Mr A Coulter
Director
Prentice Centre
University of Qld
ST LUCIA QLD 4067

19 August 1992

Dear Alan,

Attached is a copy of the proposed AARNet Business Plan. I have taken the liberty of mailing you a copy directly as this plan now contains proposals with particular impact for the Queensland network, and ones which I believe we should discuss at an early meeting.

Accordingly I have approached Alan Coulter as the QUESTnet chairman and he proposes we meet at the Prentice Centre, University of Qld at 10am on Friday 4 September. Can you advise his secretary, Jocelyn Dixon of your attendance at that meeting?

See you there.

Regards,

John Noad
Director of Computing Services

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AARNet Business Plan

Report by the AARNet Advisory Board
to the Australian Vice-Chancellors' Committee

Draft
9 August 1992

While in geological terms the isolation of Australia is but a fleeting condition, isolation has been the major feature in shaping the living character of this continent.

In economic and social terms this isolation is a continual challenge to our ingenuity. As a small southern Pacific community we have been critically reliant on communications technologies as an enabling factor for our national development. With the forthcoming undersea fibre optic cables linking Australia into the global digital network we will be living within milliseconds of Japan, America and Europe.

The challenge we face as a nation is to make effective use of these tools.

The leadership shown by the academic and research community in implementing a national communications network with ubiquitous connectivity is a significant development. However the task is not complete, and there is much more that has to be done. There is a unique opportunity for the academic and research community to further enhance its leadership position in this area and provide efficient and highly advanced communications services to the nation's scholars, researchers and their institutions.

Contents

EXECUTIVE SUMMARY

The Business Case for AARNet

The business case for the Australian Academic and Research Network (AARNet) is based on:

1. Specialised communications services to the academic and research community.
2. Connectivity services supporting multi-protocol transmissions.
3. International connectivity to the global Internet.
4. Delivery of electronic mail and netnews services.
5. Access to information services.

It is recognised that additional services may be added to this list over time.

The business plan is based on a program of providing services to the Australian Vice-Chancellors' Committee (AVCC) member institutions and the Commonwealth Scientific and Industrial Research Organisation (CSIRO). This core program provides a uniform set of services to each institution and to CSIRO, funded by the member institutions on a cost recovery basis.

In addition an Affiliate Membership program provides the program with additional business which assists AARNet in achieving a cost effective position due to economies of scale. The Affiliate Membership program has raised $0.6m in 1992, and is projected to reach a revenue level of $1.3m by 1995. An annual turnover of no less than $3.5m could be achieved by the Affiliate Membership program within the triennium, given an appropriate operational structure and marketing services.

The advantages to the AVCC member institutions and CSIRO through a commonly agreed base access funding position indicate that this purchasing mechanism should remain in place. It is proposed that the base funding position use the ISDN services to upgrade tail loops from 48Kbps to 128Kbps from 1993.

In addition individual institutions should have the ability to purchase additional levels of access capacity to the AARNet service in line with institutional requirements and overall information technology and communications strategies.

The existing Affiliate Membership program provides the sector with two major assets - the first is direct connectivity to potential research partners and service providers, and the second is economies of scale through increased levels of participation and funding, both of which are of direct benefit to the AVCC and CSIRO. This plan indicates that this program could be further strengthened through appropriate open access policies.

A change to a distinct operational entity reporting directly to the AVCC Board of Directors is recommended, while still retaining the organisational presence of CSIRO within the decision making structure. The rationale behind this is that the primary objective of AARNet is to provide cost effective operational networking services to its major customer base, the AVCC member institutions and CSIRO. This implies a different mandate and a different managerial and operational approach from that required by the AVCC Secretariat itself. It is felt that the transition of AARNet to a distinct organisational entity within the AVCC structure will assist in direct focussing of activity toward this essential primary objective.

Summary of Recommendations

The report considers the services currently offered by AARNet and examines the risks and benefits in broadening the set of services offered to client institutions. It is considered that there are distinct advantages in concentrating effort within a single focussed area of common requirements.

R.1 **It is recommended that the role of AARNet continue as a provider of digital data network connectivity and associated network information sources.** (P 7)

The report examines the operating conditions within the communications industry and notes that there is an opportunity for the academic and research sector to use a current position of market leadership as a mechanism to ensure continued influence in this area and benefit from economies of scale of operation.

R.2 **It is recommended that the AVCC use AARNet's current leadership in Internet provision to maintain continuing significant influence and to ensure future economies of scale directly benefit the Australian academic and research sector.** (P 12)

Highly specialised, very high speed communications services will not be commercially viable for some time to come, and research-based access to such services would necessitate special governmental funding support. Access to such services is considered essential for a number of research areas including various high performance computing-based research programs. Positioning AARNet to assist in research-based access to such services is considered a necessary component of the AARNet program.

R.3 **It is recommended that AARNet ensure it positions itself as the communications and organisational structure within the academic and research sector which will support the focused introduction of highly specialised leading communications technologies, as a component of the national research infrastructure.** (P 13)

Rapid growth has been a characteristic of the first two years of operation of AARNet. There is an increasing diversity of use across all areas of institutional activity, and an increasing intensity of use by more sophisticated user applications. The factors behind this growth, and the likely directions in terms of institutional requirements lead to the conclusion that this growth will continue over the forthcoming triennium.

R.4 **It is recommended that the planning process for AARNet take into account the continuing high levels of growth of the national and international communications requirements of all institutions within the academic and research sector.** (P 22)

The organisational structure of AARNet as a service provider is considered. It is concluded that the activity (and its clients) will benefit from operating as a distinct entity focussed on providing a communications service. Mechanisms to allow economies of scale to be used to the benefit of the academic and research sector are recommended and the issues of stability of services in the longer term time frame are also considered.

R.5 **It is recommended that the Memorandum and Articles of Association of the AVCC be altered to include the role of management of the operation of services provided to the institutional members of the AVCC.** (P 27)

R.6 **It is recommended that AARNet assume a distinct organisational identity within the AVCC corporate structure, with separate accounting, funding and management structures.** (P 27)

Various charging mechanisms are evaluated in the context of the specific services provided by AARNet. Subscription based mechanisms without incremental usage-based charge components are recommended as being the most appropriate for these services.

R.7 **It is recommended that the charging model for AARNet be based on an annual subscription rather than incremental usage-based tariffs.** (P 30)

An analysis of institutional requirements with respect to the various mechanisms of provision of services indicates that the most effective means of service provision is one which allows each institution to have the ability to independently determine the level of access to externally provided services, and resource the associated costs as a component of the overall institutional resource allocation process. In addition various common purchasing programs for AVCC member institutions are examined in order to determine whether there is cost benefit to the institutions in a common purchase of a uniform base level of services.

R.8 **It is recommended that institutions continue to participate in a common purchasing program for network services, on the basis of common purchase of a uniform base access level, together with the ability for individual institutions to purchase enhanced access levels at incremental cost.** (P 32)

Overall operational mechanisms for AARNet are proposed which are intended to set up the service provision activity on a viable and stable basis. The intent is to further broaden the domain of service provision and use the economies of scale and margins of operation to the direct benefit of the AVCC member institutions and CSIRO while still operating within a general common interest provision. There is a window of opportunity available to the academic and research sector to maintain the current position of leadership in this area. In the longer term it is noted that failure to shift toward an increasingly open-access policy will lead to the position where AARNet would be constrained to be a specialist and uneconomic operation due to competitive pressures from other potential service providers.

R.9 **It is recommended that access to the network be operated under an access and usage policy which admits use of the network by any organisation with interests compatible with the academic and research sector.** (P 39)

R.10 **It is recommended that operational surpluses from the Affiliate Membership program be used to underwrite the costs of providing services within the AVCC and CSIRO common base service levels.** (P 39)

1. INTRODUCTION

The Australian academic and research networking environment has changed significantly over the last five years. This period has seen the establishment and consolidation of institutional local area networks and the establishment of the national Australian Academic and Research Network (AARNet). The Australian Vice-Chancellors' Committee (AVCC) has acted as a focal point for the development of the national facility, and has taken on the role of operational manager and financial underwriter for the network in order to foster its implementation and initial development. This has been undertaken with the active involvement and participation of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the financial support of the Australian Research Council (ARC).

There are now a number of reasons why the approach to national network service provision must be further refined if the future needs of the Australian academic and research community are to be successfully met. Importantly:

1. The agreed funding position for the AVCC member institutions and CSIRO for the first triennium of AARNet's operation expires at the end of 1992. Consequently the AVCC has requested a review of the program's operation.

2. The ARC has advised that recurrent funding for AARNet under the Mechanism C program is to cease at the end of 1992. This funding accounted for some 36% of the operational funding requirements for AARNet over the 1990 - 1992 triennium.

3. The level of demand for national and international communications services has tripled over each of the two years of AARNet's operation to date. Given the increasing user population within the academic and research sector, the increasing diversity of network-delivered services and the increasing intensity of use of the network, continued growth over the forthcoming triennium is anticipated. Even though economies of scale imply that cost will not rise at the same rate as traffic levels, some growth in cost levels is anticipated for the triennium. Determining the most appropriate mechanisms for funding such high levels of continued growth in demand for the services currently provided through AARNet is a major objective of this plan.

4. There are now significant economies of scale to be achieved by a planned approach to procurement and traffic management on a national basis, operating within a broader role as a value-added carrier and supplier of Internet connectivity. While the technological approach adopted by AARNet in 1989 was unique in the Australian context, there are now significant levels of interest in such technologies across the broader national domain. Significant strategic and financial benefits to the academic and research sector in both unit cost and quality can be realised by broadening the client base of this network. However the window of opportunity here is a limited one, and it is considered highly likely that one or more high volume commercial carriers will be operating within the next 6 - 9 months if AARNet does not undertake a broadening of the current Affiliate Membership program into a larger open access structure.

5. As closer interaction between research and industry is a stated objective of the national publicly funded research program, it is appropriate that the further development of national academic and research networking services be positioned within an environment where industry and government can also participate as peer clients within a common communications and service environment. Here a single operational service structure is a reasonable objective, as multiple networks could increase barriers to free exchange of information between research groups in Australia as a result of technical difficulties regarding links between networks.

The key issue facing AARNet is in establishing a strategy for continued service provision which is in the best interests of the member institutions of the AVCC and CSIRO.

The environment in which this business plan is being drafted is one where there is a rapidly growing demand for communications and network services on a national and international basis from all areas of the domestic economy. Accordingly, the major strategic issue is that of the future domain of activity. In this context it should be noted that even today AARNet is not simply a university network: as well as serving CSIRO with communications service requirements AARNet also provides services to some 250 other organisations through the Affiliate Membership program. AARNet also interconnects with some 100 other international networks within the structure of the worldwide Internet, and within the Internet there are a wide variety of academic, research, commercial, industrial, military and governmental organisations all using a common communications and service domain.

From the perspective of AARNet's operation this broad customer base has produced both strategic benefit in terms of enhanced support for collaborative activities between the academic and research sector and various commercial and industrial organisations, and also produced financial benefit for the academic and research sector. It is anticipated that this level of participation would increase dramatically if there was a policy and connectivity environment which supported the growth of the network to act as an open Internet services carrier within Australia.

The position at the other end of the spectrum is to position AARNet as a dedicated service limited to the academic and research sector. While this may position the network with a very tightly focussed outlook on the sector's requirements, there is the very real risk that individual institutions would quickly leave AARNet to join likely alternative commercially available services due to similar service offerings and significantly lower access and usage costs due to the volume of competitive operations. In such a scenario any advantages inherent in the current position of leadership in this area will be lost to the academic and research sector.

The AVCC has tasked the AARNet Advisory Board to consider these issues in the context of the preparation of a Business Plan for AARNet for the 1993 - 1995 triennium.

2. AARNET - A DESCRIPTION

The Role of AARNet

AARNet operates as a value-added network provider, providing multi-protocol communications capabilities in interconnecting Local Area Networks (LANs). In this role AARNet has a direct clientele not of individual users (as such users are directly connected to the LAN rather than AARNet), but of the LANs themselves. The domain of operation is as a national provider of such services, together with a role as a national component of the broader global Internet. In so doing AARNet also has the responsibility for operational support of the network, a task which is undertaken at present by both direct activity and contracting of regional operational tasks to the various Regional Hub host sites.

AARNet also provides network information services within its overall role. Such services are related to informing member organisations about the capabilities of the network, and acting as an information source regarding services which are available across the network. In this role AARNet has prepared a number of brochures and information documents, maintains a guide of resources available over the network, and also has contracted the preparation of AARNet User Guides. This activity is not a direct service to end users of AARNet, but a support role to the various user consultants within each member institution, who in turn provide focussed support to the end users.

Outside of this direct service role with respect to network information AARNet does not have a direct active role in the provisioning of general services to the user population. Such services (such as a library online public access catalogue, or a scientific database, or a document archive) are provided, in the first instance, within the member institutions as services accessible over the local network. The marginal costs of extending the service to allow access to the broader AARNet user population are very low. Indeed the majority of such costs in extending the domain of access to the service are based in the provision of remote user support structures rather than the provision of the service per se.

Such a structure provides a number of powerful features which work to the benefit of the end user population. In general the services that are provided across the network are provided by those institutions which have the greatest capability to provide the service in a cost effective manner, and other institutions can use AARNet for remote access to the service with the (lower) incremental cost of local support services. Thus each member of AARNet takes on the role of both service provider and service client, providing services to the AARNet user population where there are direct local requirements and local capabilities, and using remote services in other cases. In some cases, where there is an identifiable cost associated with the operation of the service, services may be provided on a usage fee basis as an arrangement between the service provider and the individual clients, while in many other cases the service is provided free of charges. The determination of such arrangements are not within the realm of AARNet, which acts in a role of communications provision rather than attempting to assume an active role in the structure of a service provision.

Accordingly it is noted that the role of AARNet is defined to be that of a network provider, operating in the capacity of a provider of network connectivity and associated network information.

The Current AARNet Client Base

The client base of AARNet is made up of three broad components: the university sector, CSIRO (the public research sector) and others (drawn from government, industry and commerce through the Affiliate Membership program).

There are some 250 organisations which are provided with services via AARNet. A complete list of this client base (as of June 1992) is provided as Appendix A.

An alternative metric of the client base of AARNet is that of individual users. A node count in June 1992 indicated some 49,000 nodes connected to AARNet. With an average user population of 7 active users per node[1] this would indicate an active user population of some 350,000 individuals at present. Growth rates indicate a doubling of the active user population each 9 months.

The Service Layer

As AARNet is a network connectivity provider, user services are, very strictly speaking, outside the domain of direct interest to AARNet. However such a view is unrealistic, and it is noted that a network only exists to support the connectivity and communications requirements of the user base through their use of relevant services. The services provided are:

Electronic mail - is the most ubiquitous service, providing a 1:1 communications medium with an addressable peer population of over 10 million individuals within the world wide academic and research community. Of all the network services mail is the most widely implemented and the most widely used service.

Netnews - is the most commonly used networking group communications tool. Netnews covers a similar readership as electronic mail, and with a single posting to a local netnews service the information is passed automatically across the hundreds of thousands of systems on the Internet within hours, and may be viewed by up to 2 million regular netnews readers across the globe. It is no surprise that netnews currently carries over 30Mbytes per day, and covers a highly diverse range of technical and discipline-related subjects as well as many other topics.

File Transfer, Remote Access - remote access allows a remote system to be transparently accessed across the network. The file transfer service allows the user to initiate a transfer of data (information in the form of data, documents, images, programs, recordings and almost any other digital artefact) either retrieving remote data, or initiating a transmission of local data to a remote site.

Information Services - above the basic services listed above are layered a diverse structure of information services. Many libraries have placed their online public access catalogues and specialist databases, as an aid to users in identifying and locating materials which may then be obtained through interlibrary loan. There is considerable potential for expansion of personalised information services which are typically layered above the remote access service.

