EdNA Online
Education Network
AUSTRALIA

BANDWIDTH REQUIREMENTS

for the Australian Education and Training Sector

Olaf Moon

Wildtwo (Consulting) Pty Ltd

August 1999

About this document

Table of Contents

Foreword

The Federal Government, through the Department of Communications, Information Technology and the Arts (DCITA), has established the National Bandwidth Inquiry to examine Australia's current position and to investigate issues relating to the capabilities of the Australian communications networks to deliver adequate infrastructure support for a full information economy. This report was commissioned by the Department of Education, Training and Youth Affairs (DETYA), as a contribution to the Inquiry to assist the work being undertaken by DCITA on bandwidth demand projection modelling as part of the Inquiry.

The main aim of the Inquiry is to provide authoritative information about known bandwidth availability and pricing matters, and to promote understanding about the strategic issues raised by the transition to a databased method of providing communications services.

The report has been prepared in consultation with the education and training sector, which is one of the largest users of telecommunications bandwidth in Australia. DETYA supports the view that it is critical for the sector to have adequate access to telecommunications bandwidth at a globally competitive price. However, the views expressed reflect a diverse range of stakeholder interests, and do not necessarily represent the views of DETYA.

The report will also be used to inform development of the Education and Training Action Plan which is being prepared by DETYA in response to the Commonwealth Government's Strategic Framework for the Information Economy. It is expected that further and more in-depth work on bandwidth issues will be undertaken at a later date.

1 Executive Summary

This report on Telecommunications requirements of the Australian Education Sector is very timely.

Access for all Australians to the Internet (and other data services), has become a fundamental component of business, government, education and recreation. Yet equity of access is a growing issue. The report shows that the lack of availability of telecommunications bandwidth, at a globally competitive price, is a key constraint to Australia's continued capability in the education and training sector. Some respondents to our surveys have reported that it is *the* key restraint in making this sector globally competitive, and is therefore limiting Australia's overall advancement in both the national and worldwide marketplace.

The study also shows that growth in Internet usage is likely to be logarithmic (grow by magnitudes of 10, not just multiples) over the next few years, in the education sector. Growth estimates for Internet usage are extraordinarily hard to make, and are regularly exceeded. For example, in 1997, private US analysts estimated that e-commerce would reach US$7 billion worldwide by 2001, but found that this number was exceeded by 50% in 1998! A growing proportion of this is on-line education in the VET and university sectors.

The report contains recommendations that support the use of information technology and global telecommunications networks, as a fundamental capability of this country. It defines the education and training sector as a primary catalyst supporting this capability, both through skills of Australians, and infrastructure.

Bandwidth is telecommunications capacity. Just as a larger plumber's pipe may carry a higher volume of water, so too can larger optical fibres carry a greater volume of data. In September 1998, and for the first time in history, Australian networks carried a larger volume of data than telephone traffic[2]. This fact fundamentally changed the way our telecommunications companies (carriers) such as Telstra and Optus, viewed their future business strategy.

In combination, the education sector is one of the largest users of telecommunications bandwidth in Australia.

AVCC members are the largest single user group in Australia, with about 750 000 users. This report shows that infrastructure has developed immensely over the last three years, lead by the University sector, but remains far from satisfactory, especially for schools and the VET sector. To some degree, Australia suffers from our position in the world, where we need to pay for Internet connection infrastructure across the Pacific, to Asia and Europe. Australia is a net importer of electronic information, at a ratio of 1:3.5, which was previously as high as 1:63.

Yet many industry commentators (such as IDC4, Forrester Research and Gartner Group) show that Australia has the second-fastest take-up of new technologies (such as the Internet) in the world, following the USA.

Currently, 31% of Australian homes have access to the Internet5 with much higher overall computer ownership.

This connection rate grew from 12% in just one year. Wider studies show that 65% of homes with school-age children have access.

