to its application in an educational environment. A select bibliography is provided in Appendix B.

1.4 The EDSAT project originated in the Royal Melbourne Institute of Technology (RMIT) which is still the site of the developmental work, although policy direction of the project is now vested in the National Working Party on Telecommunications in Tertiary Education. The Working Party was formed in 1984 to investigate the issue of

establishing a national telecommunications network for tertiary education, based on the Australian satellite system. EDSAT is envisaged as a mesh network interconnecting universities, colleges of advanced education and TAFE colleges throughout Australia. It would use transponder capacity on an AUSSAT satellite as a private network. It would be designed to support voice, data, graphics and electronic mail transmission, and eventually video, between institutions. Progress to date has included negotiations with AUSSAT and design work on a relatively low-cost earth station, involving discussions with potential suppliers.

1.5 The SPEARNET (South Pacific Educational and Research Network) project, first mooted in 1984, was formally initiated in May 1986 by an Interim Management Committee which included members of the three organisations primarily proposing the project, ie the University of Queensland (Prentice Computer Centre), the CSIRO Division of Information Technology and Digital Equipment Corporation (Australia) Pty Ltd, (DEC), together with representatives from James Cook University of North Queensland, the University of Western Australia and Victoria University of Wellington (New Zealand). The project envisaged creation of a computer-based communications network for the education and research community of the South Pacific region, initially involving the universities in Australia and New Zealand.

Progress to date has included agreement on a common interim communications protocol, (Coloured Books, a set of protocols developed for the United Kingdom Joint Academic Network), and the implementation of network links among a number of Australian universities and the six universities in New Zealand. These links employ the facilities of common carriers such as Telecom and the Overseas Telecommunications Commission (Australia), (OTC). In addition, gateways have been established with some other Australian and overseas computer networks. It has been planned that the network should be developed to provide such facilities as electronic mail, electronic conferencing, file transfer, bulletin boards and remote resource sharing, but initial emphasis has been placed on the first three of these functions.

1.6 The AVCC Working Party on Networking Policy, set up by the AVCC and under the chairmanship of Professor K R McKinnon, first met in October 1986. The Working Party has subsequently recommended to the AVCC that it register and own the name SPEARNET, with an AVCC-owned enterprise/company whose management group would be responsible to the AVCC, to establish and operate a tertiary network.

1.7 The issues, other than the two project proposals already referred to, which appear to deserve special attention in this report include:

the scope for shared resource use in the field of computers, particularly in the case of super-computers and other particularly expensive and specialised facilities,

library resource sharing, especially in terms of information retrieval techniques applied to academic serials and specialised monograph holdings,

distance education, including continuing professional education for graduates.

These issues are dealt with in subsequent sections of this report.

1.8 The review of networking and its potential impact on tertiary education in Australia is made particularly timely by the rapid technological and commercial developments in this field. These include the increasing integration of computer and telecommunications networks, the progressive emergence of effective international standards for computer networks and advances in the design of gateways between previously incompatible computer systems. Current policymaking and planning, if it is to be effective, should make provision for the continuation of rapid developments in these and other communications-related areas.

1.9 The remainder of this report considers the potential uses of networking in tertiary educational institutions, the current and foreseeable technological options, the factors dictating the relative cost-effectiveness of alternative approaches and the organisational, political and legal factors which may be relevant.

PART 2. NETWORK FUNCTIONS

2.1 In the broadest terms, a network is a set of nodes at different locations joined by communications links which allow the delivery of information or services between the nodes. In the context of this report a network will be taken to refer to networks employing modern computer and telecommunications technology and, unless otherwise stated, will imply a wide area network, ie connecting nodes which do not lie within a single premises or campus.

2.2 The following is a summary of the main types of electronic communication:

a. voice - one-way, eg radio broadcast
- two-way, eg telephone conversation

b. data - one-way, eg telex, cable, computer message or file transfer
- two-way (interactive), eg computer-conferencing or virtual terminal

c. video - one-way, eg television broadcast
- two-way, eg videotext or video-conferencing

d. facsimile (image transmission based on scanning).

2.3 Until recently voice and video transmissions used exclusively analogue transmission, while computer and facsimile transmission employed digital transmission. There is a growing use of digital transmission for voice as digital exchanges and PABXs are progressively introduced by Telecom and private users. Techniques have also recently been developed to an operational stage for digitising and compressing television signals.

2.4 Transmissions may employ one or a combination of cable, optical fibre, microwave or satellite links. Depending on the nature and configuration of the physical links, the connection between users may be a continuous actual circuit, a virtual circuit involving successive transmission over a series of separate connections, or a broadcast available throughout a defined reception area. A continuous circuit may be intermittent, eg a dial-up connection, or permanent, eg over a leased line. Transmission may be by a continuous stream of signals over a circuit-switched link, or by packet switching, whereby signals are formed into discrete groups for transmission and reassembled into a continuous stream before reaching the recipient.

2.5 Within Australia there are three sources for providing communication links for a wide area network. In a limited number of circumstances private links may be established, usually by microwave. A second source is AUSSAT, which can provide either transponder capacity for a private network based on private earth stations or connections through the

AUSSAT major city earth stations. The main source of communication links is Telecom, which can provide a range of methods. These include dial-up use of the public switched telephone network (PSTN); leased lines between specified points; telex, facsimile and electronic mail services; videotext (Viatel); and a packet-switched service, (Austpac). Services beyond Australia are necessarily handled by OTC, which employs both cable and satellite links which provide communication to virtually all parts of the civilised world.

Each service has distinctive characteristics in terms of rate of transmission, type of service, cost structure, reliability and convenience. These factors are addressed in subsequent sections of this report.

2.6 In addition to the networks provided for general use by the public carriers, commonly known as PTTs (Postage, telephone and telegraph), there are some well-established private networks within Australia. These include:

CSIRONET, originated by CSIRO primarily for its own use, but now more widely used by both public sector and commercial organisations, uses its own packet-switching network. It is currently under consideration for separation from CSIRO in a move towards privatisation

ABN, the Australian Bibliographic network, administered by the National Library of Australia and connecting a wide variety of public, State and academic libraries

CLIRS, a proprietary network designed to make legal material such as case notes and statutes available to legal practitioners and other subscribers

ACSnet, the Australian Computer Science network. This was developed progressively by Computer Science departments at various Australian universities, with the University of Sydney taking a leading role. It exists mainly between UNIX-based computers linked over Telecom dial-up lines and the Austpac packet switching network. In addition to universities and some other tertiary institutions, participants include many divisions of CSIRO, other public sector research establishments and some private sector research departments. As a result of the network configuration most traffic passes through one or more intermediate nodes on a `store and forward' basis which limits the service mainly to messaging, including news and small-scale file

transfer, rather than interactive work or resource sharing. The store and forward method involves a separate transmission over each of a series of inter-computer links joining the originator and ultimate recipient nodes, where there is no direct connection between them. There are several gateways to other Australian networks, including CSIROnet and SPEARNET. A gateway is a hardware/software device for providing a means of communication by conversion between two systems or networks using different communication protocols. In addition to local gateways to other Australian networks, there is a gateway to overseas networks through the University of Melbourne, with the primary link being to the American UUCP network (UNIX to UNIX CoPy). This also enables access to be attained to a variety of other networks worldwide. The features and limitations of ACSnet are discussed in more detail in a subsequent section of this report.

2.7 Many of the most significant overseas computer networks are directed to academic and research use. These include:

BITNET (Because It's Time NETwork), which is a cooperative network serving several hundred sites, mainly universities in over twenty countries, although primarily in the U S A.

JANET (Joint Academic NETwork), a centrally funded United Kingdom network of large university and research establishment computers

ARPANET, formed with U S Department of Defense support and now part of a larger network known as ARPA Internet, links a variety of United States research establishments, while several university networks are also part of ARPA Internet, as are various overseas networks

ROSE (Research Open Systems for Europe), an EEC-funded network of research and development projects throughout the EEC

NSFnet, founded by the United States National Science Foundation (NSF) to develop network access to a number of newly established super computer centres across the country

CSNET, an American network whose main purpose was to provide electronic mail services among computer science researchers, but with additional functions available on some parts of the network

RARE (Reseaux Associees pour la Recherche Europeenne), a metanetwork (ie linking other networks together) formed as an attempt to unify and standardise European national networks

AUSEAnet, a metanetwork linking ASEAN countries with Australia for the purposes of microelectronics development and fabrication, with the University of Indonesia as the regional centre.