Information Retrieval Tools - recent developments have integrated all of these basic tools into a cohesive information retrieval environment. Tools such as the Wide Area Information Service (WAIS), World Wide WEB (WWW) and Gopher servers attempt to provide access to information based on both traditional title-based retrieval as well as more flexible content-based indexing and cross-referencing of information across digital documents. Using such tools the user can phrase complex information requests and thereby initiate a complex sequence of information searches which are performed immediately on systems located across the network. The results of the search are immediately available to the user, typically within seconds.

1 This estimate of the average number of users per network node is drawn from John Quarterman's article "How Big is the Internet?" published in The Matrix, Vol 2, No 2, (June 1991).

One major aspect of service provision within the network domain is the flexibility of approach which the network can offer. Some services are supplied ubiquitously - each host system participates as a peer member in the provision of the service (Mail and netnews are examples of this). Other services are provided by specialist areas (such as library services) as an extension of existing service obligations, and other services of a very specialised nature are provided within smaller communities as a service to the research or academic special interest community in question. This diversity of service and client is the major asset of the network. Any individual or group can act as a service provider and publish information or access services to other users on the network. In so doing the network can reduce the time taken as well as infrastructure costs of publication and dissemination of information, and directly addresses one of the major areas of cost of support for the academic and research endeavour.

The architecture of AARNet that supports these services is detailed in Appendix B.

Directions in Technology

The general direction in communications technologies is higher bandwidth at lower unit price. Over the forthcoming three year period it is highly likely that changes will occur in the mid speed area (56Kbps to 2Mbps), with a shift to dynamic switchable logical link facilities with dynamic access configurations, using Frame Relay technologies to support this functionality.

At the higher performance end of the market it should be noted that the market is constrained by high provisioning costs and low market volume, indicating that unit costs will not necessarily shift downward to any great extent. In terms of forthcoming technologies it is likely that by the end of the triennium the initial gigabit capacity technologies may become commercially available. At this stage it would appear that Asynchronous Transfer Mode (ATM) cellular switching techniques will underpin such a high speed transmission service. As ATM is both a high speed LAN and high speed WAN capable technology, with support for isosynchronous packet streams (voice and video) as well as asynchronous packet switched data, the introduction of ATM will entail a large change in the installed base of the networking community. Such a change will therefore take some time to be deployed on a widespread basis. Accordingly the current outlook for digital communications transmission technologies for the triennium is that of significant change associated with the introduction of customer access to ATM switching in the latter part of the triennium. For the period until the introduction of ATM technologies it is anticipated that there may be incremental improvements in the unit cost of carrier services due to the expanded market for such services over this period, but it is not anticipated that there will be substantial changes in the characteristics of such services.

In evaluating likely directions for protocol support, it is considered that protocol technologies will also not change substantially over the next three years. The very slow introduction of the Open Systems Interconnection (OSI) protocol suite is more an expression of the longer term inherent problems with the objectives of the standards bodies rather than any short term impediment to widespread deployment, so immediate changes are not anticipated here. In terms of alternate protocol technologies to TCP/IP there are no clear alternate contenders for such a role, given the high degree of functionality, widespread availability and low access cost.

The conclusion drawn is that the technology base of AARNet is not anticipated to shift dramatically in the immediate future until cost effective access to very high speed digital services is implemented on a national scale. The anticipated timescale for such a shift is not just based on estimates of availability of the relevant technologies and estimates of high speed user requirements from the academic and research sector. It is also based on

the national carriers' access to such high speed technologies and the carriers' broad investment strategies in transmission and switching infrastructure.

Therefore within this three year outlook there is a pending shift in technologies and associated capabilities, the uncertainties in terms of timing have implied that this report takes a conservative position based on use of existing carrier services and available technologies. Accordingly a WAN infrastructure based on multi protocol support for LAN-to-LAN transmission across dedicated point-to-point carrier services is the appropriate technology for this activity.

Other Communications Roles

Communications technologies can cover more areas than data communications requirements, and voice, fax and video technologies can be regarded as eligible areas for consideration within a national service provision role.

However there are a number of observations which should be noted, particularly with reference to voice and video communications requirements.

Voice applications can be viewed as two application areas. One area is voice mail, where voice is used in the same context as text in a one way message. Here the sender records a message in digital format on the local system and the digital message is sent to the recipient who can then replay the message. Experimentation with voice equipped mailers within AARNet indicate that such a means of communication is highly effective, and with the increasing use of workstations and personal computers equipped with audio recording and playback facilities, widespread use of voice mail can be anticipated in the near future. From the network viewpoint voice mail does not present any additional problems in terms of support. Digital voice mail is indistinguishable from any other digital transaction and requires no additional technologies to transit through the network. However voice mail does present volume considerations. For example this paragraph takes 1Kbyte to store as text. If stored as a spoken voice message this same paragraph would take some 350 Kbytes. It is useful to bear such comparative figures in mind when looking at future networking requirements, given that widespread use of voice mail as an annotation to text transactions is a highly likely development in the near future.

The second area, that of support for voice conversations or broadcasts in real time, require support for full duplex analogue traffic streams. Digital telephony systems provide such support by use of dedicated digital streams, implemented by the use of a dedicated circuit switching equipment. This is contrasted with packet switching techniques where packets for a number of applications are multiplexed within a single bearer on a demand basis rather than by static allocation. In attempting to provide a mixed circuit and packet environment a basic carrier structure (circuit or packet) must be selected. In general circuit switching environments are a very poor environment for packet-based data traffic due to highly inefficient bearer utilisation and expensive switching requirements. The alternative approach is to provide circuit streams within a packet switching environment. Synchronous channel support with existing technologies has a high entry cost in terms of the requirement for equipment and interfacing to a wide variety of local private exchanges, and a low level of comparative benefit over the national and international public telephony infrastructure. As noted in the previous section this position could change with the introduction of cost effective B-ISDN (Broadband Integrated Services Digital Network) access (here ATM is the likely technology for B-ISDN services). However, due to the uncertain nature of B-ISDN services at this point in time, it is not considered reasonable to speculate on the potential changes with respect to voice support within the context of this business plan.

Video applications present a similar problem to voice, but consume greater bandwidth resources. Dial-up video (ISDN aggregation services) or satellite-based leased access is currently more cost effective for occasional broadcast or unicast transmissions. Video is a high bandwidth synchronous medium which assumes dedicated access to analogue transmission facilities. Given the low levels of expressed demand for point-to-point video applications at present it is more cost effective to address such requirements within the existing public communications services as an on-demand service rather than make a significant investment in permanent capability within AARNet. A similar caveat to voice support in reference to future directions with very high speed digital networks is relevant to video support.

Fax services are one area of application where AARNet is directly capable of providing services. Current investigatory work with computer controlled fax interfaces allow the generation of faxes directly from computer-based documents, bypassing the process of printing and scanning documents for transmission. It is anticipated that digital fax volume will grow substantially over the next three years as the network brings on additional gateway services to cope with the anticipated volume of activity. The advantage in this approach is that from the network provider's perspective fax transmissions are processed as asynchronous digital messages and no additional network transmission equipment is required.

Summary

The overall conclusion is that the breadth of services is both an issue of identification of opportunity as well as identification of the resource base required in terms of investment levels, risk of investment and perceived level of return.

The conclusion drawn from the first two years of operation of AARNet is that there is a distinct advantage in concentrating effort in a single area of definite common requirement - in this case data communications - to the exclusion of other more marginal (in terms of return on investment) communications services.

R.1 **It is recommended that the role of AARNet continue as a provider of digital data network connectivity and associated network information sources.**

3. THE COMMUNICATIONS ENVIRONMENT

The Regulatory Environment

Within the communications environment Australia now has what is termed a deregulated environment. The controlling legislation is the *Australian Telecommunications Act 1991*, and the provisions of this act are overseen by the regulatory body, the Australian Telecommunications Authority (Austel). The major shift in this deregulation is a move away from a traditional semi-governmental monopoly to a set of explicit conditions which define the extent of the exclusive position of the providers of the basic telecommunications network infrastructure (the common carriers), and the definition of the ability of other organisations to provide any other services on an open and competitive basis.

Within the provisions of the regulations the common carriers (currently AOTC and Optus) maintain a distinct price advantage in basic carriage services (BCS) which include the public telephony environment, and basic point-to-point transmission.

Other organisations can provide networks and services under the provisions of a Service Providers Class License (SPCL) (issued by Austel in accordance with section 209 of the *Australian Telecommunications Act*). In this area there is a defined position of equal levels of access to the common carrier's transmission structure, and discounts (if offered by the carrier) are only applicable on the basis of volume of business and must be available to any of the common carrier's clients.

The Positioning of Communications Carriers

The common carriers have the reserved ability to provide line link services and a commercial pricing advantage in BCS. The public cable plant, the public telephone system (including the mobile telephone network), and basic point-to-point transmission services (both analogue and digital) are included within this line link and basic carriage environment. Associated with this position of a licensed common carrier is regulatory protection from any civil or criminal liability relating to the content of material passed across the basic network.

As well as these reserved services carriers may also provide value added services to the open market, but do so in an environment which is open to any other potential provider of such services. This regulatory environment has allowed three major areas of operation to emerge:

- private networks,
- value added networks, and
- reseller networks.

Within this environment AARNet operates as a value added network service provider. The major component of additional service layered onto the basic carriage service is the provision of multi-protocol data packet switches which provide a set of protocol-specific virtual networks layered above the underlying transmission structure.

It is reasonable to indicate that there will be other providers in service areas which intersect with those of AARNet. The anticipated scale of the investment decisions by such providers in this sector of the market will in all likelihood be based on the future positioning of AARNet, due to the technological leadership position AARNet currently maintains and the size of AARNet's network operation.

The Positioning within the Internet Environment

The second component of the environment in which AARNet operates is that of the organisational structure of the Internet itself.

The Internet is not a single network provided by a single organisation. The Internet is the collective name for the set of interconnected networks which provide communications services based on the Internet protocol suite, and collectively implement a common traffic exchange policy which allow each user to initiate seamless end-to-end transactions which may span across a number of component networks. For example a network connection from Australia to Finland traverses AARNet and the NASA Science Internet to reach the United States, the NSFNET to traverse the United States, NORDUNET on the trans-Atlantic hop to Sweden and from there to FUNET in Finland.

There are now over 100 component networks which make up the core of the Internet. The majority of these networks serve academic and research domains on either a national basis or on an agency or common interest basis on a national or international basis. Within this international environment AARNet is a major player. In terms of traffic passed across the major international exchanges, the levels of traffic to and from AARNet are third behind the United States and Canada when broken down on a national basis. Considering that AARNet is one of the more recently established networks on the Internet this is a remarkable observation on the level of uptake of advanced networking services by the Australian academic and research community.

The interaction between component networks of the Internet is based on mutual acceptance of peer traffic, and a zero dollar inter-network provider settlement arrangement. Thus each component network is required to provide at its own cost the internal network infrastructure, and to provide at its own cost interconnections to other Internet component networks. There is little doubt that these arrangements have proved very effective for the Internet. The zero dollar settlement arrangements are complementary to the connectionless nature of the Internet traffic (where there is no matching concept of a call initiator or even a call - concepts which form the basis of traditional charging and settlement arrangements in the communications industry) and allow interconnections to be implemented on the basis of engineering requirement and undertaken with no additional cost overheads associated with detailed accounting and associated settlement.

In general terms however zero dollar settlements are only stable where there is a perception of equal benefit and positioning between the two parties. This in turn implies a requirement for a degree of homogeneity across the component networks of the Internet, which is indeed the case at present. The general usage characterisation of the component networks at the start of 1992 is that of predominant academic and research related use, with various forms of commercial use as minor users (typically the commercial use is defined as "related" or "value added" from the perspective of the academic and research environment).

However all of these networks are subject to similar pressures for development. The pressures are emerging from two areas: the growing customer base and the agenda driving government support for such networks.

The Internet is growing rapidly. The worldwide network is doubling in size every 8 months in terms of the number of connected hosts and the total end user population. The Internet has achieved sufficient size that almost any organisation which has an information technology investment has some level of requirement to access organisations already connected to the Internet, or access services that are provided most cost effectively via the Internet.

As well as growth the other pressure for change within today's Internet networks is the role of government funding. Many of these networks have significant funding from

governmental bodies as a component of infrastructure support for public research programs. The agenda associated with such support is that of the provision of a technology to a public sector which, due to the size of the sector, cannot be achieved through normal commercial activities. In general governments do not see such funding programs as being long term open-ended commitments. Once the activity has assumed critical levels of size direct government funding would cease and the activity would be undertaken as a normal commercial activity, with access costs for the service being within reasonable proportions due to economies of scale of operation. Thus the motivation associated with government funding and involvement is more concerned with the creation of a commercially viable and efficient service environment which can address the continuing needs of the public research and educational sector as a part of a larger service operation.

It is then not surprising that within the Internet the overall picture in 1992 is that of commencing this transition from a dedicated research related support activity to that of a component of industrial infrastructure. Already large scale commercially operated Internet networks are operating in the United States, and similar operations are being implemented in Europe and Japan, as well as the emergence of international commercial providers spanning both the Atlantic and the Pacific. The role of governments in such an environment is shifting from that of active funding support of a non-commercially viable program to that of a more detached regulatory position of commercial activity.

The issues that arise from this brief examination of the Internet environment is the consideration of evolution of AARNet in a direction which is consistent with our peer networks, and within a timetable which is also in approximate synchronisation with these peers. Not to do so would place AARNet in a position of isolation from the Internet, and return the end user community to a position of effective isolation from their peers. In such an environment there would be no basis for the continued existence of the network.

The overall trend within the component networks of the Internet is toward a role of a commercial provider of volume services on the open market. The driving factors include the agenda of government funding in those cases where the network is currently funded through a governmental program, and the recognition of the benefits available to the academic and research sector through participation in a service structure which offers significant economies of scale of operation.

The Networking Environment

The information technology environment within the academic and research sector is no different from the general industry profile. There has been a direction away from a small number of large computing systems and an associated terminal access network towards a heavily distributed environment using personal computers and local networks (LANs).

The major difference between AARNet and other commercially available networking services is that AARNet is reflection of this general trend in the computing environment. Commercially available network offerings to date have concentrated on providing remote access to mainframe computer systems. The approach taken by AARNet is to engineer a network which seamlessly interconnects the LANs, and does so in a way which offers appropriate management ability in terms of access and security controls.

There has been a significant movement into this style of networking connectivity within other industry sectors. While AARNet was the first major purchaser of multi-protocol routers two years ago (the equipment which is used to implement this type of internetwork connectivity), the market for such equipment has grown rapidly, and some thousands of such units have been sold in Australia over the past 12 months. To date these units have been used to implement corporate networks in commerce, industry and government, generally working within a closed private network environment.

With such an installed base there is an emerging demand for open access networking using the same technology. The potential demand for such services covers the majority of governmental service areas, technology related service industries, the library and publishing sector, open electronic messaging services, and on the basis of the wealth of technical interchange on the network, any organisation with an investment in information technologies.

The current set of open public switched data network services, based on X.25 technologies, are reaching the end of their productive life cycle. The only viable direction for such services is using Internet technology, and it is here that AARNet has placed the national academic and research sector in a leading position in this area.

AARNet has the gathered the specialised technical expertise and operational experience in what is already Australia's largest data network, and is accordingly uniquely placed within the national environment to meet the emerging demands for open Internet connectivity. By taking on an open service role within Australia the academic and research sector, and the AVCC and CSIRO in particular, can use their current position of leadership in this area to ensure a continuing position of significant influence, as well as ensuring that economies of scale of operation can be used in servicing the continuing communications needs of this sector. Failure to maintain that leadership position will inevitably lead to loss of control and influence by the academic and research sector as other organisations capture the initiative.