The report focuses on three education groups:

?? Public Schools
?? The public Vocational Education and Training (VET) sector (usually TAFE colleges)
?? The University members of the Australian Vice Chancellor's Committee (AVCC) and other related research bodies.

Through time constraints, most of the non-government school sector and the commercial RTO's (Registered Training Organisations) are excluded from the data. Preparation of the report was done in a very short time-frame, so areas of potential additional focus and research, are regularly noted.

The recommendations are divided into three sections:

?? Policy Recommendations.
?? Proposed activities.
?? Observations; that are on the periphery of the Scope of this consultancy, but which were mentioned by a number of respondents, and are highly relevant to the broader matters of online education and training.

1.1 Policy Recommendations

The consultant recommends that DETYA and NOIE determine the most appropriate timing for consideration of these policy recommendations, in particular their juxtaposition to the Telstra 2 share float.

1. That the EdNA Schools Advisory Committee (ESAG) and EVAG prepare a proposal to the Commonwealth and MCEETYA, to instigate a national telecommunications discount program for the schools and VET education sectors. (This might be named AUS-E-RATE and benefit from the lessons learnt in the USA, both positive and negative, via its E-RATE Program.) Further that, on obtaining the costs comparison for each state, DETYA (in conjunction with the States) negotiate with Telstra and DCITA for consistent education pricing across Australia, especially for regional locations.
2. The consultant recommends that AUS-E-RATE be financed by the relevant deliverer of the USO, from its service margin.
3. That the Commonwealth should modify policy, and legislation if necessary, to allow AARNet to develop AARNet 3, with the inclusion of any other legitimate member of the education community including schools, research organisations and members of the VET sector, both public and private.
4. That, at an appropriate time, the Commonwealth put the Universal Service Obligations (USO) to public tender and re-consider inclusion of data components in that tender, such that regional users may obtain parity pricing for data services, with their city counterparts.
5. That the Commonwealth, through continuation of its program of de-regulation of the Telecommunications Sector, encourage increased competition in the telecommunications sector, particularly for "last mile" telecommunications services, with the objective of allowing market forces to determine broader telecommunication pricing regimes and delivery protocols.
6. That the Commonwealth defines a policy of not supporting transitionary telecommunications technologies such as asymmetric data delivery, where they may discriminate against remote, rural or other disadvantaged groups or individuals.

1.2 Recommendations for Action

7. That the EdNA Reference Committee, with assistance from DETYA, allocate resources to regularly (and at least annually) survey:
   - ?? the network structures and their maximum theoretical capacity for the education sector
   - ?? the proportion of this bandwidth used, by each State
   - ?? the monthly growth rate in that usage.
   - ?? the comparative costs of equivalent data services, by regional location.

And publish the results to the entire sector. Further, that DETYA encourage the EdNA SAG to utilise the information to better negotiate and bargain for appropriate services, on a national and collaborative basis.

Estimated cost is one salary, or equivalent, at $50 000 per annum.

8. That, in 1999 MCEETYA set a new National Education Data Standard (NEDS), for the provision of minimum bandwidth for every school and VET teaching location in Australia of at least 128Kbps in 2000, 256Kbps in 2001 and moving to 2Mbps by 2004.6 Further, that the standard recognises an increased bandwidth requirement for every institution, where the number of students exceeds a total of 200.
9. That the EdNA Reference Committee prepare a proposal to MCEETYA to develop a national strategy to ensure that all schools and VET providers in Australia are able affordably to gain access to bandwidth to at least the minimum benchmark levels.
10. That States give consideration to the provision of regional Points of Presence (POP) services from selected institutions, to enable cost effective dial-in Internet services for teachers and all students, thus enabling flexible learning and some distance delivery. Limitations should be to educational domains or material, rather than to particular student groups.
11. That DETYA consider developing a program of one-off funding of sixteen "Lighthouse Schools" (such as the Special Schools listed in the section below) across all states and territories, to specifically fund high-performance networks for key teaching applications, to the value of $80 000 per school. Schools must apply for the grants, and as quid pro quo, supply digital teaching materials in return, with the IP made freely available to any school in Australia.
12. That the Commonwealth co-sponsor a joint industry/AARNet/government proposal for an ultra high capacity (at least 5 Gbps) commercial network, to be paid for by users, similar to the Internet II Project in the USA. This project should be cost neutral to Government over five years.
13. That the ERC and DETYA consider annually, the likely new applications to be used on education networks, and make an estimate of the increased bandwidth that may be required on a macro level to Australia and across the sector, for the planning benefit of DETYA, DCITA and other Commonwealth agencies.
14. That, should the NBI not be able to provide precise comparisons of pricing for standard data services in the international education sector, that DETYA commission a separate consultancy to obtain this data for equivalent education organisations in the USA and other appropriate countries. The estimated cost is $25,000.