2.8 A network, depending on its particular configuration and the nature of the links it employs, may permit some or all of the following services:

a. voice communication between one node and one or more other nodes, permitting single conversations or teleconferencing among a number of participants

b. electronic mail or messaging, directing textual or numeric data, or in some cases graphics, from one node to one or more other nodes, where it can be read immediately or stored in electronic form, available for later perusal, either on a screen or in hard copy

c. file transfer, the transmission of substantial sets of data from one computer system to another in electronic form, permitting the use or manipulation of the data by the users of the recipient system

d. news service, a form of messaging whereby specific information is sent to all or defined subsets of users of the network with recorded interest in a particular subject area

e. computer conferencing, involving the exchange of messages sequentially among two or more users of the network, enabling a form of discussion and accumulation of views on a particular subject

f. remote job entry, permitting specific applications to be processed in batch mode on a host computer system by a user submitting the input data from another node of the network

g. virtual terminal use, whereby a user of a terminal on one system may work interactively with a different host computer in the network

h. resource sharing, an extension of remote job entry and virtual terminal techniques to a point

where planned rationalisation of hardware and software is possible among the users of two or more computer systems, overcoming the need which would otherwise exist to make separate provision for the users of each host system

i. directory service, providing users of a network constantly updated information on the mode of communicating with other parts of the network

j. information retrieval, enabling user access from any point in a network to information held by libraries or other organised databases, such as bibliographic data or even the text of part of particular monographs or serials

k. facsimile transmission enabling graphic, written or printed material to be sent from one node to specified users at other nodes

l. video broadcast to all the nodes within a defined reception area

m. video-conferencing, permitting interaction in conversational mode with both voice and visual communication.

In addition to making available some or all of these direct communication methods, a network may also provide the basis for such shared services as education and training, user advisory services, joint software development and co-ordinated acquisition arrangements for software and hardware products.

PART 3. UNIVERSITY AND OTHER TERTIARY APPLICATIONS

3.1 In relating the range of potential network services to the needs of Australian tertiary educational institutions it is necessary to make certain basic assumptions. In the case of this report these assumptions include the following:

a. that the period of primary interest is the next seven to ten years, because predictions of social, economic and technological factors become increasingly tenuous and unreliable as the period is extended

b. that individual institutions will retain approximately the present level of autonomy in allocating their resources and shaping their formal courses and research activities during the suggested planning period

c. that the real level of funding available to tertiary institutions, relative to their student load and other measures of their commitments, is unlikely to improve and may well deteriorate over the planning period

d. that as a consequence of the two preceding assumed conditions, any major new function undertaken by tertiary institutions would be either the subject of additional public funding or would need to be capable of becoming financially self-supporting.

3.2 For convenience, consideration of current and potential uses for network functions is dealt with in three distinct areas, administrative applications; academic use for teaching and research; and library services. This division reflects the present separation of functions and systems in most Australian tertiary institutions, but it must be regarded as arbitrary to the extent that interactions and shared use of resources occurs. Closer integration of functions could reasonably be expected to occur as information networks become more pervasive and effective.

3.3 It is obvious that any reliable assessment of the perceived priorities among possible applications, the volume of data involved and the possible resource impact of introducing networking methods, would require a carefully designed and executed survey of all the relevant institutions. Such a survey would need to combine responses from those parts of each institution concerned with possible applications and, most importantly, those with responsibility for the overall pattern of resource allocation within the institution. If the latter input does not operate effectively, any survey results could be little better than a `wish list', concerned with possible benefits in isolation from the associated sacrifice of alternative uses of the funds required to obtain them.

Since this report must precede any such possible survey, the following assessments should be taken as an unverified, but possibly indicative view of possible uses.

3.4 The administrative systems of tertiary institutions are dominated by applications such as student records, personnel records, payroll, accounting and associated sub-systems, property management and inventories. The administrative, managerial and external reporting requirements amongst the institutions, particularly in the case of the universities, would seem to be so similar as to facilitate at least common software development, even if not complete standardisation. Experience has shown that the differences in administrative structure, scale, State requirements, academic regulations and historical development, when taken in conjunction with a keen sense of individual autonomy, have been sufficient to limit severely and even to frustrate attempts at common approaches. Although, therefore, an effective network could assist in activities such as joint software development or shared use of software, it would seem unrealistic to expect any major move in this direction in the foreseeable future.

3.5 Despite the different systems in use, there is a consistent but relatively low level of data transmission at the operational administrative level. This is most often concerned with records of individual students who may have transferred between institutions at some stage of their academic career or undertaken a course offered jointly between two institutions. Less urgent cases are adequately dealt with by mail, while a telex request and reply, or more conveniently a facsimile reply can satisfy most needs for an immediate response. In any case the volume is likely to be too low to be significant in justifying any new network solution. There are already in operation in several States, systems for dealing with the records of applicants under joint entrance application schemes. A more extensive and robust communications network might give some marginal improvements in the administration of these schemes, particularly during the peak enrolment periods.

3.6 Apart from the transmission of detailed records, there is a consistent traffic between university administrations on a wide variety of topics, including arrangements for meetings and information on current issues of administrative interest or concern. Most of this traffic is at present dealt with by a combination of telephone, telex, facsimile and ordinary mail. It is possible to envisage the substitution of electronic mail through an inter-university network for the other media. Electronic mail has the advantage of greater speed, compared with ordinary mail, and unlike telephone conversations it can provide a hard copy record of each message. Where the intra-institutional local area network (LAN) permits, electronic mail can be

directed to specific users by the sender more readily than with telex, which entails manual delivery within the recipient institution. It has few other obvious advantages over either telex or facsimile and lacks the ability to reproduce graphic or handwritten material. In particular it does not share the great advantage of facsimile in avoiding the need for keyboard input from other records, although advances in scanning techniques may rapidly overcome this limitation.

Possibly the main limitation of electronic mail for administrative purposes relates to user convenience. Where the user is accustomed to spend regular periods at a computer terminal or other workstation daily, as is the case with many computer specialists and some administrative staff, electronic mail offers a familiar and readily used method of communication. For senior administrators whose use of a computer terminal is at most intermittent, facsimile offers a more convenient, versatile and easily mastered medium. Even where actual transmission is delegated to secretarial or other staff memebers, the hard copy output of facsimile is usually more attractive to non-computer users.

Another use of elecronic mail networks is the distribution of news, which in the administrative context may well constitute announcements of CTEC requirements, recent legislation of general university interest and overseas information. The merits of this type of news distribution depend largely on the value of communication with minimum delay, compared with postal circulation.

3.7 One service which a network could provide has some definite potential attractions for administrative use. This relates to the creation of a central database of information likely to be of regular interest to a variety of institutions and also subject to frequent change or updating. It could include the results of the many AVCC surveys of university practice, Commonwealth Tertiary Education Commission (CTEC) guidelines, requirements and decisions, various governmental statements and requirements, a regularly updated and classified list of academics and researchers, course regulations, academic calendars, individual and consolidated statistics and many other similar matters. Such a database might enable the network also to facilitate the handling of enquiries and enrolments by overseas students. The maintenance and administration of such a database would not be trivial and would require central authority and management to be effective. The possible savings from greater efficieny and some avoidance of printing costs would need to be measured against the cost of establishing and maintaining such a service. If, however, much of the material would in any case be required by CTEC or AVCC, the marginal cost may not be excessive.

3.8 There is some potential for replacing conferences or meetings on administrative issues by the use of telephone conferencing, already available through Telecom, or either computer conferencing or video-conferencing. Neither is a perfect substitute for face-to-face discussion and the making of personal contacts. As the volume of such proceedings is not great, apart from those at the most senior level which would almost certainly need to continue regularly on a personal attendance basis, this application might best be regarded as a useful by-product, rather than as justifying any major development.

3.9 Overall, the main potential for administrative use would appear to be adequately met by a network which permitted electronic mail and possibly facsimile over links provided by normal Telecom services. Other functions, such as video-conferencing, could be supplied as needed by Telecom, although if there was a considerable growth in demand, a cost comparison should be made with their incorporation into the network. One significant issue for most administrative applications is the level of security of transmissions from unauthorised access or misuse. The topic of security is addressed in more detail in a subsequent section of this report, but it may be noted that, particularly where satellite communication is involved, the encryption of data is a necessary prerequisite of secure transmission.