R.2 **It is recommended that the AVCC use AARNet's current leadership in Internet provision to maintain continuing significant influence and to ensure future economies of scale directly benefit the Australian academic and research sector.**

The High Speed Communications Environment

The trend toward commercial provider roles for Internet networks does not imply that there is no role left for governments in the area of communications infrastructure for the research sector. The visible trend in the United States, the United Kingdom and Europe is to shift direct government involvement away from what is becoming a viable volume market to that of support for research sector access to advanced very high speed (gigabit) network environments. Such specialised environments are now in the late stages of development. The timetable leading to deployment is controlled as much by expectations of customer requirement and associated risk of investment as the considerations of engineering. The role of active governmental support in such an area is to accelerate the timetable of initial deployment by making such technologies available to the research sector, and in so doing assist the carriers to bring them onto the market quickly in order to provide a competitive advantage to the national infrastructure.

While no such government programs are in place within Australia, there are currently two proposals before government advocating the installation of very high speed network capabilities as a component of the national research infrastructure. The proposals are from the Australian Science and Technology Council (ASTEC) who have received a submission from the AVCC in response for a call for proposals for major national research facilities, and the second is from the Prime Minister's Science Advisory Council, also advocating a similar facility.

The demand for access to very high speed networks (gigabit technologies) is based not only on the cumulative sum of existing applications using existing end user technologies, but also on the expectation of the widespread uptake of new high volume applications as an outcome of initial research activity in access models and applications associated with this new communications domain.

Certainly, if the requirements of the network infrastructure by the Australian academic and research sector move at the same pace as the US, European and Japanese sectors, and if the pace of developments in this area of technology continue unaltered for the next three years, then it should be stated that a gigabit network in Australia by 1995 is not an unlikely requirement. Within the United States the Federal Government is providing an additional $400 million in funding over the next five years to the four Federal Agencies in order to provide and operate a gigabit national research network over this period. A similar program in the United Kingdom will see the UK Academic and Research Network (JANET) upgraded to 622 Mbps capacity within the next 12 months and a further upgrade to 2,400 Mbps capacity within 2 - 3 years.

While it is reasonable to anticipate the availability of gigabit technologies in this period, and equally reasonable to indicate that sections within the academic and research sector will be voicing their legitimate requirement for access to such a very high speed national facility to support the national research endeavour within this time frame, it is difficult to offer any substantive advice on the likely costs of such a facility, apart from the general comment that it would in all likelihood be of the order of some $4m- $8m per year as a minimum, in addition to existing commitments. As with overseas programs, direct governmental involvement in the area of specialised high speed networking is a likely scenario given the high levels of initial investment required to bring such technology into the service of the research community.

It is recommended that provision for very high speed facilities not be explicitly addressed within the context of this business plan. Further efforts in this area should await the outcome of Governmental consideration of current proposals in this area. In so doing it is considered prudent to ensure that there is an appropriate broad communications and organisational environment which can support the focused introduction of highly specialised leading communications technologies as a component of the national research environment.

R.3 **It is recommended that AARNet ensure it positions itself as the communications and organisational structure within the academic and research sector which will support the focused introduction of highly specialised leading communications technologies, as a component of the national research infrastructure.**

4. THE COMMUNICATIONS NEEDS OF THE ACADEMIC AND RESEARCH SECTOR

This chapter examines the needs of the academic and research sector for communications services on the basis of the activities undertaken within the major user groupings, and provides some indication in the growth of usage based on analysis of usage patterns over the first two years of operation of the network.

There is little doubt that information technologies will have a revolutionary impact on the academic and research sector. The sector's major resource and asset is that of an effective information base, and the shift in computing and communications technologies over the past decade alone will have profound structural ramifications in this sector for decades to come. The access costs of high capability systems are now at a level commensurate with the electronic typewriters of two decades ago, and the increasing sophistication of these systems is being used to create more user intuitive information access and processing environments. As an example, shifts in the accessibility and capability of these technologies imply that for an institution the acquisition of information sources is increasingly involved with communications capabilities and information technology management. The management of information storage and flow is within a similar process of change as digital technologies introduce more effective strategies in this area.

A study of the usage of AARNet at the Curtin University of Technology and Murdoch University in October 1991 (some 16 months after the implementation of AARNet) indicated that some 20% of staff were users of the service, and a further 60% of staff were aware of the service and expressed a strong desire to use it given appropriate training. Within the time frame indicated both figures are surprisingly high, and indicate that the services provided through AARNet appear to be extremely well attuned to the actual requirements of the end user population both now and in terms of future directions. The following sections indicate this in further detail across each of the major areas of activity.

Academic Programs

Communications technologies are playing an increasingly significant role in this area of activity. The use of computing systems in the traditional sciences area is well established within higher education institutions, and the integration of access to AARNet and the Internet as a venicle for access to information databases and recent papers in scientific disciplines is a common aspect of many academic programs.

Also of note is the extent to which AARNet is already being used in the humanities areas as a component of academic programs. Political Science programs at the University of Melbourne and Macquarie University regularly use AARNet within their teaching program to participate in an international political simulation. Law courses use the network to access legal databases and language courses are using the network to access electronic texts for linguistic analysis by computer.

As well as an instructional resource in itself the network is being used in some cases to support distance education services. While AARNet does not provide video or audio broadcasting facilities it does provide a fast and efficient messaging service, and this service is being used in a number of distance education programs already. For example the University of Western Sydney uses AARNet and the Internet to support tutorial assistance to a nursing teaching program being conducted at the Hong Kong Baptist College. A national distance education access program for remote students, ADENet, is being constructed on top of AARNet. This layered network is intended to provide direct interactive computer access to distance education centre institutional facilities using local call cost structures for the remote student population, thus providing significant savings in communications costs for these institutions.

Research Activity and Collaboration

The needs of the research commun[illegible]y for national and international networking services are perhaps the most immediate a[illegible] most significant. For research to be a cost effective and competitive undertakinc [illegible]s to informational sources, and direct and immediate access to an international c[illegible]ulation are basic prerequisites.

One of the initial motiv[illegible] a national communications network was the support of supercomputing centr[illegible]earch use. AARNet provides communications support for the various superc[illegible]facilities located at Canberra (the Australian National University), Melbou[illegible].RO, and the Australian Computing and Communications Institute), Sydney, [illegible]e and Perth, linking some 12 specialised supercomputer facilities together ir[illegible]tional high performance computing network, which in turn is connected to peer [illegible]works internationally through the Internet. AARNet's support framework for supercomputing has proved capable of meeting their communications requirements to date, and it is anticipated that this will remain the case across the forthcoming triennium. However it is noted that if there is a supercomputing-based requirement for significantly enhanced communications capabilities, it would be likely that a program-based funding mechanism would be required to supplement the current common funding arrangements, as noted in the previous chapter in the section on high speed communications issues.

The ways in which AARNet is now being used by the research community are as diverse as the research areas themselves. As well as use of the network to access remote high performance computing systems, AARNet supports research activities including international research collaborative projects, use of the network for remote data collection and analysis, use of the network as an information resource and an information storage system, collaborative authoring, access to library catalogues, access to texts and papers, and use of powerful network-wide search engines to locate potential answer to specific queries, as just a small set of examples within such a large and diverse environment.

Increasingly institutional, national and international network access is as basic a prerequisite for individual researchers as the telephone handset, and inherently a much more valuable asset for the researcher. It allows the individual to work within the rich contextual environment of the peer community, enabling direct and timely access to information and provides a vehicle for dissemination of information and collaborative activity.

The network also facilities one of the major objectives of the publicly funded research program - that of the rapid and productive integration of research outcomes into the industrial and commercial environment. In an environment where the network spans both domains the research activity is more visible the potential consumers of the research results allowing faster uptake of outcomes, together with the benefits to productive research programs in being cognisant of the actual industrial and commercial expectations of research activity. In such a way the network is facilitating an additional CRC to the set of physical group[illegible]ready established - a CRC whose scope is national and whose domain of endeavour is [illegible]ncompassing the entire research endeavour of the nation.

Information Publication and Dissemination - Library Activities

The needs of the library in the communications area are also significant. The current area of activity is the OnLine Public Access Catalogues (OPACs), and many libraries have already placed their OPACs on AARNet. The benefits in so doing are quite high - each individual with a computer or terminal on their desk has in effect access to a virtual library

composed of the sum of the collections of libraries throughout Australia and elsewhere, making publication searches an efficient and low cost service.

The needs of this sector however span more than catalogue browsing. The interlibrary loan business is currently conducted via extensive use of fax systems. Not only is this system expensive in terms of transmission costs the architecture of the fax system implies that the most expensive component of the actual transfer is the staff time in preparing and scanning the material for fax transmission. The Ariel project of the Research Libraries Group has already produced an inexpensive network-based configuration of a computer controlled scanner and printer which can perform document scanning at significantly faster rates, and once scanned the document can be stored in digital format so that subsequently requests for the same material can be automatically serviced. Similar approaches may be taken to the provision of 'reserve collection' high use material to both on campus and remote clients. It is noted that there are currently copyright issues in this area which are as much a factor as technical opportunity.

The concept of a virtual library with material distributed throughout physical libraries throughout Australia and elsewhere has gained great acceptance. A spectrum of need can be discerned in which some material is required immediate in physical form, some within an acceptable time in a physical form, and some electronically. It becomes a strategic decision for the organisation as to which material is to be held locally and which is to be accessed remotely.

From the viewpoint of the author of the material it becomes an interesting issue whether a publishing house is the most effective way to disseminate information. The alternative to the traditional publication process is for the author to make the information directly available across the network using the local desktop system as the publication mechanism. In so doing the information can be made directly accessible to the intended readership within seconds rather than a costly process taking months. It is estimated that already some 20 terrabytes of information has been published only in electronic format, and it is reasonable to anticipate that this figure will spiral upward quickly given the ease with information can be disseminated in this fashion.

The academic and research library area also has a strong interest in advocating that the access policies for AARNet include provision for network to be accessible by the broader library sector, to ensure that each institutional library operates as effectively and efficiently as possible. Common undertakings such as inter-library loan operations and common cataloguing activities are anticipated to make extensive use of communications technology in the immediate future, but such a strategy also implies that all library participants have the ability to access a common communications environment.

Administration

Administrative activities of the higher education institutions also are growing users of the network. The network is already being used as a communications and messaging tool, with queries, discussions, documents and data being passed across the network by the administrations of the institutions.

In this area the network offers a more useful alternative to fax services for document transmissions (as the document is amendable when received rather than existing as a facsimile of the original working document) and is capable of supporting group activity as a productive adjunct to face to face meetings through mailing lists and remote access mechanisms.

In the immediate future on of the major common administrative activities will be shifted onto AARNet. The DEET Statistics Collection, which is currently undertaken through a

cumbersome process of disks, tapes and the postal service will be hosted on the network, with data sets being transmitted directly in electronic form across the network. Involving all institutions and some hundreds of megabytes of data this is a reasonably large undertaking for administrations, and will make the process of submission of this data a more efficient exercise.

It is anticipated that this operation is an initial step in a direction which will see extensive use of communications technologies in administration. This will include the use of communications and information systems to greatly enhance access to institutional administrative information and procedures both on an institutional basis and in sharing information requirements across the national system.

A Projection of Needs for AARNet

The above sections indicate that AARNet is already providing services in a wide range of areas of activity within each institution, and the available information indicates that significant growth in the volume of usage from each of thee areas is likely to occur in the immediate future. The following section performs an analysis of likely directions in demand for services based on current usage profiles and current growth trends.

To prepare forward estimates it is necessary to have a reasonable model of demand growth over this period which can give quantitative estimates of anticipated future needs. Underlying the construction of such a model is a judgement on the available technology during this triennium, and the likely uptake of such technologies from the client base. Given the vary active level of technological development in the communications domain, and highly flexible position of the consumer base to react to new technologies as soon as they are placed on the market, any future demand model for communications services will have a reasonable degree of uncertainty.

AARNet is used to transmit messages and information from system to system. Application usage analysis indicates that the majority of the usage is concerned with file transfer, electronic mail, news messaging, interpersonal communications and the directory service. The relative level of traffic generated by these applications, as analysed on a packet basis is presented in Figure 1.

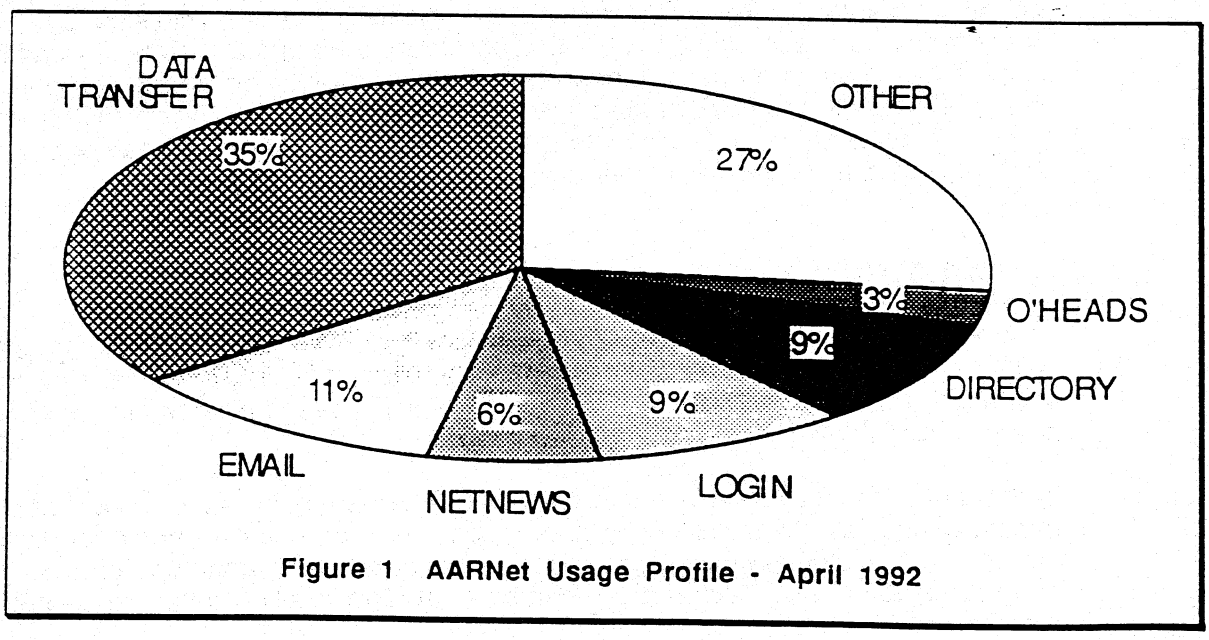

Figure 1 AARNet Usage Profile - April 1992

A model of usage of this application set would indicate that levels of network use per individual users could not be expected to grow at more than a slow linear rate. Thus the major growth factors in such a model is the growth of the total user population, which given the model of the spread of usage of information technologies in academic and research populations, a linear growth trend is a reasonable conclusion. Thus, if the average per user "intensity" of network use were relatively constant, then growth of demand would relate more to growth of the total user population, and it would be reasonable also to anticipate this would result in a slowing of growth trends after the initial period once usage penetration within the sector reached full levels of potential usage.

However such an essentially static view of the growth and development of communications technologies and applications, and their pattern of usage is somewhat inaccurate. It is entirely reasonable to expect that through the continuing development of this technology, and associated user facilities, network usage will increase significantly as expressed on a per user basis, and it is reasonable also to expect that there will be an increasing use of time critical applications to support such facilities as voice and video messaging. The impact of these technologies would be significant given the data sizes and timing requirements for such data flow.

US trends over the previous five years indicate that this factor is the major factor behind the growth in demand for network resources, and as a consequence the previous 5 years have seen an exponential growth in the demand for networking services in that country. The growth rate has been a factor of around 3 - 4 per annum over this period in that country.

Within AARNet the period of experience has been somewhat shorter (2 years), but even over this period, the recorded growth rates of usage are comparable to overseas levels. Figure 2 (overleaf) shows the total traffic across all AARNet interfaces measured on a week-by-week basis. A growth model for the first 24 months of operation indicated an average weekly growth rate in traffic of just under 2% per week, or doubling every eight months.