1.3 Related Observations and Implied Recommendations

The following items were mentioned by a number of respondents, but are peripheral to the Scope of this consultancy. To provide a complete teaching and training capability, they should be considered by DETYA and NOIE.

15. That DETYA consider supporting and promoting programs, that not only assist States with rollout of telecommunications infrastructure but also support critical related capabilities:
    - ?? Computers in Schools and TAFE colleges, with a target of one computer for every two students by 2003.
    - ?? LAN infrastructure including servers, NOS, routers and cabling.
    - ?? Education and learning software (with a target of 50% Australian digital content) that supports teaching across ALL subjects disciplines.
    - ?? Specialised instructional programs for teachers and parents.
16. That, in conjunction with the States, DETYA investigate the most appropriate and cost-effective way to either acquire or develop Australian digital teaching materials for school students, that are eventually available for all subjects in the school curricula. Such materials should include:
    - ?? Face-to-face teaching materials
    - ?? Online, flexible learning materials
    - ?? Centrally held resources.
17. That the Commonwealth continues to develop ways to stimulate tertiary skills development amongst Australians in areas of telecommunications and information technology.

Respondents strong and consistent view was that truly competitive bandwidth would only be supplied in a deregulated and highly competitive telecommunications marketplace.

2 Terms of Reference

The consultant was commissioned to undertake this project, following submission of a competitive tender to DETYA dated 7 July 1999. The project was seen primarily as a desk research task in the first instance, which would feed into the demand projections and modelling being undertaken as part of the NBI.

2.1 Objectives

The stated objectives were to address:

1. The nature and existing demand for bandwidth in the education sector.
2. Whether the sector's ability to take full advantage of online technologies is being constrained by bandwidth accessibility. If so, why, and how?
3. Make an estimate of bandwidth requirements for the sector over the next three to five years; note the types of applications that would drive consumption trends; the likely cost of meeting these requirements under the current pricing regimes.
4. Comment on innovative approaches to addressing bandwidth needs, including some that may be evident from overseas experience.

The report discusses all these matters. The time frame did not allow a full estimate for item 3, but does develop a formula for this and makes an approximation.

2.2 Methodology

The essence of the consultant's methodology was:

1. Read and summarise current reports and papers from the last four years to ascertain the trends.
2. Research current programmes via the Internet.
3. Research current data for each of the three sectors, schools, VET and University via direct survey, often by telephone.
4. Tabulate the data and anecdotal responses.
5. Make recommendations.

The consultant worked with members of the following agencies and committees:

1. DETYA staff.
2. Representatives of the EdNA Reference Committee.
3. Representatives of the EdNA Schools Advisory Committee (SAG).
4. Representatives of the EdNA VET Advisory Committee.
5. Representatives of the Higher Education sector.
6. Members of commercial businesses.

3 An Outline of Terminology, Current Technology and Applications

3.1 The Internet Today[7]

The Internet today connects almost 140 countries, with connections to the Mars probe being constructed by NASA as InterPlaNet, due for completion in 2008. The Internet is a network of networks, which includes over 44 million computer servers and an estimated 150 million users worldwide.