3.10 Developments to date, internationally, have shown that the potential for network use is much higher for academic applications than for administrative purposes. Already in Australia ACSnet carries a significant volume of electronic mail and news, both that originating and delivered within Australia and material passing through the international gateway to or from overseas networks. Although the largely unregulated nature of the network means that much of the traffic does not have to justify a cost-effectiveness test, the continuing investment of time and effort by both organisers and users suggests that real needs are being met. There is also evidence from the recent development of the SPEARNET network that parts of the academic community not now serviced by ACSnet have similar needs for electronic mail and news services, both national and international, and possibly also bulletin boards. In the absence of any specific evidence, it is not possible to determine even approximately the relative volume of research-related to teaching-related traffic. However, in view of the much greater degree of inter-institutional interaction in matters of research than in development and teaching of formal courses, it would seem reasonable to assume that the former predominates strongly. In this context research-related uses are taken to include the dissemination of information which enhances the knowledge and effectiveness of academics

in relation to their discipline. It is reasonable to assume that increased access to a convenient messaging network would encourage a greater and generally beneficial interchange of ideas, information and educational resources among academics in respect of both research and teaching matters. For any rapid increase to occur, it would probably be necessary to plan forms of staff development which would encourage appropriate use of such a network. This is a matter of importance, discussed in more detail in section 3.20.

3.11 For reasons similar to those discussed in relation to administrative tele-conferencing, it would appear that there is potential for substitution of network services for some meetings involving travel by the participants, but insufficient to justify any extensive special facilities in the near future. Expanded conferencing may develop later as a result of more intensive interaction through a messaging network.

3.12 Ability to transfer files can facilitate joint research activities between academics at different institutions, through shared use of research databases. It can also permit, subject to copyright constraints, the sharing of software of a specialised nature. As more development occurs in the field of computer-aided and computer-based instruction, the great investment of effort involved in preparing such materials may provide an incentive for more widespread shared use among different institutions. This may involve negotiated licence fees to the originating institution. Although such packages could be transmitted in the form of transportable electronic media such as floppy disks, there could be a convenience factor in the ability to get on-line access. Particularly fruitful areas for such shared use are likely to arise in distance education and especially in continuing professional education, where there is a probability of negotiating a self-financing basis with relevant professional bodies.

3.13 The specific proposals considered in this report are directed to networks of an inter-institutional variety and with one exception do not address the question of communication between institutions and students off campus. The exception is the reference in the EDSAT proposal to inclusion of study centres of particular institutions in the network. Such an application has already been used via Q-net, the Queensland State Government network, by the University of Queensland School of Extension Studies and Continuing Education and other communication links have also been used with study centres by other institutions over public carrier facilities. There is scope for future expansion in the use of both study centres and communication links with individual students. The latter are more likely to benefit from computer links than from broadcast media.

Even in the case of video, the availablility of a videocassette is likely to be more suitable than a video transmission. It enables the student to view the material at leisure and to re-run sections as required. It is relevant to note that educational material does not normally require the immediacy of availability applicable, for example, to a commercial news service. Any educational advantages of direct student response by video-conferencing compared with less expensive methods would need to be carefully evaluated against the relative cost structures.

There is no obvious reason why links to off-campus students, or even to study centres, should be an integral part of an inter-institutional network. It is probable that all the traffic would normally be between one institution and its own students and study centres. This does not eliminate the possible desirability of creating gateways between an inter-institutional network and any such institution-specific networks.

3.14 Apart from the question of information retrieval, which is discussed below in connection with library applications, probably the most significant area for academic use of a network is that of resource sharing. This may occur either by way of remote job entry or by remote logon virtual terminal use. The latter tends to be relatively inefficient in making economic use of communication links.

There are some instances of fully planned sharing of computer facilities between institutions, for example the Prentice Computer Centre serving both the University of Queensland and Griffith University. There are also more numerous instances of ad hoc use by individual academics or departments of installations at other institutions. These cases of shared use are, however, relatively limited when considered in the light of the problems which continue to face universities and other tertiary institutions in finding the financial resources necessary for acquiring adequate computing facilities and keeping them abreast of current technological advances. There is little evidence of the impact of repeated exhortations in CTEC reports for planned rationalisation of computing installations among institutions. The reasons for this situation existing up to the present time can be found largely in the unsatisfactory nature of communication links, leading to legitimate fears of unsatisfactory service, over-centralisation and lack of control over priorities in processing and in application development. It is also likely that decisions have been influenced by the fact that most essential computing could be carried out on the institution's own facilities, even if with some delay and constraints on individual user access.

This situation is rapidly changing in two ways. There is now a rapid advance in communications technology, including a range of intelligent gateways between hitherto incompatible systems and the emergence of networks which are increasingly `transparent' to users, ie not impinging on their use of the system significantly. (A parallel would be the way in which telephone exchanges have over the past fifty years become less obvious to users as human operstors have been replaced by automatic local, STD and ISD calls.) The second factor is the appearance of supercomputers, which combine extremely high processing power with prices beyond the present budget of most Australian universities. Although supercomputers have become available only over the past few years, in many avenues of research it is no longer possible to keep up with the cutting edge of the discipline without access to supercomputer power. This does not necessarily apply to all computationally intensive applications, since some can be satisfied by use of less powerful machines even though they take longer to complete the computations. In some areas, such as meteorological forecasting or some aspects of artificial intelligence research, however, the immediacy of results of complex calculations is vital. This now applies to research in a growing range of disciplines.

3.15 Overseas the demand and cost factors related to supercomputers have already led to the establishment of resource-sharing networks, the most notable being NSFnet in the United States, which comprises five supercomputers at universities and research sites across the nation, each catering for users at other institutions. In Australia CSIRONET installed the first supercomputer in the country and encoursged both commercial and research use via the network. A proportion of time was allocated to university researchers free of charge. Despite this generosity, a significant proportion of users expressed disappointment at their experience in using the facility. This reaction could be attributed in part to the unfamiliarity of new users with the extent of work required to revise existing approaches and programs to take advantage of the special capabilities of the supercomputer, particularly in parallel processing. The CSIRO machine itself has also been said to be less `user-friendly' than some other types of machine. It is likely that a major factor, however, was the lack of recognition by both CSIRONET and users, initially, of the extent to which the latter would be dependent on immediately and locally available advice and support services to make effective use of their time allocation. This factor is relevant in any consideration of plans for supercomputer resource-sharing within the tertiary education sector.

If a sufficiently transparent network can be established, the physical location of a supercomputer centre, whether for national or regional use, should be a matter of indifference

to users, subject to an important proviso. This is that adequate decentralised user education and support services be established to ensure ready availablitiy to users, irrespective of their institutional location. Given this condition, there would appear to be considerable merit in early investigation of the justification for such a centre, probably on a national basis. As with other widely shared facilities, the most reliable and least contentious method of funding the capital cost would be by central allocation by the relevant funding authority, with consequent adjustment, if necessary, by that authority of allocations to individual institutions for their own equipment acquisitions. This means that any decision to proceed with such a centre should take into account the other claims for equipment of all types which are at present unsatisfied.

3.16 There is less pressing justification for shared hardware resources in other areas of computing, because of the enhanced power and falling cost of relatively small computers in the micro and mini categories. This has led to a rapid increase in distributed computing to departmental or individual user level, combined with more extensive interconnection through LANs. Except for a few specialised areas, such as those requiring the use of very large databases or very high precision graphics, the need for mainframe centralised computers is fast diminishing. Given the use of effective local networks of increasingly powerful workstations and access to remote supercomputing capacity, the need for general-purpose mainframe computers for academic use, both teaching and research, can be expected to decline dramatically over the next few years.

3.17 From the viewpoint of existing need and potential benefit, it would appear that in the academic sphere the first priority is for a computer network able to provide electronic mail and file transfer services on a more universal and secure basis than is currently available on ACSnet. The greatest potential need in the foreseeable future is likely to be for wider and more convenient access by specialist researchers to supercomputer capacity, which suggests a strong case for the use of networking for resource sharing. Other services appear to be less pressing and less likely to justify significant outlays, although any large scale expansion of computer aided and computer based instruction and in distance and continuing professional education could encourage a demand for inter-institutional co-operation in educational software.