There is a reasonable degree of uncertainty about extrapolation of such growth levels as forward trend estimates - particularly concerning whether this growth rate is too conservative. The underlying assumptions in such figures are that growth pressures will continue to operate under current conditions for some time.

Technology trends would indicate that there are considerable pressures for significantly greater levels of growth, and layered service provision activities would also reinforce this view by constructing an information rich environment to complement the communications services.

Constraining these pressures are cost constraints on the part of the institutions, the profile of investment in information technologies and associated training programs within each institution and the overall institutional program of resource allocation and strategic objectives. These factors influence the levels of uptake of networking services, and in effect determine the maximal rate of growth of service usage. There is a second set of factors within this system, relating to the bounded total potential user population, and on a theoretical basis the rate of growth should slow once service usage levels of 80% - 90% of the total population is reached (such a bounded growth model assumes a model of communications requirements and associated technological capabilities for each individual user which remains relatively static over the user population growth period - an assumption which must be balanced against the current rapid development and deployment of new technological capabilities in this area). At this stage there is no overall reliable data relating to levels of usage of AARNet, nor is there data relating to intensity of usage, so that any estimates of inherent total demand levels for AARNet services would have to be highly speculative in nature.

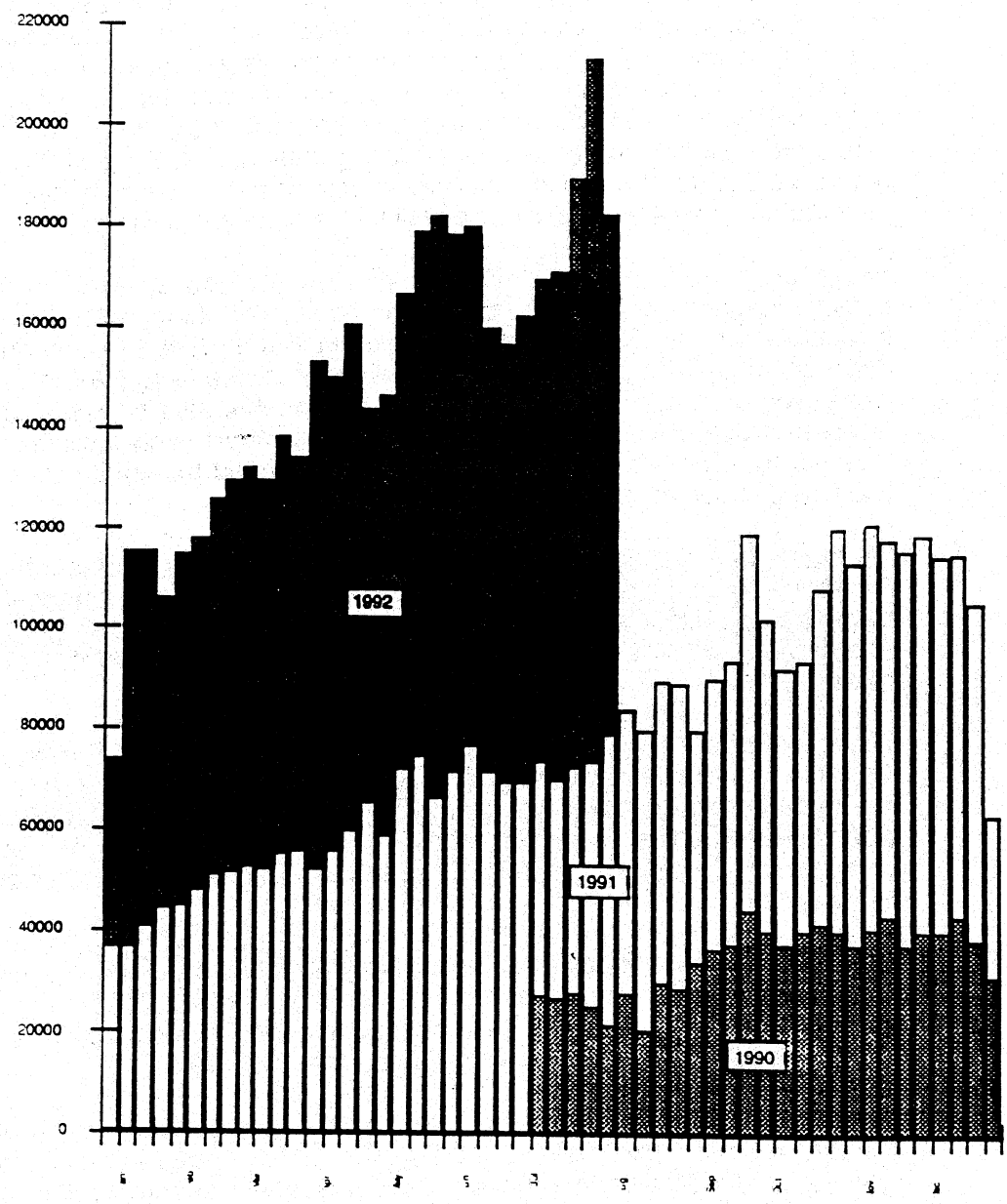

Figure 2 Total Weekly traffic levels across AARNet (Mbytes)

Extrapolating current usage levels, and including a cost-restraint factor, would indicate a usage growth level of between 5 to 10 over the forthcoming triennium. Applying this growth factor to existing trunk facilities[2] over the next 2 - 3 years would see an engineering requirement for:

international connectivity capacity of 2 - 4 Mbps,

2 It must be noted that these are very preliminary engineering estimates, and that specific engineering proposals would need be evaluated in detail as and when such upgrades are required. The schedule presented here is intended simply to provide pointers to potential capacity requirements as an extrapolation of total traffic trend analysis.

Melbourne / Canberra / Sydney capacity of 8 - 10 Mbps,

Brisbane, Adelaide and Perth capacities of 3 Mbps to each location, and

Darwin and Tasmania capacities of 0.5 - 1 Mbps to each location.

It should be noted that this schedule is intended to indicate, in very general terms, the technical feasibility of providing capacity which is capable of accommodating these growth levels, and is not intended to form the firm basis of future engineering activity. It should also be noted that at current tariff schedules these upgrades in capacity by factors of between 10 and 40 could be provided at cost levels which are less than 5 times current cost levels, as unit price generally decreases significantly with volume of purchase in communications facilities.

The above growth estimates take into account the increasing use of network services from within the broad academic and research sector using current technologies. There are two additional factors which have not been included into the trend analysis, due to the high levels of uncertainty in both areas.

Scope of the Client Domain: the consideration here is the extent of potential growth in the network given a strategic direction by the universities and CSIRO to optimise their individual positions through pursuing economies of scale of operation. In such a scenario growth estimates for the three year period would be in the broad range of between 5 and 50, with a more precise figure dependant of competitive position, market size and growth, marketing ability, market position, service organisation ability, and quality of overall delivered service.

New Services: the second factor is the estimate of the level of demand for very high speed (gigabit) data services over this period. While the entire broad community would derive levels of benefit through trunk access to very high speed and capacity communications links[3], the client subgroup who have particular requirements for precisely such services is (at least initially) much smaller. This group initially includes the remote clients of high capability computing systems, who have a requirement to send and receive gigabytes of information across the network within seconds, and researchers working in advanced computing-based applications which involve multimedia interfaces. This group of users will grow as switched video and audio capabilities are integrated into local computing and communications environments, and there is little doubt that use of a high capacity communications environment will be widespread in the medium term future. However there are reasonable levels of uncertainty within this overall trend, sufficient to justify exclusion from the presented trend analysis included here.

Engineering Capacity Considerations

Engineering a total communications system where internal trunk capacity is commensurate with average volume levels passed across from the client LANs is essential within the Internet environment. Reliable transfer of information and effective flow control of packet trains within the total packet switching environment of the Internet is based on end-to-end timers and retransmission techniques. The effective data capacity of any Internet link reduces sharply in periods of very high load (sustained load levels in excess of 80% of capacity) due to packet loss and packet retransmission, and the elapsed time for network

3 Although the level of benefit for the majority of users through faster transaction speeds for high volume transactions is not one which is proposed as being a critically important issue at present.

transactions increases sharply. In such an environment the overheads of reliable datagram transmission network rapidly fill the entire link capacity, making the service unusable for all potential clients. Thus in order to provide any service at all it is essential that trunk capacities are set to levels which, at a minimum, match imposed volume levels from client LANs.

In looking at the relationship between the AARNet trunk network (and the individual links within AARNet) and the client LANs the controlling mechanism for the management of traffic can only be based within the client LANs themselves. Attempting to use the trunk network itself as the control point, by limiting trunk capacity, is not a useful means of managing growth. The overall result of such an approach is catastrophic breakdown of the entire network due to congestion collapse, resulting in a completely unusable system. Similarly attempting to exercise control over traffic levels by limiting tail loop capacity on one or more tail loop circuits induces more localised congestion breakdown while not addressing the requirement for local management of the use of the resource.

Accordingly it is necessary to impress on clients the requirement to exercise appropriate management controls on their traffic sources if the objective of managed overall growth is to be achieved. Such policies of local management are considered to be outside the scope of this business plan.

From the perspective of AARNet it is incumbent on the trunk network to provide a facility which, in terms of link capacities, is internally consistent, and matches local demand capacities and volume levels. In considering current usage levels the most critical link at present is the Australia - US link. This link is now (August 1992) running at 90% utilisation levels for 4 - 6 hours per working day, and it is anticipated that critical congestion and subsequent performance collapse will be experienced before the end of 1992. In looking at engineering options to upgrade this circuit, the next available bandwidth levels are 0.75Mbps and 1.5Mbps. The Australian end half circuit costs are $35,000 per month for the current 0.5Mbps circuit, $50,000 per month for the 0.75Mbps circuit and $69,000 per month for the 1.5Mbps circuit. The unit costs of the circuit do not alter in the case of the 0.75Mbps circuit, and fall by 30% in the case of the 1.5Mbps circuit. It should be noted however that any upgrade of the Australia - US circuit will require additional funding for the matching US circuit. While PACCOM has provided support for a 0.5Mbps half circuit to Australia with NASA program support, further upgrades of capacity will require Australian funding for the US half circuit in the absence of further US funding.

Within the trunk network it is anticipated that the links to Western Australia (currently 128Kbps) and Tasmania (currently 48Kbps) will require additional capacity in order to alleviate peak congestion. In the case of the link to Western Australia the next service level is the use of a 2Mbps Megalink service, while the link to Tasmania could be upgraded to 128Kbps in the first instance. Both upgrades are considered necessary to be implemented in 1993.

In addition the 48Kbps tail loops within AARNet are subject to congestion periods in peak hours. Here it is possible to use ISDN services to provide 128Kbps tail loops at pricing levels which are slightly lower than the current 48Kbps DDS prices, providing double the effective tail loop capacity.

R.4 **It is recommended that the planning process for AARNet take into account the continuing high levels of growth of the national and international communications requirements of all institutions within the academic and research sector.**

5. THE ORGANISATIONAL STRUCTURE OF AARNet

The Objectives of AARNet

The objectives of AARNet are as follows:

- AARNet will provide national telecommunications and related information services, with the major client base consisting of the national research and education community.
- AARNet will provide operational management to the network plant, and provide registration, coordination consultancy and technical help and assistance facilities to the clients of the network service.
- AARNet will take responsibility for providing quality control and service level guarantees. AARNet will endeavour to provide services in cooperation with overseas peer service providers where appropriate.

Organisational Options

The options considered include:

- the winding up of AARNet,
- a continuation of the existing operational group within the AVCC Secretariat,
- a continuation of operation within the AVCC, but reporting directly to the AVCC Board of Directors as a distinct entity, and
- the formation of a company structure as the basis of continued operation.

It should be noted that the requirement to establish a private network within Australia by the academic and research sector was due to the lack of a suitable offering from Telecom Australia or other potential carriers in 1989, rather than any intrinsic desire by the academic and research sector at the time to establish a private data network.

It should also be noted that the grounds for AVCC participation in the project was not an expression of an AVCC policy objective to manage such a national network. Indeed such an operational role for the AVCC was evidently never envisaged by the member institutions when the AVCC was established. The operation of AARNet (or indeed the operation of any common service provision activity to the academic and research sector) by the AVCC falls outside the objects for which the AVCC is established as there is no provision for such an activity within the Memorandum and Articles of Association of the AVCC. Indeed the AVCC undertakes no other common operational service activity outside of AARNet, and as an organisation it has had to adapt itself to the changing requirements of AARNet as the activity increases in size and scope.

The major objective of the AVCC in the context of this activity is to follow a path which offers cost effective provision of required services to AVCC member institutions while working within the parameters of the most effective relationship with institutional service programs and planning structures. This implies that there is no implicit and absolute requirement for the AVCC to continue to operate a national communications network - its role in this area is on the basis of providing a platform for common activity as a cost effective means of addressing a common requirement for network services.

As there is no alternative source of supply of national and international Internet services in Australia the winding up of AARNet is not considered to be in the institutions' or CSIRO's

best interests. The requirement for continued stability of access to a national and international internetwork is considered the paramount objective here, so the winding up of the network without an alternative supplier is not a viable option.

The continuation of the existing operational group within the AVCC Secretariat is not without attendant problems, which are likely to be exacerbated given the expectation of continued growth in the scale of activity. The requirements associated with operational and financial management call for an organisational structure which is attuned to a distributed service role, and this is not without problems in operating as a group within the AVCC Secretariat, whose major mandate is the determination of common policies concerning publicly funded research and higher education. Within such an environment there is a strong risk of insufficient levels of appropriately specialised financial management simply due to the disparity of financial reporting requirements between the AARNet program and the remainder of the Secretariat's activities. In addition the decision making structure has the risk of being unwieldily due to the relative positioning of the AVCC Secretariat's management structure with the AVCC Board of Directors and the two relevant Standing Committees which oversee AARNet and the Vice-Chancellors' committee itself. Such problems have not proved intractable in the past and the current situation can continue to provide services with reasonable efficiency and effectiveness if so required.

However the options which associate a dedicated organisational entity with the continued operation of AARNet appear to offer greater levels of benefit here. In such a scenario a dedicated entity can operate with a clear organisational mandate to manage a network facility, and can structure appropriate decision making, operational and financial controls into the organisation to make the operation of the network more efficient and effective.

This could be achieved by altering the reporting structure of AARNet to report directly to the AVCC Board of Directors as a distinct entity. This scenario would see the existing AARNet Advisory Board be structured to take a more direct managerial role in AARNet, and in effect delineate matters of common policy determination to the Standing Committee on Information Resources and have the AARNet Board act as in a capacity of delegated operational management for and on behalf of the AVCC Board of Directors. Such a structure would allow the continuation of AARNet as a program focussed on an academic and research service role, and would allow the sector to maintain overall control of the operation.

Additionally the establishment of a private company has been considered. The factors supporting such a direction are based on the following factors:

- A company can operate with a clear organisational mandate to manage a network facility. It is dubious whether the peak policy body of the higher education sector can effectively operate in the open carrier commercial environment. In order to achieve participation levels which can allow the continued operation of the network at cost effective levels an appropriately focussed organisational entity to undertake the activity is a necessity.

- The company structure allows each client to purchase services in an open and potentially competitive environment, allowing the company to focus on meeting individual client requirements as the mechanism for further development.

- In achieving continued efficiencies of operation through economies of scale AARNet will increasingly be dealing with both the public and private sectors. It is anomalous that this commercial activity of value-added network management be undertaken under the auspices of the peak body of the higher education sector as a long term management structure.

- Through share holding being either limited in entirety to AVCC member institutions and CSIRO, or with a majority share holding position being reserved to this

grouping, ownership, and effective control of AARNet can remain clearly within the domain of the academic and research sector.