The Internet has doubled in size every year since 1988. Estimated users by the end of 2000 will exceed 300 million people. By 2047, the world's population may reach 11 billion people. If only 25% of that population use it, then the number will be 3 billion users, being ten times (or one magnitude increase) over the number at the end of this millennium. The network is so intermeshed that it would be almost impossible to turn it off.

Take-up of Internet connections has been faster in Australia than the take up for cars, VCRs or telephones.

Data traffic generally, has already exceeded telephony traffic in Australia and is expected to exceed it worldwide by 2003. By comparison, half the world's population has yet to make a telephone call!

The numbers are truly staggering, yet our best estimates have been constantly exceeded. Governments as yet do not generally understand that growth in application size will continue in **magnitudes** not in multiples. For example, a plain text e-mail message may be 22 to 40Kb but a single frame of PAL resolution TV (being one twenty-fourth of a second of delivery) is typically 1 to 2 MB. A highly crafted, single frame of full movie quality (termed D1 resolution), with composite animation overlays, is 20 MB and larger!

This is important because one of the most productive uses of streaming audio and video services is for education, followed closely by health and social services. Therefore, far greater bandwidth will be required, requested, in fact demanded.

3.2 A Little History

It is incumbent upon us to remember that in less than 100 years we have moved from communications via an irregular physical mail service transferred by sailing ship and horseback to complete global electronic systems.

Mail and the first telegraph services were provided by a monopoly, the Postmaster General's Department, later renamed Telecom, and later again, Telstra. Today, Telstra is an emerging global telecommunications company, with real competition in some of its traditional market segments.

Telstra owns our national copper wire network, with millions of kilometres of wire strung through some of the harshest terrain on the earth. That it works at all is a credit to Australian ingenuity and plain hard work. Called POTS (the plain old telephone system) and now called the PSTN (or Public Switched Telephony Network) by some, it was built for low capacity voice traffic. Its strength is that it is ubiquitous. On behalf of the Commonwealth, Telstra owns the "last mile" to 98% of households

and businesses in the country. The last mile or the "local loop" and other residential and SME connections, is a key link in the cost equation for the education sector.

3.3 Un-timed Local Calls

"A government's decision to retain un-timed local telephone calls is ultimately an investment in the country's youth".

So said Nicholas Negroponte[8], Professor of Media Technology and Founding Director of the MIT Multimedia Laboratory. The fact that Australia has un-timed local calls is a considerable benefit to education in the country. Respondents indicated that it should be retained despite considerable pressure from carriers to alter this arrangement.

The ACCC decision in July 1999 to enforce competition for local calls was a step in the right direction. However, it does not assist rural users, nor will other carriers find it easy to negotiate ready access (and competitive rates) to Telstra's local loop. Australians will simply have to wait and see the result. It is necessary to note that call costs are one half of the equation. ISP charges also vary by location and should be structured to encourage educational use of the network, with equitable allowances for access.

3.4 Current Technology

From December 1999, the days of party lines and hand-plugged switchboards are almost over. Telstra's FMO Program (Future Mode of Operations) was a Government decree, as part of the USO, to update exchanges across the country to digital format. Digital exchanges provide cleaner lines and special features such as Call Waiting and Caller Identification. In parallel, Telstra has laid thousands of kilometres of optical fibre, particularly in regional areas and smaller states. This is not necessarily altruistic.

3.5 National Networks

These optical fibres enable a carrier to reduce its costs by returning the processing and management of calls to a few central locations. Theoretically, a single optical fibre has no capacity limit. However, under today's connection technology, it is generally accepted to be about 5Gbps per fibre[9]. Moreover, the cost of additional fibres in the same bundle is a minimal increase. Therefore it is common for carriers to lay multiple fibres in one bundle, up to 16, underground.