3.18 As was commented upon in the case of administrative applications, there would appear to be a strong basic similarity in the operations and therefore in the computer system needs of all academic libraries. In fact there has been a greater tendency for common systems to be employed than for administrative purposes. These have generally

covered acquisitioning, cataloguing and circulation control, mainly through the use of commercially available software packages. There has not been unanimity, however, in the selection of such packages, nor even in some details of cataloguing. Most university libraries and some in the advanced education sector have become members of the Australian Bibliographic Network and therefore follow a common bibliographic regime and share access to cataloguing information on a nation-wide basis. Other smaller State-based networks have been developed among groups of institutions in the advanced education and TAFE sectors. There is an established interloan system, the Australian Lending and Document Delivery Network, which includes most academic libraries. It does not depend on a separate communications network, but for requests employs telephone, telex, mail and facsimile on the public carriers, as well as some use of electronic mail. Loans are usually dispatched by mail, but telex or facsimile, and in some cases electronic mail, are available in urgent cases. Although much of the traffic is not sufficiently urgent to justify additional communication costs, library interloan would be a suitable application for a tertiary education network, if established. The benefits of a comprehensive national bibliographic system precludes any purely academic bibliographic system from serious consideration, but an academic computer network could provide links for some institutions to ABN on a more economic basis than is currently available.

3.19 It is in the area of information retrieval that the greatest future potential of an academic network exists in relation to library services. There already exist information retrieval systems covering limited fields, such as Medlars for medical information. Such systems can combine access to relevant bibliographic data with an ability to retrieve from the database selective extracts, and possibly summaries, of textual material. It is understood that the National Library of Australia has had some discussion regarding a European system which can make available to a library network copies of a range of current scientific journals in electronic form. Although licencing costs would obviously be significant, there would appear to be the opportunity for major rationalisation of Australian academic serial holdings, at least in the lesser used categories. Users would receive visual and or hard copy versions of either selected articles or of the whole publication with virtually no delay. The extent to which such a procedure may spread to other categories of journals is difficult to predict, in view of both copyright and technological questions, but it could be of great potential benefit to the academic community.

As more and more monographs and other library material is converted to or directly produced in electronic form, a

trend which is now gaining momentum, the more general use of information retrieval techniques will develop in parallel. The existence of an effective academic network would not only offer greater convenience to both staff and students, but would also allow gradual rationalisation of holdings. Such a change is likely to occur over an extended period, rather than as a sudden revolution in library use. Nevertheless the implications are of such potential importance in terms of both costs and services that provision should be made for the likely extension of information retrieval in any medium to long term planning.

3.20 In addition to the more specific potential applications and benefits from the introduction of a comprehensive academic computer and communications network in Australia, there is the factor of `institutional learning'. This refers to the fact that the effective use of new technology does not normally occur simultaneously with its introduction. There is a wealth of anecdotal evidence to show that, for example, each new generation of computer technology has led to a learning period before enough people in an organisation had sufficient experience to ensure effective use of the new development. The learning period has typically been marked by widespread instances of disappointed expectations and some outright failures. Nevertheless in general those organisations which started early and persisted have tended to gain a competitive advantage over those which delayed. The latter in most cases still experienced similar problems during their own learning period.

There is massive evidence that developed economies will continue to become more dependent in most fields of activity on complex information flows using newly developed communications technology. The tertiary education sector, and in particular the universities, have therefore a dual reason for gaining the necessary experience and mastery over these developments. The first reason is to enhance progressively their own efficiency as organisations, while the second is to place them in a better position to ensure that graduates in many diverse fields have had an opportunity of exposure to the use of these technologies. There is already evidence of a mounting national demand for graduates with technological and professional skills in networking, involving elements of computer science, communications engineering and other disciplines. Extension of network facilities throughout the tertiary sector, accompanied by a widespread program of education and training of academics, both as users and in appropriate disciplinary areas as networking specialists, would provide an effective foundation for national progress in this economically and socially important field of development.

The point of these comments is that decisions should be based on broader considerations than just the immediate expectation of cost savings, although these must remain an important factor. The opportunity for tertiary institutions to gain experience has itself a corporate and social value.

PART 4 EVALUATION OF ALTERNATIVE APPROACHES

4.1 Although the priorities suggested in Part 3 are based mainly on a subjective assessment of possible applications of networking and the likely relative importance of each in meeting present and future needs, they do provide a preliminary basis for examining and evaluating the two specific project proposals, EDSAT and SPEARNET, and other possible alternative or complementary lines of approach to networking. It is emphasised that a definitive evaluation should be preceded by a comprehensive survey of needs, as outlined in section 3.3. Such a survey should be designed to produce, on an institution by institution basis, a listing of envisaged applications with each identified in terms of priority of need and urgency of timing. In view of the likely predominance of academic uses over administrative applications, primary emphasis should be placed on obtaining academic responses. An assessment should be sought of immediate and longer term benefits from cost savings, as well as contribution to efficiency of services and any other intangible factors. Estimates should also be sought of costs whose incidence would be directly on the particular institution. Costs which are expected to be commom to the network as a whole under any proposed system, irrespective of whether they would be met by central funding or allocated to individual institutions, should be omitted from any cost-benefit assessments prepared by individual institutions, but should of course be taken fully into account when considering the network proposal in its entirety. Consideration should be given to both the immediate and medium term impact of proposed developments, for example by seeking estimates related to a one-year, three-year and six-year planning period. Because of the essential role of the survey in any definitive evaluation, it is recommended that it be proceeded with and completed at the earliest possible date.

4.2 It should be noted that in this report and specifically in the tentative evaluations in this Part, attention is directed to the implications of an inter-institutional network. It is assumed that evaluation of the most appropriate form of local area networking and communication within each institution would be the responsibility of that institution, given that the network would provide a suitable interface to the wider area network. Any other assumption would not only represent an intrusion on the internal policies of autonomous institutions, but would also extend the scope of this enquiry by an order of magnitude.

4.3 Any policy decision on whether or not the development of a comprehensive academic network is justified must rest in part on a broad assessment of the cost-benefit balance in relation to the best alternative approach, although the number of variables and forecasts necessary make any precise

quantitative evaluation illusory. In fact, however, the choice is not between a network and no network, but rather between a comprehensive, centrally planned network and a series of smaller and potentially incompatible networks which would inevitably emerge in the absence of a comprehensive network.

Given an assumption that some form of comprehensive academic network is desirable, the choices should make due allowance for such factors as (not necessarily in order of importance):

ability to fulfil the immediately desired range of functions

flexibility to extend the range of functions to future foreseeable needs

capacity to accommodate the maximum likely level of immediate usage and also future growth by means of an economically acceptable expansion path

adequacy in terms of reliability, redundancy or back-up, security and ease of administration

ability to incorporate future advances in available technology readily and economically

avoidance of major unilateral development costs through use of accepted or standardised technology

cost-effectiveness in relation to other options.

4.4 Options exist for a variety of attributes in a network, some of the more significant of the choices being as follows:

a. Network service provision.
This may take the form of standard common carrier services provided by PTTs, a private network supplied and at least partly managed by a PTT, or a physically separate private network.

b. Network links.
These may be satellite-based, giving a broadcast coverage, or terrestial, in the form of cable, optical fibre or microwave. Some or all types may be combined in a single network.

c. Circuit type.
These may be permanent, as with leased lines, continuous transponder capacity or private microwave links, or temporary, as with dial-up connections. These also can be combined in a single network.

d. Network transmission.

This may be either circuit-switched, or packet-switched.

e. Network topology.

This may be a mesh, potentially connecting all nodes directly to each other, by broadcast or by use of PTT networks, or in the case of permanent links such as leased lines, may be a simple ring, star, or backbone or some more complex configuration.

f. Connectivity.

The connections may be direct, in an actual or virtual circuit, or may be based on store and forward techniques.

g. Bandwidth.

The bandwidth, which effectively determines the potential speed of transmissions, can vary from the conventional voice circuit at 1200 bits per second to data rates of 2 megabits (million bits) per second , or more on special circuits. Bandwidth is governed by both the nature of the physical links and the means of connection, eg modem capacity. Greater bandwidth provides both speed and versatility of function. For example a higher bandwidth is required for video than for voice or data. Costs tend to vary directly with bandwidth, but not necessarily in a linear relationship. For this reason a choice of bandwidths is desirable when traffic is likely to vary in urgency and in type, so that the most effective combination of service level and cost may be selected.

A brief summary of the basis of charging for various Telecom, AUSSAT and OTC services is given in Appendix C. The complexity created by a wide range of alternative ways of providing similar services, together with the interaction of traffic type, volume, distance, pattern of peak demands and relative urgency, makes any generalisation as to preferred service arrangements unreliable. This necessitates individual studies of particular situations or scenarios, based on estimates or forecasts of the relevant variables, before detailed decisions are made. As a result, inherent flexibility and adaptability in network implementation is a significant advantage.