- In terms of the mandate of publicly funded educational institutions and publicly funded research organisations, it is not the objective of the government that these bodies use their privileged position to commence wide scale commercial undertakings. The objective of the government in this endeavour is to ensure that the outcomes of this sector's activities are available to the national environment through the efforts of commerce and industry, and the effective mandate here is the transition towards the establishment of entities which can continue such activities on a commercial basis.

Regional Networks

There are two typical models used in peer Internet networks to provide services to clients. In the United States, as an example of a regional approach, the structure used is one of a federally funded backbone network (the NSFNET) and a collection of regional networks which provide local reticulation of the service to the end clients. The structure employed in the United Kingdom by JANET, as an example of a unified national approach, is one of a single network entity which provides services directly to each client.

The relative merits of each structure were considered by the AVCC in December 1989 during the planning for AARNet, and an AVCC policy decision was made to operate a single and consistent national communications program which had the mandate to provide network services directly to each individual institution.

In re examining this area, and assessing whether the national approach adopted by AARNet is still the most effective and efficient organisational structure for the task at hand, the approach advocated is a continuation within the current policy of a single national network. Regional networks may threaten the viability of a national network by weakening the ability of the network to ensure uniform levels of access and service to each client institution. Indeed the regional network structure is perhaps the major weakness of the situation in the United States, where differing operational policies and marginal operational viability of some of the regional networks, together with the astounding operational complexity of the total network environment, and are major issues at present.

The approach adopted within AARNet to date in this area has been to liaise with regional management and technical bodies on the basis of exchange of information and advice, and the resultant flow of information into the AVCC has ensured that strategic decisions pertaining to the operation and further direction of AARNet have been attuned to both institutional and regional requirements. This allows advocacy for regional issues to be directed into the national managerial structure, while the national structure ensures that each client of the service participates in the national program on an equal basis, and is serviced by the network on a similar uniform basis. It also does not inhibit regional activities providing additional services or infrastructure above those provided by the national program, but such activities are undertaken within a framework which ensures that there is a common service environment spanning the entire client base.

Recommended Organisational Structure

The recommended organisational structure for AARNet is that of a transition towards an organisational entity with a clear focus on the operation of network services.

The benefits to the academic and research sector in maintaining control of the activity are recognised, and it is considered that such benefits outweigh, for the present at least, the potential efficiencies that could be realised in operating through a distinct private company.

Accordingly it is recommended that the organisational structure of AARNet change from an operational unit within the Secretariat to that of a separate organisational entity within the AVCC corporate structure, reporting to the Board of Directors of the AVCC. Within the AVCC structure AARNet would take on an operational role, acting as a provider of network services. This structure can be seen as a position of AARNet assuming a distinct organisational identity and distinct mandate and domain of activity under the umbrella of the AVCC company structure as a wholly owned subsidiary. This will shift AARNet from the position of being a program within a larger central structure to that of a distinct entity with separate accounting, funding and management structures as required for the operation.

In terms of the relationship with CSIRO it would be appropriate that this entity provide a line of reporting to CSIRO and that there is an appropriate mechanism for CSIRO representation within the management process of the entity.

Management Structure

A key element in ensuring the continued success of AARNet is the manner in which it is to be controlled in terms of decision making. A balance has to be struck between the need of operational management to have the ability to make day-to-day decisions and the requirements of the owners of the entity to be in a position to provide competitively priced services to the customer base available on a long term basis to meet their needs.

This report proposes a 3 tier structure of responsibility, drawing a distinction between strategic and ownership decisions, tactical decisions and operational decisions.

1. Strategic and ownership decisions would be taken by the owners of the entity. In the case of the proposed organisational structure this would be the Board of Directors of the AVCC. General policy direction would be provided to the Board of Directors of the AVCC via the various AVCC standing committees, including the Standing Committee on Information Resources.

2. Tactical decisions would be taken by a smaller body which would be appointed by the owners of the entity, and operate under appropriate delegation of authority. Such a group would function as a Management Board. An annual operating plan and budget which would define in detail the activities of AARNet on a year by year basis, and would be presented to the Management Board for approval. It is envisaged that CSIRO representatives would be placed on this Management Board, and that there would be a path for information to flow between this Board and CSIRO as well as to the AVCC Board of Directors.

3. All decisions and areas of responsibility not explicitly reserved to the owners and the Management Board would be delegated to the Operations Management of the entity.

It is envisaged that the composition of the AARNet Management Board be similar to that of the existing AARNet Advisory Board. It would include representation from the AVCC and CSIRO and also include representation from the major user sectors including the library, information technology management and administrative areas as well as the end client population.

Staffing Requirements

The current staffing structure for AARNet is currently a three person structure, with a Manager and a position of Network Coordinator: Technical Services currently filled. The position of Network Coordinator: User Services, has not yet been filled.

If the activity is to be set up as a distinct operational entity there is an immediate requirement for the additional fractional position of Financial Officer to manage the operation in terms of overall management, budgetary and inventory control, staff services and management of operational funds. Additionally there is a requirement for general clerical and secretarial support on a part-time or fractional basis. These activities are currently being undertaken on a fractional staff basis from within the AVCC Secretariat. It is anticipated that an additional technical support position will be required from mid-1993 due to the increasing scope of the technical support activities being undertaken by the group.

Accordingly a projection of staffing levels for AARNet is as indicated below.

FUNCTION	1993	1994	1995
Manager	1	1	1
Financial Officer	0.5	0.5	0.5
Technical Support	1.5	2	2
Service Support	1	1	1
Clerical Support		0.5	0.5

R.5 **It is recommended that the Memorandum and Articles of Association of the AVCC be altered to include the role of management of the operation of services provided to the institutional members of the AVCC.**

R.6 **It is recommended that AARNet assume a distinct organisational identity within the AVCC corporate structure, with separate accounting, funding and management structures.**

6. EXPENDITURE AND FUNDING

A Review of the 1990 - 1992 Triennium

A breakdown of the expenditure and funding program for the 1990 - 1992 triennium and a detailed breakdown of 1992 expenditure is indicated in Appendix B.

AARNet is currently funded to a budget drawn in the third quarter of each calendar year by AARNet operational management, endorsed and recommended by the AARNet Advisory Board, and approved by the AVCC as a component of the overall AVCC budget.

Institutional support of AARNet is a component of institutional support for the AVCC itself, funded through a formula pro-rated to the operating grant of each institution.

CSIRO contributes to the funding of AARNet by two mechanisms: a single allocation of funding from CSIRO Administration to the AVCC based on an agreed proportion of total costs, and divisional funding for connections from divisions to the closest point of presence of AARNet. ARC funding for AARNet in the 1990 - 1992 triennium has been based on an AVCC application for Mechanism C funding support, with the application being based on a proportion of total costs of AARNet.

Support is also provided to AARNet by the United States through the PACCOM program. This program purchases a matching half circuit and tail end circuit and equipment to terminate the Australian international half circuit, and the program also provides operational support for the link. PACCOM is managed through a program within the University of Hawaii and is supported within the United States by the University of Hawaii, NASA, the National Science Foundation and the Department of Energy.

In addition the Affiliate Membership program provides funding support for AARNet, where Affiliate Members are charged AARNet access fees based either on a fixed annual sum (for Mail access) or on a capacity-based sliding scale of charges (for Network access).

Charging for AARNet Services

Charging models for communications services generally use a combination of proportions of three areas: access to the service, duration of access and volume of data transferred, and assume that there is a transactional (or call) model of client access to the service. The relative settings of the access, time and volume components of a tariff environment are determined as an investment and marketing decision by the provider and constrained by the technology in terms of accounting mechanisms.

There are two broad approaches to charging for a shared resource:

- *incremental usage-based tariffs*
- *fixed subscription rates*

Incremental usage-based tariffs (low access charges, high time and/or volume charges) imply that each service client is charged for the use of the service in accordance with the level of usage. In this situation the tariff structure must cover not only any incremental costs in servicing the client's access, but must also include a component to recover all fixed costs through incremental usage. The resultant tariff structure is an outcome of the provider's expectation of access volumes at each potential tariff level and selecting a particular level on the basis of minimal investment risk and maximal level of return. Where the market is small or not highly competitive (a monopoly position) the provider has the ability to set tariff levels which exploit this situation at the expense of the client base. Where the market is highly competitive the tariffs are set low, increasing the risk of

investment considerably so that only a small number of high volume service providers can remain within the market.

However in general usage based accounting is expensive to undertake. The steps of data monitoring, collection of accounting data, process of data, generation of invoices, the process of collection of payment and the cash flow position of the provider where the service is provided in advance of payment all add to the cost overheads of the service - a cost which ultimately is funded by the client base and is not a component of the actual delivered service.

A subscription mechanism is one where the charge allows access to the service, and there is no incremental charge for volume of use. The subscription charges are based on the operational costs on providing the service and the number of clients of the service.

However the parameters which drive the decision making process here are more than the size of the potential market, investment profiles and anticipated participation rates. The capabilities of the technology itself in respect of accounting is a major constraint within this process as well.

The network service provided by AARNet is an internetwork connectionless datagram delivery service. This implies that there is no network process of call setup, call-based usage or call teardown. Without such a call structure within the provided service there is no service level visible transaction time structure, so there is no feasible method of collection of per transaction duration information. Similarly there is no mechanism for collection of per transaction volume information. Also in considering volume information the datagram architecture implies that packets may be dropped by the service provider in response to local congestion events. Furthermore this architecture implies there is no mechanism of determining the transaction initiator when looking at and end-to-end packet exchange to determine who should be charged for the transaction. Finally the internetwork aspect of the service implies that the direct clients of AARNet are not individual end users, nor are they individual computing systems. The actual direct clients of the network (in a technical sense) are the local network service providers and the exchange is that of an exchange between networks rather that of a sequence of individual user driven transactions.

Within such an environment incremental end-user usage based tariffs, whether by end user, by project or by host are not supportable.

The alternative charging mechanism, that of subscription rates, where a single access fee covers all usage of the provided services, is closely attuned to the technical characteristics of the service itself. The major cost item for the service provider is capacity (point-to-point links are provided on an annual access tariff where the tariff schedule is based on the capacity and distance of the link), and the these costs are effectively volume independent. A subscription rate allows the client to purchase access to the actual network provider's resource: capacity, and the rate can then be determined by the access capacity of each individual client.

From the client perspective there are a number of compelling efficiencies in this subscription rate environment, including the reduction in service provision overheads and the benefits of payment for access in advance of usage in terms of the provider's cash flow position and in terms of the client's ability to plan expenditure levels associated with purchase of the service. The client can nominate an expenditure level and a quality of access through selection of a particular access capacity, and the service provider can determine appropriate trunk capacities to provide within the network infrastructure as an outcome of the sum of access capacities.

R.7 **It is recommended that the charging model for AARNet be based on an annual subscription rather than incremental usage-based tariffs.**

Purchasing AARNet Services

The funding mechanism for AVCC member institutions for AARNet for the period 1989 - 1992 was based on a fixed proportion of institutional operating grants. The average institutional funding commitment for 1992 was $27,000, and is set to 0.03% of the institutions' operating grants for 1992.

The advantage of this funding mechanism from the common institutional perspective is that the non-metropolitan institutions are not unduly disadvantaged in terms of the higher access costs for the service. Also larger institutions, which have in general a higher level of usage of AARNet, pay proportionately more for the service as compared to the smaller institutions, who are lower volume clients.

However there are limitations within such a model of an agreed common funding level. Firstly a common funding level tends to operate at the lowest commonly accepted level. Such a common decision process is conservative in its ability to react to change, and tends to act as a disincentive for any institution who wishes to make significant use of the service simply because the institution cannot purchase individually a level of service which is commensurate with their intended usage. Secondly the increasing resource demands that information technologies have placed within institutions have resulted in a high priority being placed on the development of effective management practices for both financial and resource control at the institutional level. Equally, information service provision must be closely aligned with the achievement of the institutional objectives and strategic planning for integrated services in a devolved environment may place constraints on the means of achieving the necessary controls. AARNet will therefore need to exist in an environment of diverse institutional clients, each with individual objectives and priorities for funding information technology programs.

What is required is that each institution gain the ability to set a level of service provision from AARNet on the basis of perceived institutional needs and priorities. For example construction of local library facilities may be deferred or cancelled through access over AARNet to other regional or national resources and hence the institution may wish to purchase a higher level of access to AARNet services.

The devolution of decision making regarding the level of services contracted through AARNet can lead to improved institutional decision making in terms of assessment of requirements and improved operational management regarding the use of the contracted service. It is seen that issues regarding appropriate and inappropriate use of the network, and control mechanisms regarding levels of use can be regulated to some extent through a more direct relationship between costs and service.

The key issue here is that it is appropriate that the financial control of the undertaking rest with the clients of the service as purchasers of a service, rather than having the clients be participants in a process where overall financial control is in the hands of the service provider and the clients are placed in the position of underwriting the service costs.

The outcome of these considerations is a need for prior negotiation between each institution and AARNet regarding the level of delivered services, the costs associated with such service levels and the local management requirements associated with the ability to purchase an agreed level of service from AARNet. This will also impact on the engineering requirements within AARNet, as there is a commitment on the part of AARNet to maintain a network which sits within the contracted levels of income and is capable of providing the associated levels of service.

The overall model which preserves the essential attributes of common funding and still allows individual institutions to determine increased levels of access is that of a common

base funding, plus a schedule of incremental subscription rates for provision of increased levels of access over that defined within the common base model.

This two-tier approach preserves the advantages of common purchase of a basic level of services and reduces the risk levels of the service provision operation through the definition of a commonly funded core operation, while admitting the ability for institutions to purchase additional levels of access to AARNet services in accordance with a schedule of additional charges. In this way as individual institutions plan for increased use of external services across the network, the access capacity can be increased in accordance with such institutional objectives.

R.8 **It is recommended that institutions continue to participate in a common purchasing program for network services, on the basis of common purchase of a uniform base access level, together with the ability for individual institutions to purchase enhanced access levels at incremental cost.**

AARNet Service Offerings

This report advocates a service structure for AARNet as follows:

AVCC member institutions use a commonly funded level of basic uniform service. This service extends to each institution. The service provided is 37 tail loops of a uniform capacity and national and international trunk services. For 1992 this common access capacity is 48Kbps. For 1993 the common access capacity is proposed to be 128Kbps (using ISDN services 128K access can be provided at similar cost levels to the current 48Kbps service).

Additional capacity between the institution and the Regional Hub may be provided at the institution's incremental cost. An incremental subscription rate would apply in these cases, based on the aggregate access capacity.

CSIRO purchases a organisational access position to the national and international trunk services. The access position allows all CSIRO Divisions to connect to the closest Regional Hub at their hub at a common specified maximum capacity. For 1993 it is proposed to set this access capacity to 128Kbps, to be aligned with the AVCC member institutions' common base service level. The tail loop connection is provided at the Division's cost.

Additional capacity between the CSIRO Division and the Regional Hub may be provided at the Division's cost, with an incremental subscription rate being applicable in such cases, based on the aggregate access capacity. It is proposed use a single schedule of such charges for both AVCC Member Institutions and CSIRO.

Other Clients would purchase access to the national and international trunk services at a subscription rate based on access capacity. The access point is the closest Regional Hub, and in terms of charge schedules the client would be financially responsible for all costs associated with the connection to this access point. The access costs to AARNet are based on the proportional use of the common trunk network and a proportion of operational costs and specialised support and marketing costs. It is so structured such that this area of operation is intended to produce a net operating surplus.

The Common Base Service to the AVCC Member Institutions and CSIRO

The proposed base service program is intended to fund the following installed infrastructure:

- 2Mbps trunk services along the South East sector,
- direct connection to the backbone trunk network by the Regional Hub sites,
- 2Mbps trunk connection to an East Melbourne hub to service Monash University and CSIRO Clayton, and
- 48Kbps tails to all other AVCC member institution sites.