The ramifications are enormous. Telstra could run all Australia's telephone networks from just two switches in Melbourne and Sydney today. That means that a call made in Hobart, Whyalla or Kalgoorlie would run though Melbourne with no discernible degradation to the caller. This doesn't happen because the current legislation does not allow it, rather than for technical reasons. The down side is the reduction in investment in regional areas, both for equipment and employment.

3.6 The CAN

Another limitation is the "tail" or "last mile connection". These form the CAN or Customer Access Network and are usually copper wires, which generally carry a maximum of one service and a 56Kb asymmetric service to a home via a standard analogue modem. In Melbourne and Sydney, some private subscribers can access a hybrid fibre-coax (HFC) service (similar to that mostly used for Pay

TV) to obtain some Internet services at near to 10 MB/s, depending on other users. In early 1999, Telstra also successfully tested (but has not yet released) multiple services on a single copper line.

ISDN, xDSL and Other New Subscriber Formats New formats get over this for data services. At a Board Meeting in Darwin in 1998, the Telstra Board voted to commence a new program, the Digital Mode of Operations or DMO. Their research for the DMO is designed to make them world competitive in data services for Australia and other countries.

Today, Telstra has invested billions of dollars in the separate ISDN (Integrated Services Digital Network), which is used by almost all schools and TAFE colleges around Australia. This is now being upgraded to the European ETSI Standard offered as the On Ramp service. No other carrier offers ISDN in Australia. While pricing has dropped considerably over the last few years, costs far exceed equivalent services in the USA (comparisons appear at the end of this report). Direct pricing comparisons are made deliberately difficult, because of the multiple component charges for the service (Connection fee, monthly charge and data rate for example—see section near to the end of this report). A single channel runs as a symmetric 64Kb link plus a control channel. Channel pairs are always connected, but payment is made for one. The differential cost of installing the second line is genuinely trivial, but is costed at about 70% of the first, a true anomaly.

For some years, carriers have been working on asymmetric technologies that would deliver high-speed downlinks to a home or small business and lower speeds in return. These are often termed xDSL services.

The best known is ADSL, which stands for Asymmetric Digital Subscriber Line. It may offer a service of 1.5Mbps with a return up to 384Mbps. ADSL has the following advantages and features:

- It operates over standard telephone loop technology, suitable for homes and SMEs.
- It will handle both high speed data and voice
- It will provide a dedicated digital IP connection
- The data rates exceed current modem speeds
- It offers a wide range of CPE options including Ethernet connections.

Variations of this type of technology (which are not necessarily available in Australia), include:

- HDSL—high bit rate digital subscriber line
- SDSL—single line digital subscriber line
- VDSL—very high digital subscriber line, as used by TransACT in the ACT with speeds from 12Mbps to 52Mbps.
- IDSL—ISDN Digital Subscriber Line
- RADSL—Rate Adaptive Digital Subscriber Line
- UDSL—Universal Digital Subscriber Line.

Other services include Asynchronous Transfer Mode (ATM) which is a high speed packet-type services and Frame Relay. Satellite services such as VSAT are offered by a number of carriers. ATM service is also offered by a number of carriers including Optus who support the AVCC's AARNet 2 under contract.

3.7 Applications

Large users have point to point permanent telecommunications lines such as those used by the major banks and government departments. These run data using a variety of standards. Some are exclusive for particular reasons, such as security.

But most applications run under the Internet standard, TCP/IP (Transfer Communications Protocol/Internet Protocol). TCP/IP was designed for the US Department of Defence as a "fail-safe" system. If one component fails, another will work to complete the sending of the message. The inter-relationship of the Internet (a network of networks) is now incomprehensible to one person. It is certainly outside the control of a single country, which makes the recent restrictive acts of individual governments, almost irrelevant.

Today the key applications in the Education Sector are:
1. E-mail for communications
2. World Wide Web (WWW) for data downloads and resource discovery.