It may be noted that Telecom, in common with other PTTs internatinally, proposes to introduce progressively over the next five to ten years ISDN (Integrated Services Digital Network) services, which would provide ultimately voice, data and video transmission in a simplified manner over the public network. Initial

plans are to provide sevice between the central business districts of Melbourne and Sydney for institutional users, commercial and public, by 1988, with two 64K (64000) bits per second voice and data channels plus a control channel. Later development would extend service to individual subscribers and would also provide some higher speed links for data and video transmission. These developments may well facilitate networking and will almost certainly influence the economics of different links. It would be unwise, however, to over-emphasise the immediate significance of ISDN, or to permit the uncertainties now surrounding its ultimate implementation to inhibit network development using currently available services.

4.5 Before reviewing the two new proposals for networking, it may be useful to consider briefly the features and limitations of the main existing academic network in Australia, ACSnet, which was outlined briefly in section 2.6.

ACSnet connects over seventy sites, including a much larger number of individual host computers, across Australia. It is reported to use a leased line between the University of Sydney and the University of New South Wales and to employ Austpac links between the University of Melbourne and each of the following - the University of Queensland, the University of New England, The University of Sydney via OTC, and the CSIRO Division of Radio Physics. The remaining links, comprising the major part of the network, are mainly dial-up lines, together with CSIRONET links. As a store-and-forward network, ACSnet passes each message between adjacent nodes, so that many have to pass through more than one link, sequentially. The existing software provides for handling mail delivery, file transfer, news delivery, and network state information. Routing is mainly performed automatically. The file transfer facility allows files to be despatched to particular users on particular nodes, or in some cases permits a user to request a named file from a remote machine. News, much of it originating overseas, is passed on through the network progressively to nominated recipients, usually members of an interest group. Overseas mail costs are met by the Australian recipients, after the mail has passed through the University of Melbourne gateway. That University provides the necessary accounting service for all international traffic. Overseas news costs are currently met by CSIRO.

ACSnet has been created and supported by the enthusiasm of a variety of individuals, mainly situated at university computer science departments. The University of Sydney has contributed the major part of the software development on a voluntary basis. Membership now extends well beyond educational institutions, to include a number of CSIRO and

other public sector research organisations, as well as the research departments of some commercial and industrial companies. The configuration of the network has developed without central planning and there is a minimum of administrative control over the use of the network. Most of the costs appear to have been absorbed by the users' own institutions, probably either at departmental level or merged with other communication costs. This presumably has been possible because of the relatively low cost involved. The network seems to be enthusiastically supported by most users, although its inherent limitations are freely acknowledged.

These limitations include the element of uncertainty which occurs because there is no positive confirmation as to when or even if a message will reach its ultimate destination, if it has to pass through intermediate points. Even the fact of actual delivery is not verified. This feature, together with a low level of security, makes the network unsuitable for critical or confidential messages, such as would tend to typify much administrative traffic. The network is said not to be robust in the sense of being able to continue absorbing any rapid further growth in volume of traffic. Any such growth would also be likely to highlight the question of cost incidence. The network has telex gateways, but not yet facsimile. The full range of functions is only available to UNIX-based hosts, which although widely distributed throughout the academic community, are by no means universal. There is also a high level of dependence on the facilities of CSIRONET, whose future status is currently in doubt, pending government decisions on privatisation. A major consideration is that the nature of the network does not permit interactive applications or resource sharing.

ACSnet is performing a very useful function, despite these limitations and could not be immediately superceded by an alternative network without major disruption and loss of services. It is capable of further improvement and work is proceeding on several features. If a more universal academic network is to be established, it would be desirable that adequate gateways should be established between them and that a deliberate policy be pursued to ensure that there is a convergence to common protocols, enabling ultimate amalgamation.

4.6 The EDSAT project has already been briefly described in section 1.4. It appears to have originated from a broad recognition that satellite technology offered new possibilities in education. This fact has also been recognised in other quarters, such as the Australian Education Council, which set up the Advisory Committee on the Educational Use of Communications Technology (ACEUCT), in 1982 to advise Education Ministers on a balanced program

of funded trials in educational applications of communications technology. The initiators of EDSAT also recognised that there was a current opportunity, which might not continue indefinitely, to acquire transponder capacity on AUSSAT. A further factor was a desire to implement a nation-wide academic network for tertiary institutions before many of them became committed to State-based networks whose predominant purpose was not educational. The main activities undertaken to date have been directed to the more technological aspects of the project, in particular efforts to design an earth station which would offer a sufficient range of services at a cost likely to be within the funding capacity of most tertiary institutions. That aim has involved careful consideration of the likely merits of various types of service - voice, data and video, on a one-way or two-way basis. There has also been a comprehensive search for possible contractors to build and install such earth stations. This has been accompanied by preparation of specifications and subsequent revisions to meet cost constraints. In addition, negotiations have been undertaken with AUSSAT in connection with the access to the necessary transponder capacity for a network, with Telecom and with other relevant parties.

4.7 The National Working Party on Telecommunications for Tertiary Education has taken some steps towards the making of a comprehensive survey of telecommunications needs among tertiary institutions, but to date there appears to have been little specific or detailed assessment of the effective demand for different types of service. Information or estimates of the likely level of demand for various services is crucial in evaluating the potential value of a satellite-based network, because such a network is likely to have a comparative advantage over other communication systems mainly in applications which involve one-to-many or broadcast communications as a predominant form of traffic. It is also likely to show favourable cost comparisons where much of the traffic is over very long distances, eg Sydney-Perth rather than Sydney-Melbourne.

The Committee has, with justification, pointed out that such a network could open the way to radical advances in teaching technology, including inter-institutional exchange of teaching resources, increased use of off-campus study centres and more extensive academic teleconferencing. These possibilities may well hold great promise for the future and should not be denigrated. They do, however, imply substantial change in the present pattern of educational delivery and inter-institutional cooperation, so that their benefits need to be somewhat discounted in assessing the immediate justification for a major investment in a communication system. As already noted earlier in this report, the EDSAT proposal does not address the most significant application in which broadcast technology would

be likely to have a clear advantage. That is the extension of distance education direct to individual students. The omission is entirely justifiable, since any widespread development of this sort would almost certainly require a national policy and associated funding, either through an open university system or by developments based on selected existing institutions. Nevertheless, the point emphasises the likelihood that the potential benefits of such a network are more likely to be realised in the medium to longer term, rather than in the more immediate future.

It is not suggested that this is a reason for failing to support developmental work or pilot schemes, since it is only by such steps that more worthwhile and larger-scale systems can be attained in the future. The rationale for support is then on a different basis from that applicable to a proposal for a system which will be self-justifying in operational terms in the immediate future.

4.8 Apart from the demand considerations outlined above, there are several features of the present EDSAT project which should receive careful consideration. The first of these is the question of network management. There are broadly three aspects to network management:

a. policy formulation and direction, including decisions on matters such as impositions of standards and protocols, cost sharing, development priorities etc.

b. operational management, including scheduling and load balancing, technical staffing, accounting, dissemination of operating information, training etc.

c. developmental activities, including adaptation to take advantage of technological advances, software development for the system or applications, gateway development, formulation or revision of standards and protocols etc.

These functions can amount to a very considerable and continuing administrative burden in an active and growing communications network. Even the policy function, which would presumably be the concern of a representative committee, would involve substantial administrative support. There is little so far documented to indicate the extent of the estimated network management costs or their incidence, in the EDSAT proposal. It may be noted that many network management functions may be contracted to either AUSSAT or Telecom in appropriate circumstances, in payment of professional fees. If EDSAT were to be developed as a full-scale network, a comparison between internal and contracted management costs should be regarded as essential.

In either case they would represent a significant cost factor.

A second issue is that EDSAT envisages most institutions installing their own earth station at a cost currently estimated to approximate $90-100,000 each. Thus a network covering only the hundred largest tertiary institutions, eg twenty-five universities and institutes of technology plus most colleges of advanced education and a small number of TAFE institutions, would involve a direct capital outlay of some ten million dollars for earth stations alone. Even if an analysis of future demand were to indicate a satellite-based network as the preferred solution, it would be clearly desirable to compare the benefits of installing a private network of the type proposed with the merits of using AUSSAT services via their major city earth stations, supplemented where necessary by Telecom links.

A further matter for consideration is the possible problem of keeping a private network based on institution-owned earth stations sufficiently up-to-date over time as technology and communication protocols improve. The common carriers can be expected to make improved services available from time to time, at a price. Given the existing and probable future constraints on tertiary education funding, it may be less easy for individual institutions to acquire equivilent facilities.