The 1993 base model is also proposed to include a number of upgrades to this set of installed facilities:

128K Common Access Level

The major proposed change is funded provision for 128Kbps connections to AVCC member institutions sites. This is an upgrade from the existing 48Kbps model of service, but can be achieved with very small total incremental cost by using AOTC's ISDN offering instead of the higher priced DDS service. Connections to 17 AVCC member institutions would be affected by this change.

Backbone Network Upgrades

The base model also includes provision for additional capacity over 1992 levels to Western Australia, taking the delivered capacity into Western Australia to 2Mbps (estimated to be installed in 3rd quarter 1993) and 128K trunk capacity to Tasmania and the Northern Territory.

Provision has also been made to an upgrade of the PACCOM Internet circuit to 1.5Mbps (T1) capacity (estimated to be installed in 3rd quarter 1993). The requirements for this additional capacity in the backbone network is based on considerations as detailed in the section on Engineering Capacity Considerations (page 22). It is noted that this installation date is planned to occur well after critical congestion is anticipated on this service (congestion and consequent degradation of the service is anticipated to be a critical issue by March 1993), but requested budgetary constraints within the 1993 program mandate this delayed implementation.

The expenditure schedule is indicated in Table E-1 of Attachment E.

The funding model for the common base services provided by AARNet assumes:

- a funding mechanism by AVCC member institutions where individual institutional funding levels are in proportion to the annual institutional operating grant.
- a constant level of CSIRO support in the base service model at the same proportional position as 1992.
- Australian Research Council funding support of $1m in 1993 and support for the Education and Development program at the level of $150,000 p.a. for the following two years.

Table 2 includes the level of funding commitment from the AVCC member institutions and CSIRO to support the common base funding.

Incrementally Purchased Services

Together with this base model is a schedule of charges associated with an AVCC member institution or a CSIRO division purchasing additional access capacity over the 128Kbps capacity provided within the base service configuration. In those cases where capacities higher than the common base level have been, or are being purchased, the institution will be required to meet additional AARNet costs as per Table 1.

The charge schedule for capacity in excess of 128Kbps is based on expectations of increased AARNet costs in engineering the trunk network to provide appropriate resources to the increased tail link and a proportion of operational costs. The underlying engineering assumption is a daytime average level of traffic utilisation of megabit capacity links of some 15% of the actual link capacity, and average level of traffic utilisation of kilobit capacity links of some 35% of actual capacity. The assumption here is that the additional access capacity is required for quality of service during short peak load periods and is installed in a timely fashion, rather than alleviating sustained and acute load problems.

Capacity	Rate $ p.a.	
128Kbps	Provided	
256Kbps	10,000	+ incremental tail loop charges
512Kbps	15,000	+ incremental tail loop charges
1Mbps	20,000	+ incremental tail loop charges
2Mbps	25,000	+ incremental tail loop charges
10Mbps	30,000	+ incremental tail loop charges

Table 1 Schedule of Rates for Additional Institutional Access Capacity

Such a charge schedule is presented in Table 1, using a exponential scale of unit cost of increased bandwidth which matches both the ability to decrease unit costs in the trunk network though the purchase of higher capacity levels and the nature of traffic levels on higher capacity media which tends more towards short burst traffic patterns over the sustained load characteristics seen at lower capacities.

This schedule of charges ensures that the effect of an institution or CSIRO division increasing its tail loop capacity is cost neutral to all other network clients, and the rates nominated here contribute to increasing the trunk capacity of the network as well as contributing a proportional amount to the total operational costs of the network.

The costs of the incremental capacity for the tail loop itself is to be met by the institution concerned in addition to the above charges. With the current purchase schedules from AOTC there is no net financial advantage for institutions in either position (discounts for scale of purchase are effectively unobtainable in the current market). However there may be advantage for institutions undertaking the provision of a microwave links (or infrared or laser under certain circumstances) within metropolitan areas as an alternative to continued lease of capacity. While the institution would have to fund the initial capital purchase costs of up to $80,000 for a 2Mbps radio link, the low recurrent costs make the configuration cost attractive after 12 - 15 months when taking into consideration the benefits the institution

would accrue in being an access provider dor AARNet providing base level access for the institution.

It is proposed that this schedule be set for 1993, and that the schedule of charges would be reviewed annually by the AARNet Management body.

It should be noted that if the current regional hub arrangements are preserved within this funding model this effectively implies that for the Queensland, New South Wales, ACT, Victorian, South Australian and Western Australian hubs, that their effective 10Mbps connection (implemented as a LAN connection into part of the trunk network within the base infrastructure) is implemented as a component of the regional hub agreements, adding a notional $30,000 p.a. to the value of the contract for Regional Hub services.

These charges would apply to AVCC member institutions and CSIRO. The possible uptake of additional capacity over the triennium is indicated in Table D-2 in Attachment D. The projection is based on a growth model of traffic levels doubling every four months, which is a continuation of traffic growth levels as experienced over the previous two years of operation.

Given such a schedule of purchase of additional capacity over base levels it is anticipated that a small operational surplus will be generated. Greater levels of purchase will enable additional backbone capacity to be installed both domestically and for the international circuits to meet the additional traffic requirements. Lower levels of uptake than those indicated above, or upgrades implemented within a longer time frame will allow a longer lead time in the installation of additional backbone trunk capacity.

The Affiliate Membership Program

As noted elsewhere in this document there are significant opportunities for enhancing the cost effectiveness of the AARNet service through economies of scale of operation by adopting open access policies and actively marketing and servicing to a large potential client population. The model used here is a progressive development of the existing AARNet Affiliate Membership program, by in the first instance adopting an access policy based on compatible interest, and subsequently examining the issues associated in AARNet adopting an open service role.

The mode of access is such that each network client is responsible for funding the connection to the closest point of attachment to AARNet (a Regional Hub), and paying an AARNet service fee based on connection capacity (although to position a service offering closer to client requirements it may well be the case that AARNet as the service provider would purchase the tail loop and the terminating router for the client on a cost basis - this would have no net effect on the revenue and costings as presented in the following tables).

The number of clients is dependant on five major factors:

- access policy constraints,
- client requirements,
- the service fee schedule,
- the level of marketing activities, and
- the quality of service and support.

The AARNet Affiliate Membership program has generated some $0.6m in revenue for 1992, at a direct interface equipment cost of $85,000 for the year, with $0.5m used to offset institutional and CSIRO contributions. Traffic levels associated with this program are some 3% of total traffic levels, so that incremental capacity costs to support this program are relatively minor at this level of participation. A breakdown of current levels of participation in this program is indicated in Table C-3 of Attachment C.

The proposed tariffs for services for the Affiliate Membership program for the triennium have been slightly adjusted on the basis of observed traffic levels and associated costs from the Affiliate Membership program over 1991 and 1992.

In assessing a three year projection for this program the factor driving the level of growth in the client base is both a policy framework which allows access to AARNet and whether the strategic decision is taken to actively market the network's services and to provide the appropriate range and quality of services to the client base.

One scenario (scenario A)is to continue along the broad lines of the current Affiliate Membership program, where there is no active promotion or marketing of the program, and the level of services offered rely on a high degree of in-house technical capability on the part of the client in order to make use of the AARNet services which are being offered. At the same time access policies would be based on identification of compatible interest to the universities and/or CSIRO. A continuation of this program would see levels of external participation in AARNet grow at a relatively small rate over the triennium. Furthermore it is reasonable to suggest that there would be alternative suppliers of Internet services who would be both actively marketing the product and matching the marketing to "plug-in" services which would be more closely attuned to many client's requirements. (Table E-3 in Attachment E) indicates the likely costs, participation levels and overall cost / return position for AARNet within this scenario.

An alternative scenario (scenario B) is to establish a broad external client base in order to achieve additional efficiencies through increased scale of operation. If it is desired to actively pursue a large proportion of the potential client base then it would be necessary for AARNet to adopt open service provider access policies without common interest preconditions. Such a policy position will increase the utility of AARNet to the academic and research client base though a wider domain of direct connectivity and could provide financial benefits to AVCC member institutions and CSIRO.

The assumptions underlying an analysis of the outcomes of such a policy position include the use by contract of an appropriately positioned commercial organisation to market the range of service offerings and to provide appropriate levels of specialised support for clients of the program, as effective marketing and high quality support are the keys to an enhanced level of external participation in AARNet. The academic and research sector is not well equipped to enter this area of commercial undertaking from a managerial or organisational position, nor is the commercial market confident in an offering which is too closely associated with this sector (the most likely factor being a perception that an academic and research sector-based service offering will be poorly attuned to their requirements).

The analysis and associated projections in this scenario are also based on a lowest risk model of program development, so that the program is assumed to operate as a self-funded program with no initial investment required, and with no net financial commitment on the part of the AVCC or CSIRO in support of the program at any stage.

Table E-4 (in Attachment E) indicates the likely costs, participation levels and overall cost / return position for this alternative scenario, taking a conservative view of the growth of the program. It should be noted that financially this scenario is not substantially different from the projections associated with scenario A for 1993 and 1994, but the net result of the

marketing program would be anticipated to be visible in 1995, and the projected net return of $2M is double that projected with scenario A for 1995.

In considering the primary objective of AARNet in providing service to the academic and research sector, then it would appear reasonable to indicate that the first scenario, that of access to AARNet through the Affiliate Membership program being based on identification of "compatible interest" with the academic and research sector, would be more closely aligned to the academic and research aims and objectives of the AVCC and CSIRO. However it should be noted that a likely outcome of such a strategic direction is the establishment of alternate open providers of Internet services. In such a situation predictions of the ultimate position of the AARNet Affiliate Membership program in terms of participation rates and net financial position has a high level of uncertainty associated with the second and third years of the triennium projections. The summary table, Table 2 overleaf, assumes this first scenario, and accordingly the levels of uncertainty relating to the figures associated with the Affiliate Membership program should be noted.

Australian Research Council support for AARNet

As a national program providing extensive infrastructural support to all institutional research activities (including national and regional distributed access to supercomputing facilities) the AVCC has received the financial support of the Australian Research Council over the 1990 - 1992 triennium through the ARC's Research Cooperative Infrastructure Development Grants, Mechanism C program.

This business plan proposes continued support by the ARC for AARNet for 1993 at a level of $1M, allowing 12 months for institutions to include within their budgetary processes provision for assuming this area of funding responsibility for 1994 and 1995. A continued role in 1994 and 1995 for developmental activities is indicated for the ARC to a level of $150,000 p.a. It is noted that the AVCC should assume an underwriting role with respect to the funding requested from the ARC.

Expenditure Projection for AARNet

The total expenditure and income projection for AARNet are summarised in Table 2.

	92 $'000	93 $'000	94 $'000	95 $'000
SERVICE COSTS				
Backbone				
Base Service (AVCC & CSIRO)				
Communications	1,962	2,363	2,863	2,863
Equipment	293	220	220	220
Licenses & Contracts	40	40	40	40
Capacity Options (AVCC & CSIRO)				
Communications		146	644	810
Affiliate Membership				
Communications		46	145	225
Equipment	85	15	16	18
AVCC Member Tail Loop Connections				
Comms	586	395	395	395
Equipment	95	323	69	69
TOTAL	3,061	3,548	4,443	4,691
OPERATIONS COSTS				
Staff	181	284	341	341
Operational Contracts	171	181	181	181
Training & Travel	62	65	65	65
Development	150	150	150	150
TOTAL	568	680	737	737
TOTAL COSTS	**3,629**	**4,228**	**5,180**	**5,428**
INCOME				
Base Service				
AVCC	1,242	1,361	2,399	2,263
CSIRO	290	326	399	377
ARC	1,000	1,000	150	150
PACCOM	470	500	500	500
Capacity Options		215	670	840
Affiliates - Mail	83	70	85	100
Affiliates - IP	549	756	977	1,198
TOTAL INCOME	**3,634**	**4,228**	**5,180**	**5,428**
NET OPERATING SURPLUS	5	0	0	0

Table 2 Summary of Total Cash Flow Projection for 1993-1995

Summary

It is recommended that the most appropriate AVCC institutional funding mechanism for funding for AARNet is that of base services uniformly funded, plus the option of institution-funded upgraded service access.

It is recommended that a "compatible interest" access policy for the Affiliate Membership program be implemented, using a subscription rate charging mechanism for access, and that further consideration should be given to adopting an open access policy.

Accordingly the following recommendations are proposed:

R.9 **It is recommended that access to the network be operated under an access and usage policy which admits use of the network by any organisation with interests compatible with the academic and research sector.**

R.10 **It is recommended that operational surpluses from the Affiliate Membership program be used to underwrite the costs of providing services within the AVCC and CSIRO common base service levels.**

APPENDIX A

THE CLIENT BASE OF AARNET

The following is a listing of the clients of AARNet as of April 1992.

There are 37 AVCC member institutions connected to AARNet, as well as the AVCC Secretariat offices.

Australian Catholic University	acu.edu.au
Australian Defence Force Academy	adfa.oz.au
Australian National University	anu.edu.au
Ballarat University College	buc.edu.au
Bond University	bu.oz.au
Charles Sturt University	csu.edu.au
Curtin University of Technology	curtin.edu.au
Deakin University	deakin.oz.au, vicool.edu.au
Edith Cowan University	cowan.edu.au
Flinders University	flinders.edu.au
Griffith University	gu.edu.au
James Cook University	jcu.edu.au
La Trobe University	latrobe.edu.au, ucnv.edu.au
Macquarie University	mq.oz.au
Melbourne University	unimelb.edu.au/mu.oz.au
Monash University	monash.edu.au
Murdoch University	murdoch.edu.au
Northern Territory University	ntu.edu.au
Phillip Institute of Technology	phillip.edu.au
Queensland University of Technology	qut.edu.au
Royal Melbourne Institute of Technology	rmit.oz.au
Swinburne Institute of Technology	swin.oz.au
University of Central Queensland	ucq.edu.au
University of Southern Queensland	usq.edu.au
University of Adelaide	adelaide.edu.au
University of Canberra	canberra.edu.au
University of New England	une.oz.au
University of New South Wales	unsw.oz.au
University of Newcastle	newcastle.edu.au
University of Queensland	uq.oz.au
University of South Australia	unisa.edu.au
University of Sydney	su.oz.au
University of Tasmania	utas.edu.au
University of Technology, Sydney	uts.edu.au
University of Western Australia	uwa.oz.au
University of Western Sydney	uws.edu.au
University of Wollongong	uow.edu.au
Victorian University of Technology	vut.edu.au
Australian Vice-Chancellors' Committee	avcc.edu.au

For CSIRO the majority of connections have been implemented through co-location with a University campus. Direct AARNet connections to CSIRO sites (as distinct from campus-hosted connections) have been implemented in Perth (Floreat Park), Adelaide (DMS), Melbourne (a shared Monash / Clayton link and the Joint Supercomputer Facility link), Hobart (Marine Laboratories), Canberra (Black Mountain), and Sydney (North Ryde). Campus hosted connections exist in Melbourne, Canberra, Brisbane and Hobart.