Compared to new technologies, already here, these are comparatively minor applications in terms of the amount of data being transferred. Academic networks were using e-mail, many years ahead of the WWW development in 1992. But things are changing. Even e-mail is becoming more complex, with "attachments" of larger documents, digital photographs and other items.

New technologies that will explode within 18 months to two years include:
1. Complex e-mail.
2. Streaming technologies for audio and video (such as MP3 and MPEG).
3. Video-conferencing
4. Virtual classroom facilities combining video conferencing with electronic white board and documents.

More advanced technologies than these, are also on the way:
1. Interactive multimedia delivery.
2. Video editing and distribution
3. Animation and VFX
4. Video on Demand
5. VRML Virtual Reality with controllable three-dimensional imaging.
6. Network computation
7. Datacasting and Multicasting beyond VOD.
8. Virtual Laboratory testing.
9. Controls Simulation, etc.

ALL of the applications in the lists above are readily available to anyone today, and being used by a small number. Video conferencing and streaming technologies are ideal for teaching environments.

The fact that these applications require more than just multiples of bandwidth, but magnitudes of growth, have not reached the comprehension of most administrators. This will cause a slowing of Australia's ability to compete in the global market, under the current telecommunications regime.

3.8 Teaching is Different to E-Commerce.

While it would be possible for E-commerce applications to require high bandwidth, in the main, they will download limited images of products and require a very small data exchange to handle the payment component. Governments, particularly state governments, are unprepared for the demands that students will place on their networks over the next three years. Some are already devising limitation strategies such as high cache usage and pay-as-you-go, for usage over a defined limit.

Therefore, it is apparent from many correspondents, that online education will be a high bandwidth user, possibly only outsized by the specialty users such as network super-computing and animation or special effects for the TV and film industries.

3.9 Mega Bandwidth Needs

Network administrators should be aware that there are some applications that will require extraordinary bandwidth, in time. Today, these are mostly in the research area. Development of a limited "Internet2" type network in Australia would see practical research in areas such as network computing, distributed user computation and online editing. Such research would benefit Australian industry in the near future.

To give an indication of the scale, a single operator undertaking online movie editing for VFX, would require a minimum of 240Mbs, per user, to handle full resolution video transmission! This is clearly beyond the capacity of a standard Ethernet LAN at 10 or 100Mbps, let alone a traditional Internet connection. LAN technology at Giga bit level is available in Australia today, again indicating the expected requirements of applications.

3.10 Distance Education and Flexible Learning

While these two terms are slowly becoming a component of the vernacular for universities and colleges, they are by no means accepted, or understood, by all professors, teachers and tutors.

Distance Education implies teaching geographically dispersed students. Multiple technologies are used, including the sending of paper based teaching materials by snail mail. Of course, video conferencing and email are also used. Distance Education Courses are generally delivered at set times, especially for tutoring, and usually have fixed start dates.

Flexible Learning takes the best elements of Distance Education, but makes it time independent, both for delivery, commencement date and assessment. The two universities with the most advanced programs are Deakin and University of Southern Queensland (who claim in excess of 28 000 remote students). However, many others have recently commenced programs, both to attract interstate and foreign students, and to improve their income to cost ratios. Flexible Learning course materials are increasingly developed and delivered electronically, either on fixed media such as video and CD-ROM, or over the Internet.

Flexible Learning offers some potentially interesting side benefits:

- Teaching materials can be genuinely interactive for *every* student.
- Learning environments can be built to act like an interactive game, and be more fun to use.
- Dangerous, expensive or remote environments (such as outer space) can be simulated in a very realistic format, without the attendant costs.
- Materials built for one institution can be very readily altered for another.
- Theoretically, a student could earn a composite qualification, from multiple institutions, having still met the required standard.
- Specialists, with only a small number of colleagues around the world, could compare programs, experiments and decisions in real time.
- And many others.