4.9 Pending a full analysis of the results of a comprehensive survey of needs and the costs associated with various ways of implementing the most appropriate network system, if any should appear justified, it is only possible to give a tentative opinion on the merits of the EDSAT proposal relative to other approaches to a tertiary education network. On the basis of the considerations discussed in this part, however, it is not unreasonable to suggest that irrespective of its future potential, such a network is unlikely to be the most cost-effective immediate solution to the more obvious telecommunications needs of the universities and other tertiary institutions. EDSAT does, nevertheless, have considerable merit as a research and development project, and one which combines the attraction of relatively low cost with an effective framework for inter-institutional cooperation and learning. It is strongly suggested, therefore, that EDSAT receive funding over the next two years, at least, at a modest level sufficient to allow continuation of planning and the implementation of a pilot project, assuming that sufficient institutions are prepared to participate in the pilot scheme.

4.10 The SPEARNET project has been outlined very briefly in Section 1.5. The philosophy of approach in this project differs in one significant respect from that of the EDSAT

project. Whereas the latter has been centred on the effective implementation of one sort of network architecture, a satellite-based mesh network with privately owned earth stations, SPEARNET has approached the networking question at a broader, less technology-specific level. It is primarily concerned with the establishment of effective user-level communication by overcoming the problems of mutually incompatible computer systems, without prescribing in advance the most appropriate form of communication links. A second difference is that EDSAT seeks from the start to combine voice and data communications, whereas the main focus of SPEARNET is on a computer to computer messaging system, with potential extension to other media in digitised form.

4.11 The major issue in establishing a network of this type is to develop or acquire and adopt a set of communication protocols which will permit direct access to the network by a diverse set of computers. In the absence at the time of a complete set of internationally accepted standards, a decision was made by the five Australian and six New Zealand universities initially participating in SPEARNET to adopt the Coloured Books protocols and to move to international standards when they became available. The AVCC Working Party on Networking Policy has subsequently recommended that universities adopt OSI (International Standards for Open Systems Interconnection) standards for future networks including X400 standard (the ISO mail protocol) when it becomes available. ISO is the International Standards Organisation responsible for the OSI standards. It may also be noted that in Australia the National Protocol Support Centre (NPSC), established as a national technology transfer centre to assist in the development of the Australian communications and information industry, is directly involved in OSI and ISDN developments.

The Coloured Books protocols were developed in the United Kingdom for use in the JANET network. They provide, at relatively low cost, a comprehensive and well-tested set of network protocols and as such, a convenient means of making the SPEARNET network operational without delay. A difficulty has arisen, however, because although the final stages of formulation of all seven 'layers' of the OSI standards are still incomplete and their implementation therefore indeterminate, the software for at least one significant standard is now commercially available. This is the X400 standard, referred to in the AVCC Working Party's resolution above. The software package is currently available from DEC at a considerable, but not necessarily permanent, discount. It appears to be generally accepted among informed specialists in communications that this standard will rapidly become universal. There is also agreement that migration of networks operating other protocols to full OSI standards is

highly desirable as soon as they are fully available. This presents intending participants in SPEARNET with the problem of deciding whether to incur not only the relatively small additional cost of acquiring both the Coloured Books and the X400 software, but the more significant cost of the associated double amount of staff training if the conversion occurs within a short timespan. There are in fact, however, some authorities on communications who express reservations about the likelihood of a comprehensive set of OSI standards covering all layers being completed in the foreseeable future. They do not oppose the use of those which become available, but consider that the ultimate solution will be the design of increasingly versatile 'intelligent' gateways between currently incompatible systems.

An obvious solution, which is technically feasible, to the present dilemma regarding Coloured Books and X400 would be to develop a means of migrating to X400 while preserving the existing user interface. A similar problem has arisen in the United Kingdom, where there is also a policy to migrate from Coloured Books to OSI as rapidly as possible. Work has commenced there and some collaborative effort may be possible. Although this issue is a practical difficulty, it is not sufficient to justify obscuring the broader issue of the desirability of implementing SPEARNET as a comprehensive university (or Tertiary institution) network.

4.12 The present implemntation of SPEARNET is as a messaging system, based primarily on the public X25 packet-switched Austpac network. It therefore provides such facilities as electronic mail, news and file transfer, but with the potential to extend to remote job entry and remote login. It is also compatible with telex and facsimile, subject to the development of the necessary gateways.

4.13 The two major attractions of SPEARNET as the basis of a comprehensive academic network are the relatively low capital outlay required for participation and its appropriateness as a means of encouraging institutions to cooperate and gain experience in the effective use of modern communications technology. This opens the way to an incremental approach to new applications and extensions as they become cost justified. At the same time the participating institutions should gain experience in maximising the benefits to be derived from use of networking and in refining their own existing applications. This would also permit incorporation into the SPEARNET network of any nodes of EDSAT which become operational, subject to development of appropriate gateways.

A further significant advantage of SPEARNET is its inherent flexibility. Since it is not irrevocably tied to a specific physical network implementation, there is the

possibility of using a variety of links and of substitutions from time to time. This offers greater redundancy and reliability in the case of any disruption. It also provides an ability to make substitutions in the form of the network links as new technology or changes in traffic volume or patterns offer opportunities for improved economy.

4.14 On the estimates considered by the AVCC Working Party on Networking Policy in December 1986, the central cost of proceeding with implementation for the SPEARNET project to develop into a comrehensive network would approximate $50,000 per annum over the next two years. This cost would be in addition to those already being carried by the University of Queensland in particular and by other participants. These costs would mainly comprise the salaries and expenses of computer centre staff and administrators involved in installing software to permit interconnection to the network or in discussions on matters of network policy and management. There is also the cost of the Coloured Book software, but this is said to be available at a modest cost of approximately $3,000 per site. In many campuses it would also be necessary to acquire a dedicated computer for network purposes, although a powerful microcomputer should generally suffice. In this regard it is perhaps relevant that at least one hardware supplier, DEC, is currently prepared to make substantial discounts on purchases of equipment and software whose primary purpose is connection to the network.

4.15 A number of significant issues need to be addressed in considering the method of administering and developing SPEARNET as a comprehensive network and these are addressed in the next Part of this report. It is suggested however, that the available evidence strongly supports a prima facie case for a policy decision in favour of official sponsorship and support for SPEARNET to fulfil this role. It offers a low cost entry into networking, with the potential to expand to meet most of the more important foreseeable needs and with considerable inherent flexibility. Again it is emphasised that decisions on specific options should be preceded by careful survey and analysis. Another attraction of the proposal is that it offers a more versatile and robust means of implementing gateways to important overseas academic and research networks than is currently possible through ACSnet. This is of increasing importance, given the geographic isolation of Australia and the increasing proportion of the world's knowledge resources becoming available through these networks.

PART 5. POLICY AND ADMINISTRATIVE ISSUES

5.1 There is a sequence of policy issues to be addressed in establishing a network of the type discussed in this report, if agreement were to be reached that a network of some type was desirable. These issues include:

a. the range of functions to be accommodated

b. the scope of the network in terms of participating institutions

c. the organisational structure for policymaking, including the method of determining priorities for future development

d. the organisational structure for standard setting, technical development decisions, network management and operations

e. the method of funding capital outlays for the necessary network equipment and software

f. the method of ascertaining, allocating and recovering operating costs, both fixed charges and those varying with intensity of use of the network

g. legal questions as to liability in matters such as alleged breach of copyright, defamation or non-compliance with regulatory requirements

h. relationships with other networks such as ABN, ACSnet, CSIRONET and overseas networks

Some aspects of these issues are considered in the following sections. There are, in addition to these policy issues, many important questions of a more technical character, such as the network addressing system, gateways to other domestic and international networks, protocols and standards, security and controls, choice of network configuration and communication links, accounting system and levels of service. As decisions on most of these are dependent on the nature of the overall policy determined, it is not proposed to enter into detailed discussion of these matters in this report.

5.2 The issue of the range of functions to be accommodated initially on the proposed network has been canvassed in earlier sections of this report. It has been suggested that there is prima facie evidence of a strong demand for a robust messaging system providing services such as electronic mail, news and directory services, file transfer and possibly telex and facsimile. The existence of a potential demand for resource sharing also appears likely,

especially in relation to supercomputer access, given suitable user support services on a decentralised basis. There is less evidence of a need to provide a private network alternative to the public switched telephone network for voice traffic or for video-conferencing or broadcasting on an inter-institution network.

These views need to be tested by means of a suitably designed survey and detailed enquiries once the probable range of participants has been determined. Respondents should be aware of the broad cost implications of various types of service. For example video transmission can be up to ten times as costly as voice.