CSIRO(Australia-wide domains)	
Audit Group	audit.csiro.au
Management Information Systems	mis.csiro.au
Institute of Information Sciences and Engineering	iise.csiro.au
Biometrics Group	biom.csiro.au
Division of Mineral Process and Engineering	dmpe.csiro.au
Division of Food Processing	dfp.csiro.au
Division of Biomolecular Engineering	dbe.csiro.au
CSIRO(NSW)	
Division of Information Technology	syd.dit.csiro.au
Division of Radio Physics	rp.csiro.au
Australia Telescope National Facility	atnf.csiro.au
Division of Animal Production	prospect.anprod.csiro.au
Division of Mathematics and Statistics	syd.dms.csiro.au
Division of Applied Physics	dap.csiro.au
Division of Manufacturing Technology	syd.dmt.csiro.au

Divising of Exploration Geoscience	syd.deg.csiro.au
Division of Coal and Energy Technology	syd.dcet.csiro.au
Division of Building, Construction and Engineering	syd.dbce.csiro.au
Division of Wool Technology	syd.dwt.csiro.au
Division of Water Resources	griffith.dwr.csiro.au
CSIRO(VIC)	
Division of Mathematics and Statistics	mel.dms.csiro.au
Division of Information Technology	mel.dit.csiro.au
Division of Manufacturing Technology	mlb.dmt.csiro.au
Division of Building, Construction and Engineering	mel.dbce.csiro.au
Division of Wool Technology	syd.dwt.csiro.au
Division of Chemicals and Polymers	chem.csiro.au
Division of Animal Health (Parkvile)	mel.dah.csiro.au
Australian Animal Health Laboratory	aahl.dah.csiro.au
Division of Atmospheric Research	dar.csiro.au
Division of Mineral Products	dmp.csiro.au
Division of Material Science and Technology	mst.csiro.au
Division of Geomechanics	mlb.geomechanics.csiro.au
Information Services Branch	isb.csiro.au
Joint Supercomputer Facility	jsf.csiro.au
CSIRO(ACT)	
Division of Entomology	ento.csiro.au
Centre for Environmental Mechanics	enmech.csiro.au
Division of Mathematics and Statistics	cbr.dms.csiro.au
Division of Plant Industry	pi.csiro.au
Division of Soils	cbr.soils.csiro.au
Division of Wildlife and Ecology	dwe.csiro.au
Division of Information Technology	csis.dit.csiro.au
CSIRO(SA)	
Division of Human Nutrition	dhn.csiro.au
Division of Mathematics and Statistics	adl.dms.csiro.au
Division of Soils	adl.soils.csiro.au
Division of Water Resources	adl.dwr.csiro.au
Division of Manufacturing Technology	adl.dmt.csiro.au
CSIRO(WA)	
Division of Mathematics and Statistics	per.dms.csiro.au
Division of Water Resources	per.dwr.csiro.au
CSIRO(Qld)	
Division of Manufacturing Technology	brb.dmt.csiro.au
Division of Geomechanics	brisbane.geomechanics.csiro.au
Division of Soils	tvl.soils.csiro.au
Division of Tropical Animal Production	tap.csiro.au
Division of Tropical Crops and Pastures	tcp.csiro.au
Tropical Forest Research Centre	tfrc.csiro.au
CSIRO(Tas)	
Marine Laboratories (Oceanography + Fisheries)	ml.csiro.au
Forestry Division	forest.csiro.au

A further 37 organisations are connected to AARNet via the Affiliate Membership program (with a direct network link), and an additional 150 organisations are connected via electronic mail.

NETWORK SERVICE AFFILIATE MEMBERS	
Anglo Australian Observatory	aao.gov.au
Atlantek Microsystems	atlantek.com.au
Austek Microsystems	austek.com.au
Australia Computing & Communications Institute	acci.com.au
Australian Antarctic Division	antdiv.gov.au
Australian Artificial Intelligence Institute	aaii.oz.au
Australian Bureau of Agriculture and Resource Economics	abare.gov.au
Australian Electoral Commission	
Australian Nuclear Science and Technology Organisation	ansto.gov.au
Australian Oceanographic Data Centre	aodc.gov.au
Australian Institute of Marine Science	aims.gov.au
Australian Seismological Centre	ausseis.gov.au
AWA Defence Industries	awadi.com.au
Australian Sports Commission	
BHP Research Laboratories	bhp.com.au
Bureau of Meteorology	bom.gov.au
Bureau of Mineral Resources	bmr.gov.au
Computer Education Centre	cec.edu.au
Comalco Research Centre	cra.com.au
Cooperative Library Association Network of NSW	clann.edu.au
Defence Science and Technology Organisation	dsto.oz.au
Department of Transport and Communications	dotc.gov.au
Earth Resource Mapping	erm.oz.au

Exicom	exicom.oz.au
Geelong and District Water Board	gdwb.oz.au
Great Barrier Reef Marine Park Authority	gbrmpa.gov.au
Internode Systems	internode.com.au
IPS Radio and Space Services	ips.oz.au
Miden Pacific	miden.com.au
National Library of Australia	nla.gov.au
Northern Territory Department of Mines and Energey	dme.nt.gov.au
Pegasus Networks	pegasus.oz.au
Pyramid Technology Corporation	pyramid.com.au
South Australian Department of Employment and TAFE	tafe.sa.edu.au
South Australian Department of Lands	lands.sa.gov.au
South Australian Department of Roads	roads.sa.gov.au
South Australian Department of Environment & Planning	dep.sa.gov.au
State Library of South Australia	slsa.sa.gov.au
State Systems (South Australian Computing Service)	systems.sa.gov.au
Sugar Research Institute	sri.org.au
Technology Park Adelaide	tpa.com.au
Telecom Australia Research Laboratories	trl.oz.au
University Co-operative Bookshop	

MAIL SERVICE AFFILIATE MEMBERS

ACT Electricity and Water	actew.oz.au
ANZ Banking Group, Global Technical Services	anz.com.au
Adept Software	adept.oz.au
Alcatel Australia	alcatel.oz.au
Aldetec	aldetec.oz.au
All Graphics Industries	agi.oz.au
Anti-Cancer Council of Victoria	accv.oz.au
Apple Computer Australia	apple.oz.au
Ausonics	ausonics.oz.au
Australian Airline	ausair.com.au
Australian Centre for Unisys Software	syacus.acus.oz.au
Australian Computer Society	acs.org.au
Australian Council for Educational Research	acer.edu.au
Australian Defence Industries	adied.oz.au
Australian Institute of Criminology	crime.oz.au
Australian National Botanical Gardens	anbg.gov.au
Australian National Parks and Wildlife Service	anpws.gov.au
Australian Radiation Laboratory	arl.oz.au
Avid Systems	avid.oz.au
BHP CPD Research and Technology Centre	kembla.oz.au
BHP Information Technology, Newcastle	bhpese.oz.au
BICC Communications	bicc.oz.au
Bain & Company	bain3.oz.au
Boral Elevators	jpl.oz.au
Burdett Buckeridge and Young	bby.oz.au
Byrne and Davidson	bnd.oz.au
CITEC	citec.oz.au/qsg.gov.au
CSA	csa.oz.au
Canon Information Systems Research Australia	canon.oz.au
Chancery Lane Computer Services	clcs.com.au
Chiron Mimotopes	chiron.com.au
Classified Computers	ccpl.oz.au
Co-Cam Computer Group	cocam.oz.au
Codex Software Development	codex.oz.au
Coles Supermarkets	coles.storesys.oz.au
Colonial Mutual	
Com Tech Communications	ct.oz.au
Commercial Dynamics	cdsyd.oz.au
Communica Software Consultant	communica.oz.au
Communications Development and Research	cdr.oz.au
Computechnics	ctechnics.oz.au
Comperex Systems	cx.oz.au
Computer Power Software	cpg.oz.au
Computer Sciences of Australia	csasyd.oz.au
connect.com.au	connect.com.au
Corinthian Engineering	ci.oz.au
County Natwest Australia	county.oz.au
DECUS	decus.com.au
Data General Australia	dg.oz.au
Datacraft Limited	datacraft.oz.au
David Burren	eyrie.oz.au
David Nugent	csource.oz.au
Defence Service Homes	dsh.oz.au
Department of Agriculture and Rural Affairs, Victoria	agvic.gov.au
Department of Health, Housing and Community Servics	hhcs.gov.au
Dept of Conservation and Environment, Victoria	msl.oz.au
Dept of Premier and Cabinet, Victoria	vicgov.oz.au
Dialix	dialix.oz.au
Discreet Logic	dl.oz.au
Duesburys Information Technology	dues.oz.au
Environmental Resource Information Network	erin.gov.au
ESRI Australia	esri.oz.au
Eastek	eastek.oz.au

Expert Solutions	esa.oz.au
FGH Decision Support Systems	fgh.oz.au
Fujitsu Australia	fujitsu.oz.au/faloz.oz.au
Fulcrum Consulting Group	fulcrum.oz.au
Functional Software	pyrmania.oz.au
Genasys II	genasys.com.au
Gestetner Pty Ltd	gestetner.oz.au
Graphics Computer Systems	gcs.oz.au
Highland Logic	highland.oz.au
Honeywell	honeywell.oz.au
Iconix	iconix.oz.au
Industry Commission	
Information Technology Consultants	itc.oz.au
Insession Pty Ltd	insession.oz.au
International Development Program	idp.edu.au
International Railroad Systems	tirs.oz.au
Ipec Metro Distribution	main.com.au
Irvine and Associates	irvine.com.au
John O'Brien	wsa.oz.au
Labtam	labtam.oz.au
Lancorp Pty Ltd	lancorp.oz.au
Land Information Centre	nswlands.oz.au
Leeds and Northrup Australia	lna.oz.au
MHS Systems	mhs.oz.au
MINCOM	mincom.oz.au
Megadata	megadata.mega.oz.au
Melbourne Information Technology Services	mits.com.au
Menhennitt Consultants	mencon.oz.au
Metal Trades Industry Association of Australia	mtia.oz.au
NEC Information Systems Australia	necisa.oz.au
Network Solutions	nsg.com.au
Nick Andrew	zeta.org.au
NorTel Technology Centre	c/o uow.edu.au
NSW Department of Agriculture	nswda.oz.au
OTC	otca.oz.au
OpSys Can Unit, Telecom	canocc.telecom.oz.au
Ozware Developments	ozware.oz.au
Philips PTS	philips.oz.au
Praxa	praxa.com.au
Prentice-Hall	prenhall.com.au
QH Tours	qhtours.oz.au
QPSX Communications	qpsx.oz.au
Queensland Department of of Primary Industries	qdpi.oz.au
RUNX Unix Timeshare	runx.oz.au
Roads and Traffic Authority, NSW	rta.oz.au
SBC Dominguez Barry	dbsm.oz.au
Santos	santos.com.au
Silicon Graphics	sgi.oz.au
Snowy Mountains Authority	sma.oz.au
Software Developments International	sdi.oz.au
Softway	sw.oz.au
Solbourne Computer	solbourne.oz.au
Sony Australia	sony.oz.au
South East Queensland Electricty Board	seqeb.gov.au
Stallion Technologies	stallion.oz.au
State Bank of NSW	state.com.au
State Electricity Commission of Victoria	secvic.oz.au
Stockdale Prospecting	spl.oz.au
Tandem Australia	tndsyd.oz.au
Tasmanian Department of Education	tased.oz.au
Tech Pacific	techpac.oz.au
Technix Consulting Services	technix.oz.au
Telecom - Customer Network Management Branch	cnm.telecom_cnm.oz.au
Telecom - Network Management Systems Development	nimrod.ta.oz.au
Telecom - Network Management Systems Development	nnmdmelb.telecom.oz.au
Telecom - Network Management and Protocol Development	nmpd.oz.au
Telecom Australia - Integrated Network Products Unit	card.inpu.oz.au
Telecom Australia, WA	telecomwa.oz.au
Telecom Network Engineering and Support Services	tne.oz.au
Telectronics	tpl.oz.au
The Australian Museum	austmus.oz.au
The Preston Group	tpg.oz.au
The Southport School	tss.oz.au
Toshiba International	tic.oz.au
Tower Technology	towers.oz.au
Turbosoft	abccomp.oz.au
Tusc Computer Systems	tusc.oz.au
Unixpac	unixpac.oz.au
VME Systems	vme.oz.au
Vibro Acoustic Sciences	vibro.oz.au
VSM Software Services	vsm.com.au
Webster Computer Corporation	wcc.oz.au
Wesley College	wesley.oz.au

APPENDIX B

The Architecture of AARNet

The basis of AARNet's architecture is to build on two factors:

- the significant investment in Local Area Network (LAN) technologies made by every member institution over the past five years or more (an investment which is well in excess of $200 million across the higher education sector), and
- the opportunities created by interconnecting the Australian network facility to similar facilities provided to peer scholars and researchers overseas.

The most effective component of the approach adopted by AARNet is this transparent interworking of the local and wide area networking environments: end users see no visible difference between transactions across the local network or transactions carried across AARNet. As a consequence there is no requirement for new applications, for re-equipping the local environment or for retraining of end users in order to use the WAN environment effectively. More importantly from the perspective of the end user the physical topology of AARNet is not visible - the interior structure of AARNet is a single very large switching exchange between the attached LANs. The physical interconnection is implemented by connecting each LAN to AARNet via a network router deployed at each client site. These routers also act as the internal exchange switches within the network and are physically interconnected through dedicated point-to-point digital transmission streams. This structure is indicated in Figure B-1.

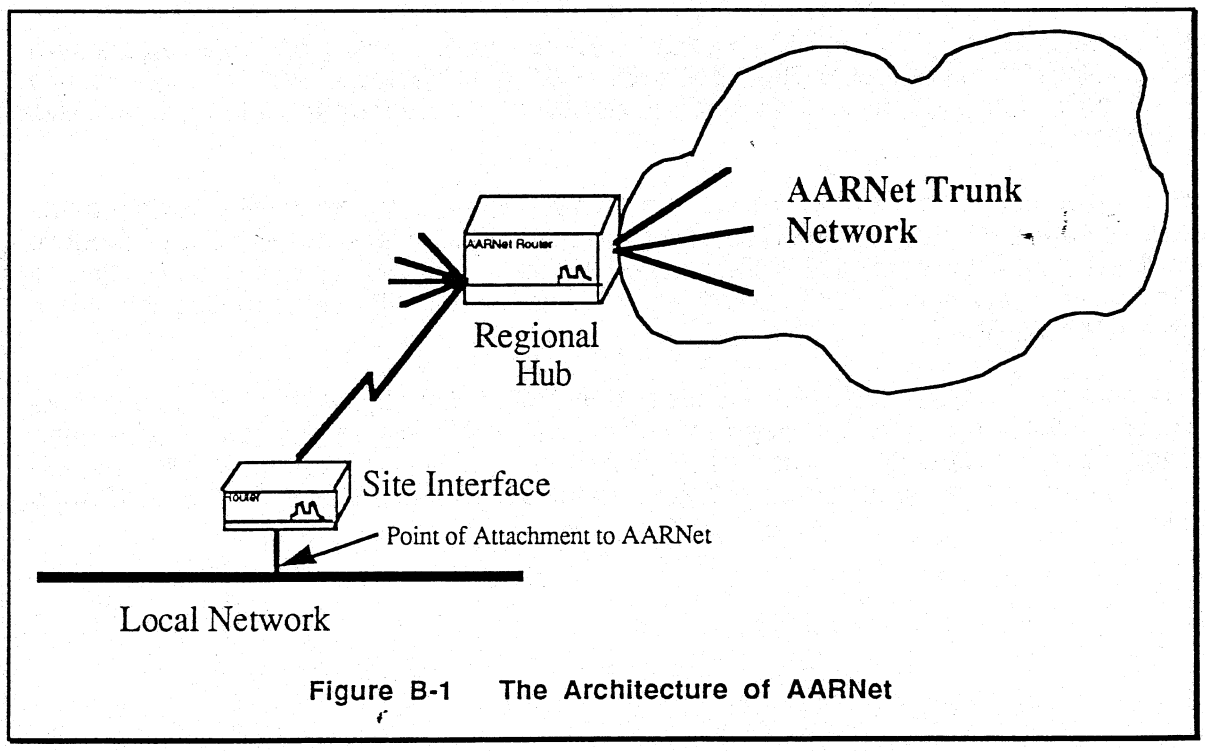

Figure B-1 The Architecture of AARNet

This architecture is very effective, due to its underlying simplicity and flexibility. The interconnection of the routers can be implemented by any reliable digital transmission medium, including low and high speed leased lines, switched circuits (such as ISDN or

X.25), microwave, fibre cable or satellite links. This flexibility allows AARNet to purchase the most cost effective digital services at any point in time.

As well as providing flexibility in terms of basic connectivity options the routers also allow considerable flexibility in terms of supported protocols[4]. The major protocol supported by AARNet is the Internet protocol suite. There is also support of a national Phase IV DECnet, and support for X.25 and Appletalk protocols within regions of AARNet.