5.3 The scope of the network in terms of categories of participants has significance in several ways, including the method of funding and cost recovery, the organisational structure for policymaking and network management, the acceptability of the network in terms of the rules of Telecom, AUSSAT and OTC, the network configuration and the priority for development of gateways. In general terms, the wider the range of participants, the greater the potential problems, particularly in relation to meeting regulatory requirements for common interest groups and for arriving at acceptable funding and cost recovery policies.

Telecom regulations are intended to preserve the exclusive right to carry all public communications within Australia, while allowing private networks to service different parts of a single organisation or some group of users with a defined common interest. In the case of private networks, there are safeguards to prevent external users from sending traffic over the network in competition with the services provided by Telecom. Comparable constraints apply to the protection of OTC interests in relation to international traffic. The concept of a common interest group is susceptible to varying interpretations and individual cases would have to be decided on their merits. It is also reported that the regulatory framework itself is currently under review.

On the basis of past interpretations it would seem likely that a strong case could be made for the fact that the Australian universities constitute a common interest group, on the basis of their similarity of objectives, the specialised nature of their traffic and the dependence on a common source of funding. The same arguments could be applied to institutions in the advanced education sector and, perhaps with slightly less cogency, extended to TAFE institutions. A vital aspect may well be the nature of the organisation with ultimate authority. Thus CTEC sponsorship, for example, would tend to strengthen claims on behalf of a comprehensive tertiary education sector network as a common interest group. The position is less clearcut

in respect of the admission of public sector research establishments, including CSIRO. If CSIRONET were to become privately owned and operated on a commercial basis, this could be a barrier to its use as an integral part of the network, but presumably would not preclude the use of a gateway. The inclusion of private institutions, even if primarily engaged in research activities, would seem to be less likely to gain approval, even though such participation in CSIRONET and ACSnet appears to be tacitly tolerated. The issue of national interest in encouraging more effective interaction in research between industry and the universities may be well worth pursuing in this context. Although no definitive ruling has been obtained, it seems likely that international links of an inter-university type and restricted to academic traffic could well be acceptable.

5.4 The policymaking function is best served by a two tier structure, with an upper body representative at a senior level of all funding authorities and participating institutions, to consider broad policy issues and to give final approval to more specific development proposals. In the case of a solely university network, the AVCC would most appropriately fill this role, but a wider network would need respesentation of other categories of user institution. CTEC sponsorship and participation would certainly appear appropriate, particularly in the event of central funding. The second body should also comprise selected representatives of participating institutions, but with a more limited membership, preferably of individuals with direct interest in the network, as users or specialists in related technologies. An augmented version of the existing AVCC Working Party on Networking Policy could be an appropriate composition.

5.5 The AVCC Working Party on Networking Policy has already recognised the need for a body responsible for the functions of standard-setting, direction of implementation of development projects and monitoring of operational management performance, in its recommendation for the formation of a representative Networking Management Committee. The most appropriate membership would depend on the final decisions on the range of network participants. The AVCC Committee has also appropriately suggested that executive responsibility for network development be vested in an individual appointee, responsible to the Network Management Committee. A further question to be considered is whether the same executive should have direct responsibility for operational management, or whether a further position is ultimately necessary and justifiable. If so, this appointee also should be answerable to the Management Committee.

5.6 If the proposed network follows the functions initially proposed for SPEARNET, primarily related to messaging applications, the direct capital funding required for essential equipment and software is relatively modest in relation to the total equipment funds of individual universities, although it will be competitive with other demands on those funds. An estimate obtained from DEC for the minimum cost for a dedicated Microvax II computer as a network server would be approximately $40-50,000, including the cost of the Coloured Books and X400 and other necessary software. with the currently available discount. The cost of an Austpac connection is $1,000 for between 2400 and 19200 bits per second installations. The monthly rental at 2400 b/s is $275. In addition to these costs, there is likely to be a continuing cost for necessary software development and gateway design for the benefit of the network as a whole. As a minimum this could be expected to involve the salary of one specialist and associated support costs, a total in the range of $60,000-$100,000 per annum, at least for the first few years. Some proportion of this cost may be properly regarded as part of the capital outlay to establish the network, but there is no particular advantage in seeking to make any arbitrary division. Under normal university accounting methods, such costs would be met from recurrent grants. It would appear that the specific capital costs would be of an order which would permit participating institutions to absorb their equitable share, however determined, of the establishment costs, probably by a combination of direct outlay for their own campus requirements and a contribution or `joining fee' towards joint costs.

Reference has already been made in section 4.8 to the fact that current estimates for EDSAT suggest a cost of approximately $100,000 per campus for an earth station. The present proposal is that each institution would provide its own funding.

A much more significant outlay would be involved if the network were to incorporate resource sharing involving the acquisition of a supercomputer. This raises the question of the desirability of central funding. Such a policy has applied in two notable overseas networks, the NSFnet in the united States and JANET in the United Kingdom. As previously indicated, NSFnet involved the location of five supercomputers, the purchase of which was centrally funded, at universities and research establishments across America. In the case of JANET, the Joint Academic Network, the central funding included not only the capital costs, but also all operating costs, making the network cost free to users.

If major capital outlays are to be made for a resource-sharing network, it would seem that the most logical and

non-controversial means of funding would be for CTEC to make a specific allocation for the purpose. This would presumably be subsequently reflected, without specific detail of the effect on each institution, in the normal equipment grants.

5.7 The operating costs of the network fall into two categories, although the boundary between them is not always clearly defined in practice. The first group comprises the fixed costs necessarily incurred in any period to keep the network operational, irrespective of differing levels of traffic or intensity of use. The development costs referred to in the preceding section involving the salary and associated costs for a network development officer fall into this category more appropriately than into that of capital expenditure. Similarly, the cost of operations management would be a fixed operating cost. Another such cost would arise if dedicated links in the form of leased lines were used for part of the network. There is no uniquely justifiable or logical way of allocating such costs to individual participating institutions, although there is a multitude of reasonably plausible formulae for doing so, such as on some one or more of factors such as the size of the institution, or its recurrent budget, or recorded intensity of usage of network resources, or location, or by simple averaging. The more complex the basis, the more expensive is its administration. As with taxation, any system which produces adequate recovery and minimises opposition from the most powerful or the most potentially vocal participants is usually regarded as justifiable.

An alternative approach, as with JANET, is for all operating costs to be centrally funded. Such an approach simplifies accounting, but it necessitates some other form of rationing of usage, by quota or evaluation of the merits of various proposed uses, except in the unusual situation where demand can be fully met by available capacity. The absence of a user charge may also give encouragement to relatively low value or wasteful use of network resources.

Possibly the most satisfactory method is for each member institution to meet all identifiable traffic-related charges and for the fixed costs of the network to be met either by central funding or by charge determined on the basis of some index of capacity to make use of the network. This index might be, for example, the number of computers, terminals and other devices within the institution with access to the network, or more simply, the size of the academic and administrative staff of the institution.

5.8 The operation of a communications network can involve a variety of forms of potential legal liability. Although aware of the nature of some of these, the writer of this report is not professionally competent to give a

comprehensive statement or to advise on such issues. Attention is therefore drawn to the need to seek appropriate legal guidance in matters such as the agreements between the participating institutions and the organisation charged with network management and the constitution of the latter if it is to be separately incorporated. Specific issues deserving special attention in relation to legal liability include:

a. copyright, particularly in relation to the use in the network of software of a proprierary nature, or transmission of copies over the network for use at sites other than those originally licenced

b. distribution by message, news service or bulletin board of material which is potentially actionable as defamatory or otherwise

c. carriage of traffic between users who do not fall within the approved common interest group applicable to the network, eg from a private individual or organisation external to the university to a similar recipient in another city via a university to university link.

d. responsibility for corruption, misdirection or misuse of transmitted data, arising from any alleged negligence of the network operators.

e. legal status of negotiations and commitments made via electronic mail or facsimile.

f. responsibility for privacy issues.

5.9 Much of the potential benefit of an academic network can be derived only through effective interaction with other existing networks, both Australian and overseas. Apart from the technical problems of establishing the necessary gateways, there are other issues to be considered. Many of the legal questions raised in the preceding section apply with even greater cogency to traffic passing between different networks. Suitable bases for co-operation, for example in relation to ABN, would need to be established to ensure the highest level of effectiveness in areas such as a comprehensive information retrieval service. Especially with overseas connections, reliable accounting and cost recovery procedures become significant and must be properly administered. It may also be noted that for satellite-based traffic, security against unauthorised access demands the use of encryption of data. This is accepted as normal practice by OTC for all confidential or sensitive material being transmitted, but it is the responsibility of the user to effect the encryption and to facilitate decryption by the recipient.

In view of the international significance of networking, the topic of international network links among universities could well constitute an appropriate subject for consideration at the forthcoming Association of Commonwealth Universities (ACU) Congress.

5.10 The issues discussed in this Part cover the main items requiring attention, but do not constitute a comprehensive catalogue of matters to which consideration must be given. It is suggested that this fact emphasises the need for a planning structure of committees and individual full-time executive appointments, as discussed in sections 5.4 and 5.5 of this report and recommended by the AVCC Working Party. These steps should be taken yat the earliest possible stage to ensure that due consideration is given to all aspects of evaluation, planning and development.

PART 6. RECOMMENDATIONS

6.1 That before entering into expenditure or commitments beyond those required to sustain present developmental initiatives, there be a comprehensive survey, to be completed as soon as possible, of the immediate and future foreseeable uses and needs of all individual tertiary education institutions in Australia for access to each of a comprehensive range of potential inter-institutional network services, the responses to such survey to embody the assessments ot those responsible for resource allocation in each institution as well as those of potential service users, to ensure a realistic forecast of effective demand.

6.2 That pending completion and analysis of a comprehensive survey, tentative assessments and planning be based on the probability that, as indicated by currently available evidence, the primary immediate demand for inter-institutional network services (as distinct from those directly available from public carriers such as Telecom) would be for comprehensive electronic messaging, including mail, news, file transfer and possibly bulletin board and facsimile; and that the major potential additional function would be resource sharing, particularly to facilitate remote access to supercomputers and other specialised installations.

6.3 That pending specific cost-effectiveness studies, it be accepted that inter-institutional voice and video traffic remain dependent on the services of the public carriers.

6.4 That specific detailed enquiries be initiated into the potential benefits and costs of:

a. one or more national or regional supercomputer centres for academic use, with provision for decentralised user training and support services

b. use of networking to facilitate information retrieval and potential rationalisation of serial and specialised monograph holdings among academic libraries

c. development of a co-ordinated system of distance education, with particular reference to self-financing continuing education for appropriate professional groups

d. establishment of a centralised tertiary education administrative database and associated news service.

6.5 That ACSnet be encouraged, on its present independent basis, to extend and refine its range of functions and to migrate to OSI standards as rapidly as feasible, with a view

to ultimate effective incorporation in a comprehensive academic network.

6.6 That EDSAT be recognised as a worthwhile research and development project justifying the limited financial support requested from the AVCC over the next two years, and as providing a useful opportunity for institutional learning and educational experimentation, but that in the absence of convincing evidence of a clear economic demand for those services most cost-effectively supplied by a private inter-institutional broadcast network, EDSAT not be accepted as the most appropriate basis for a comprehensive tertiary academic network.

6.7 That SPEARNET be recognised as an appropriate foundation for a comprehensive tertiary education network and that the recommendations of the AVCC Working Party on Networking Policy regarding registration of name and formation of an AVCC-owned company to establish and operate such a network be endorsed and implemented without delay, pending final determination of the ultimate character and scope of the network.

6.8 That the AVCC set up, preferably in consultation with CTEC, ACDP and TAFE authorities, a two-tier policy and planning organisation representative of the interests of the intended range of participating institutions.

6.9 That the recommendations of the AVCC Working Party for the formation of a Network Management Committee and appointment of a person with executive responsibility for network development be endorsed and implemented, and that the possible justification for a similar executive appointment in the area of operational management of the network be explored.

6.10 That the proposed policy and planning organisation give priority attention to the following issues:

a. the range of functions to be accommodated, initially and in the foreseeable future

b. the scope of the network in terms of the type and national location of participating institutions

c. the most appropriate methods for funding capital expenditure, development costs, fixed operating costs and traffic-related operating costs

d. relationships and interconnection with other Australian and overseas networks

e. relationships with Telecom, AUSSAT, OTC, CSIRO and other relevant public authorities and organisations.

6.11 That professional legal advice be sought on the possible legal issues arising from the establishment and operation of an inter-institutional tertiary education network, including specifically, questions of copyright, defamatory material, regulatory requirements, responsibility for the integrity of data, legal status of electronic mail and facsimile transmissions, and privacy issues.

PART 7. CONCLUSION

7.1 The help and co-operation of all those persons and organisations listed in Appendix A are gratefully acknowledged. A wealth of useful material was provided by AUSSAT, DEC, OTC, Telecom and the National Library of Australia. Special thanks are due to Professor K R McKinnon, Chairman of the AVCC Working Party on Networking Policy; Mr A Inglis, Chairman of the National Working Party on Communications in Tertiary Education; Mr A Coulter, Director, Prentice Computer Centre, University of Queensland; Dr G E Thomas, Chief of Division and Dr T Hales, Leader of the Computer Networking Group, CSIRO Division of Information Technology. A recent report prepared jointly by Dr Hales and Dr I Richards, entitled A Review of Academic and Research Networking in Australia (CSIRO, February 1987), proved a most valuable source of information, especially on more technical aspects of networking. A wide range of relevant published material was located and provided by Ms R Langford, Acting Physical Sciences Librarian at the University of New South Wales.

7.2 In addressing the terms of reference, this report has deliberately focussed primarily on the broader strategic considerations, together with a sufficient evaluation of the EDSAT and SPEARNET projects to permit firm recommendations for immediate decision and action. The issue of costs and likely future costs of networking developments has necessarily been confined to broad approximations, pending an indication of the nature of decisions on policy which are needed to allow any reasonable assumptions to be made regarding the scope and nature of any network. Some indicative examples are being prepared on the basis of arbitrarily selected but potentially plausible scenarios, but reliable cost estimates must await definition of key policy issues.

APPENDIX A. LIST OF MEETINGS AND INTERVIEWS

Organisation	Name	Position
University of Wollongong	Professor K R McKinnon	Vice-Chancellor and Chairman, AVCC Committee on Networking Policy
	Professor H Bradlow	Professor of Computer Engineering
	Associate Professor G Doherty	Head, Department of Computer Science
University of New South Wales	Professor L M Birt	Vice-Chancellor and Principal
	Professor J Ronayne	Pro-Vice-Chancellor
	Professor C H P Brookes	Head, Department of Information Systems
Royal Melbourne Institute of Technology	Mr A Inglis	Director, Education Unit and Chairman, National Working Party on Telecommunications in Tertiary Education
	Mr S Deroon	Education Unit
	Dr W Carroll	Head, Department of Communication and Electronic Engineering
CSIRO Division of Information Technology	Dr G E Thomas	Chief of Division
	Dr T Hales	Leader, Computing Networking Group
University of Sydney	Professor M G Taylor	Deputy Vice-Chancellor
	Dr R Kummerfield	Senior Lecturer, Department of Computer Science
University of Queensland	Mr A Coulter	Director, Prentice Computer Centre
	Mr G Reed	Manager, Engineering and Communications, Prentice Computer Centre

	Mr A Hartwig	Systems Programmer, Prentice Computer Centre
	Professor J D Chick	Director, School of External Studies and Continuing Education
Digital Equipment Corporation (Australia) Pty Ltd	Mr P Smith	Education Marketing Manager
	Mr R Freak	Software Consultant, Regional Network Group
I B M Australia Ltd	Mr J W Kimber	Commercial and Industry Relations Manager
	Mr P Robinson	Telecommunications Systems Engineer
The National Library of Australia	Ms J A D Baskin	Director, Networks Branch
Commonwealth Department of Education	Ms N Hawkey	
	Mr A Webster	Industry Liaison Unit
Australian National University	Professor I G Ross	Deputy Vice-Chancellor
	Dr R Erskine	Manager, Computing Services Centre
Commonwealth Department of Communications	Mr R Mere	Assistant Secretary
AUSSAT	Mr G Murray	Market Manager, Radio and Television
	Ms A Crowley	Representative - Marketing
Telecom Australia	Mr B Penhall	Manager, Commercial Engineering
	Mr J Losco	Account Director
	Mr R Verco	Principal Consultant
	Mr C Serrao	Communications Consultant
	Mr A Conomos	Communications Consultant

Overseas Telecommunications Commission Australia	Mr M Kaldor	Marketing Manager, Data Services
	Mr P Cheleski	Sales Manager, N S W
	Mr C Mutton	Manager, ISDN