Some 98% of current AARNet traffic is however Internet protocol traffic and 100% of the international traffic is Internet protocol traffic. Additional protocols can be supported as a software option without any requirement for additional equipment, greatly enhancing the ability of the network to be highly responsive to the evolving needs of the client population in the face of rapidly evolving technologies. This is perhaps the major difference between AARNet and related public communications networks which are generally dedicated single protocol environments.

The inter-router physical link topology employed by AARNet is the result of detailed consideration of a number of related factors:

- end-to-end traffic flow patterns, which in turn indicate optimal infrastructure capacities to service current and anticipated traffic demands;
- the carrier's tariff structure, where the objective to meet traffic capacity requirements with minimal expenditure on distance links; and
- provision of a reliable service.

The outcome of an analysis of these three areas with respect to AARNet is that the network topology deployed within AARNet is that of a dual level star.

Within each State a Regional Hub acts as an interconnection point, and links radiate from this hub location to each client site. Links from a National Hub, located in Melbourne, radiate to each Regional Hub, as well as to the United States to support the international traffic requirements.

The choice of such a topology (as distinct from a mesh-like topology with multiple paths between major exchange points) is a reflection both of minimising costs in terms of public carrier tariffs and maximising available capacity within the network, as well as a reflection on the quality of service obtainable from the carrier and the reliability of the routing equipment used within AARNet.

The current topology of AARNet is indicated in Figure B-2 (overleaf). High speed links (2Mbps links) interconnect the Regional Hubs located at Adelaide, Brisbane, Sydney and Canberra to the National Hub located at Melbourne. The link to Perth is at 128Kbps, the links to Darwin and Hobart are at 48Kbps and the link to the United States is a 512Kbps link.

4 Protocols within a digital network can be viewed as a common standard of formatting of information so that both the transmitter and receiver can agree on the structure of the flow of information.

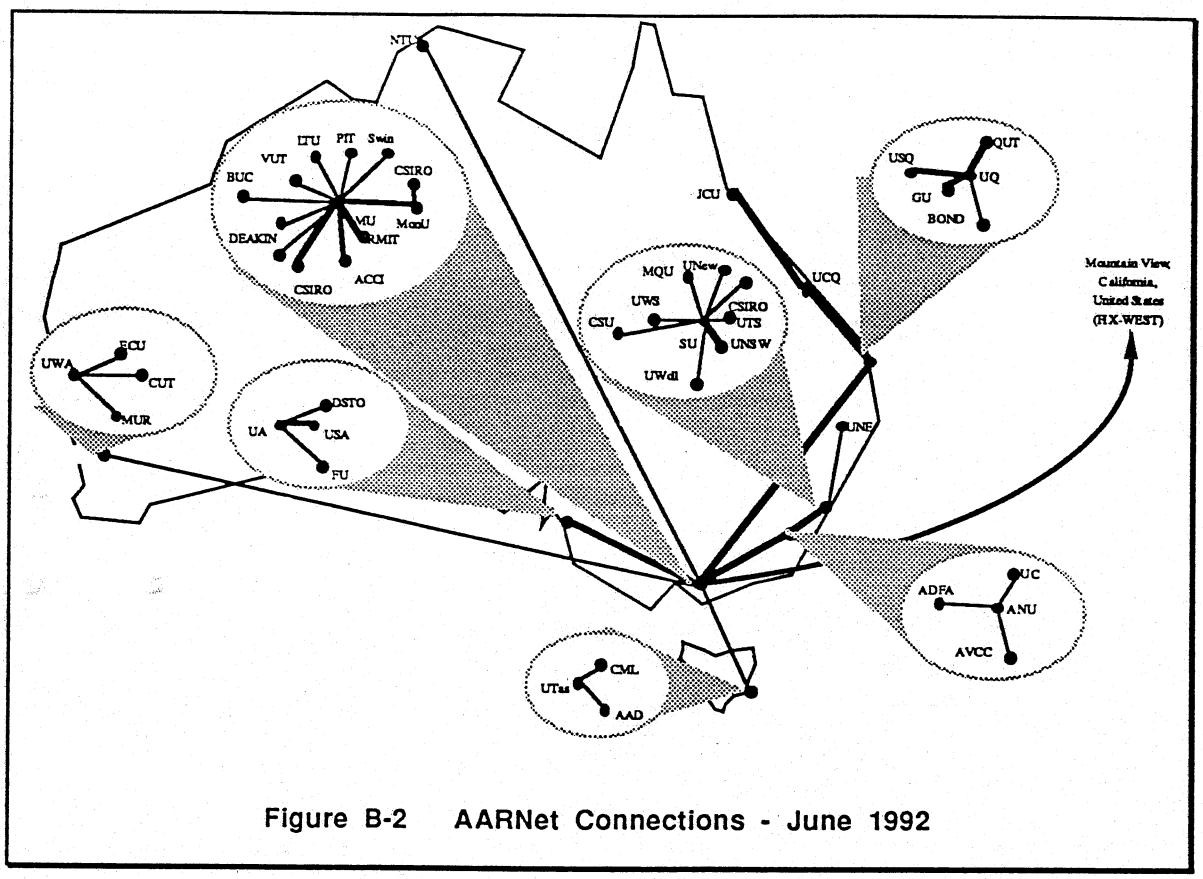

Figure B-2 AARNet Connections - June 1992

The underlying communications service for AARNet is based on leased point-to-point digital services (supplied as both clocked digital services, unclocked megabit-capable trunk services and 64K ISDN switched digital stream services as carrier-supplied services and microwave as a private high speed point-to-point transmission medium). Other carrier services of some relevance are X.25, Frame Relay and cellular-switched megabit services. The domestic X.25 offering (Austpac) is too expensive and too low in performance to provide required transmission services. Frame Relay technologies offer more opportunity, but there is no deployment of this technology in Australia as a carrier service, nor is it anticipated within the next 12 months. Fastpac is a high speed cellular switched datagram service, but at this stage the Telecom tariffs do not appear to be clearly competitive with their other transmission offerings, and the access tariff structure is unusually complex. This situation may well change in the near future as AOTC position this new service to attract an initial customer base.

APPENDIX C

1992 AARNET EXPENDITURE SCHEDULE

	1990	1991	1992	1992 percentage
Funding				
AVCC Member Institutions	1,196,578	703,111	1,241,667	34%
Australian Research Council	854,400	917,000	1,000,000	28%
CSIRO	218,749	256,576	290,333	8%
Affiliate Membership program		358,500	631,600	17%
PACCOM[5]	144,000	228,000	470,000	13%
TOTAL	2,413,727	2,463,187	3,536,253	
Expenditure				
Communications	931,818	1,401,463	2,548,109	70%
Facilities Management	165,000	152,500	170,800	5%
Education & Development		110,868	153,934	4%
Administration	253,381	268,655	269,205	7%
Communications Equipment	835,627	479,214	486,292	13%
TOTAL	2,816,826	2,412,700	3,628,340	
Surplus for year	226,901	50,487	5,260	

Table C-1 AARNet Funding and Expenditure for 1990 - 1992

5 PACCOM is the US-funded program providing US half-circuit services to AARNet. The funding levels attributed to PACCOM are equivalent to anticipated AARNet costs, if AARNet were required to provide full-circuit funding from Australia into the US.

Detailed Breakdown of 1992 Expenditure Program	
Communications:	
Telecom leased lines	1,428,402
AOTC International Link	424,800
PACCOM US half circuit contribution	45,205
Institution-supplied links	179,702
PACCOM	470,000
	2,548,109
Facilities Management	
National Hub	28,000
Vic Hub	28,000
NSW Hub	28,000
QLD Hub	28,000
ACT Hub	16,800
SA Hub	14,000
WA Hub	14,000
Tas Hub	14,000
	170,800
Education and Development	
Directory Services - maintenance of equipment	7,200
Archie - maintenance, operational support and license costs	13,934
Networkshop'92 - advance on costs	5,000
Networkshop'92 - support for intn'l speakers and comms facilities	15,000
Training Project	112,800
	153,934
Administration	
Salaries	180,639
Meeting Costs	12,000
Staff Travel	40,009
Internet Society Membership	6,700
License Fees	12,548
Sundries	17,300
	269,205
Communications Equipment	
X.25 interface	50,000
Upgrades to AARNet routers	180,233
Workstation equipment	44,466
Equipment Maintenance	134,502
Netblazer Slipserver	25,091
	486,292
TOTAL	**3,628,340**

Table C-2 AARNet Expenditure Schedule for 1992

1992 Affiliate Membership Program

Service	Number	Unit Service Charge $'000
Mail		
Mail MX (via AUUG)	100	0.2
Mail MX	63	1
IP		
Dial-up	8	5
9.6K	19	8
19.2K	1	15
48K	4	25
64K	5	30
10M	1	60

Table C-3 1992 AARNet Affiliate Membership Program

APPENDIX D

1992 INSTITUTIONAL FUNDING LEVELS

The following table presents AVCC member institution funding levels for AARNet for 1992.

Institution	*AARNet Contribution $*	
Australian Catholic University	*10,854*	0.92%
Ballarat University College	*7,562*	0.64%
Bond University	*14,251*	1.21%
Charles Sturt	*20,358*	1.73%
Curtin University of Technology	*32,754*	2.79%
Deakin University	*34,393*	2.92%
Edith Cowan University	*23,142*	1.97%
Griffith University	*29,768*	2.53%
James Cook University of North Qld	*16,877*	1.44%
La Trobe University	*42,139*	3.58%
Monash University	*72,842*	6.19%
Murdoch University	*15,109*	1.28%
Northern Territory University	*7,756*	0.66%
Phillip Institute of Technology	*12,699*	1.08%
Queensland University of Technology	*41,170*	3.50%
Royal Melbourne Institute of Technology	*28,574*	2.43%
Swinburne Institute of Technology	*15,038*	1.28%
The Australian National University	*61,822*	5.26%
The Flinders University of SA	*23,373*	1.99%
The Macquarie University	*27,639*	2.35%
The University of Adelaide	*38,813*	3.30%
The University of Canberra	*13,576*	1.15%
The University of Melbourne	*76,155*	6.48%
The University of New England	*33,974*	2.89%
The University of New South Wales	*66,776*	5.68%
The University of Newcastle	*31,353*	2.67%
The University of Queensland	*64,619*	5.50%
The University of Sydney	*83,048*	7.06%
The University of Western Australia	*34,162*	2.91%
The University of Wollongong	*21,639*	1.84%
University College of Central Qld	*10,715*	0.91%
University College of Southern Qld	*13,570*	1.15%
University of South Australia	*36,725*	3.12%
University of Tasmania	*27,182*	2.31%
University of Technology, Sydney	*33,300*	2.83%
University of Western Sydney	*31,703*	2.70%
Victoria University of Technology	*20,490*	1.74%

Table D-1 AARNet Institutional Funding Levels for 1992

APPENDIX E

1993 - 1995 EXPENDITURE AND FUNDING

Table E-1 presents the forward estimates of cost for a common base configuration for AARNet over the triennium. The changes to the existing configuration included in this table are as follows:

- Australia - US upgrade to 1.5Mbps (scheduled implementation for July 1993)
- Melbourne - Perth upgrade to 2Mbps (scheduled implementation for October 1993)
- Upgrade of 17 tail loops to 128Kbps ISDN (scheduled implementation for March 1993)
- Additional (fractional) staff positions of Financial Management and Clerical support

	1992	1993	1994	1995
	$'000	$'000	$'000	$'000
SERVICE COSTS				
BACKBONE				
Comms	1,962	2,363	2,863	2,863
Equipment	293	220	220	220
Licenses & Contracts	40	40	40	40
Total Backbone Costs	*2,295*	*2,623*	*3,123*	*3,123*
AVCC Tail Loops				
Comms	586	395	395	395
Equipment	95	323	120	120
Total AVCC Tail Loops	*681*	*718*	*515*	*515*
TOTAL SERVICE COSTS	**2,976**	**3,341**	**3,638**	**3,638**
OPERATIONS COSTS				
Staff	181	284	341	341
Operational Contracts	171	181	181	181
Training & Travel	62	65	65	65
Developmental Activities	154	150	150	150
TOTAL OPERATIONS COSTS	**568**	**680**	**737**	**737**
TOTAL COSTS (BASE SERVICE)	**3,544**	**4,021**	**4,375**	**4,375**

Table E-1 AARNet Expenditure for 1990 - 1992 - Common Base Component

The ability for institutions to purchase additional capacity into AARNet is advocated in the plan. The following table presents a median estimate of the level of purchase of additional capacity by AVCC member institutions and CSIRO divisions over the triennium.

As noted in the body of the report, it is intended that the additional charges associated with higher capacity tail loops be used to fund matching upgrades of the AARNet backbone network to ensure that the network is well balanced in terms of engineering capacity to meet imposed traffic flows. This table indicates a purchase program of additional trunk capacity based on estimates of purchase of additional tail loop capacity.

		1993	1994	1995
Levels of Purchase of Additional Access Capacity				
	Capacity	No	No	No
	256K	3	21	11
	512K		4	3
	1M			3
	2 & 10M	5	16	25
	Total $'000	**215**	**670**	**840**
Expenditure for Additional Trunk Capacity				
	Trunk Upgrades[6]	$'000	$'000	$'000
	nsw-vic	146	215	215
	Qld-nsw		209	215
	Aust-Internet		220	380
	Total	**146**	**644**	**810**
	Surplus	69	26	30

Table E-2 Projected Levels of Purchase of Additional Access Capacity

6 The upgrades listed here assume traffic growth along the Melbourne - Canberra - Sydney - Brisbane axis as being the major growth component domestically, as well as increased international connectivity requirements, following 1993 capacity upgrades to Western Australia and the Internet which are proposed as part of the common base program.

The following table, E-3, projects costs, participation levels and return levels for the Affiliate Membership program given a continuation of the current program with "compatible interest" access policies. This structure assumes that AARNet would offer basic connection services on an as-is basis within a common interest grouping, without entering into marketing or specialised support activities.

Service	Comms Cost[7] $'000	AARNet Fee $'000		
Mail MX	0.25	1		
Dial-up IP	0.82	5		
9.6K	1.85	8		
64K	7	25		
128K	9	30		
256K	15	35		
512K	18	40		
1M	21	45		
2M	23	50		
10M	23	60		
Client Projections	1992	1993	1994	1995
Mail MX	64	70	85	100
IP Access	38	55	67	80
Cost/Return		1993 $'000	1994 $'000	1995 $'000
MX Sales		70	85	100
MX Costs		-18	-21	-25
		53	64	75
IP Sales		756	977	1,198
IP Costs		-43	-139	-218
		713	838	980
Total Returns		765	901	1,055

Table E-3 - Affiliate Membership Program - Scenario A

7 Includes $50 invoicing cost as well as average transmission costs.

The following table, E-4, projects costs, participation levels and return levels for the Affiliate Membership program based on the assumption that the program would be actively marketed and supported as an open access service. Accordingly costs associated with the undertaking of such a sales and support role are included here, and participation levels are based on the assumption that this program would be the major national provider of Internet services.

Service	Comms Cost $'000	Sales Cost $'000	AARNet Fee $'000	
Mail MX	0.2	0.1	1	
Dial-up IP	0.82	4	5	
9.6K	1.85	7	8	
64K	7	8	25	
128K	9	9	30	
256K	15	9	35	
512K	18	10	40	
1M	21	10	45	
2M	23	11	50	
10M	23	12	60	
Client Projections	1992	1993	1994	1995
Mail MX	64	100	140	200
IP Access	38	63	102	169
Cost/Return		1993 $'000	1994 $'000	1995 $'000
MX Sales		100	140	200
MX Costs		-30	-42	-60
		70	98	140
IP Sales		871	1,595	3,120
IP Costs		-386	-666	-1,147
		485	929	1,973
Total Returns		555	1,027	2,113

Table E-4 - Affiliate Membership Program - Scenario B