Unfortunately, many staff fight these new trends, fearing for their employment or tenure. Employment is generally not at threat, but new skills (and new positions) are often a requirement.

4 Current Telecommunications Bandwidth Usage

4.1 Universities—Network Status and Usage

The Universities and CSIRO, through the Australian Academic Network (AARNet), brought the Internet to Australia in 1989.

The commercial components were sold to Telstra at 1 July 1995 and the academic and research component was contracted for further development to Cable and Wireless Optus in 1997. The decision was very important strategically, as it gave access to considerable bandwidth via a national ATM network, which was largely unused by other Optus customers in the first instance. The low cost of the ATM links is unlikely to be repeated in the near future. It enabled the AVCC to determine the latency of demand for Internet services quite accurately and to also practically cost the higher usage.

The technology and skills required to develop and run the network were a strategic decision to support teaching, learning, and research in Australia. Technology breakthroughs were, and still are, being made by AARNet members. Today, AARNet is extremely sophisticated. An excellent summary has been prepared by Graham Rees on behalf of CAUDIT, the Committee of Australian University Director's of Information Technology, in draft and provisionally dated September 1999[10].

AARNet is currently owned by the AVCC, a private company itself, whose members are the 37 Vice Chancellors of the majority of Australian Universities. Other members of AARNet include CSIRO, ANSTO, DSTO and AIMS.

Organisations that may have some future claim to becoming members of AARNet, but are currently excluded due to legislation, include Notre Dame, Avondale, The Australian Maritime College (AMC) and the new University of the Sunshine Coast. The importance of membership, is that "Eligible Tertiary Institutions" are exempt from some clauses of the *Telecommunications Act 1997*, allowing them to act like telecommunications companies without the onus of becoming one formally, and needing to meet onerous reporting and industry development requirements. ETI's are currently defined as members of the AVCC. The VET Institutions are excluded from this arrangement, making it difficult for them to develop a similar network capability, with a focus on Flexible Delivery of applied courses (rather than research).

The AVCC and AARNet are unusual in that they are fully funded by the users themselves, without the Government assistance that is provided in many other countries.

4.1.1 The AARNet Structure

AARNet has both a fully meshed "on-net" (internal) component and a domestic and international (or interlinked) off-net component. These are built around a Regional Network Organisation or unit, which is linked by very high speed ATM connections, generally of 34Mbps. Thirty-two of the universities are connected at this capacity, and given that they have suitable internal LAN and computer equipment, receive the highest Internet performance generally possible in Australia. Moreover it is of high, but not yet excellent, quality.

Five universities are not connected to the RNO's at the higher capacity, due to their regional location and the relative cost of connection. They are:

?? James Cook University in Cairns and Townsville.

?? Central Queensland University in Rockhampton
?? Southern Cross University in Lismore
?? University of New England in Armidale
?? Bond University on the Gold Coast

Sunshine Coast is also not connected and Charles Sturt University has a unique and pro-active solution comprising a $5 million, fourteen-hop microwave system to Sydney running at 34Mbps.

At the individual student level, Universities generally outsource the dial-in component of their student service, to commercial ISP's. Apart from having political benefits, it encourages students to pay for the level of service that they individually desire. The costing structure should be such that it encourages educational use via an equitable allocation of resources. Thereby, a student with a particular interest in using very high bandwidth, may access it for educational purposes (as distinct from personal commercial benefit, for example) at a fair price.

4.1.2 Measurement of AARNet usage.

AARNet measure their network usage in real time. Details of the maximum link capacity, and percentage average usage, between RNO's are available from the General Manager at the AVCC, Mr George McLaughlin.

For example:

USAGE Growth Rate for AARNet, Per Annum			
1996	1997	1998	1999
120%	100%	80%	50%

1. The fully meshed, peak rate out of Australia is over 80Mbps per second.
2. This varies with the time of the year. For example January is quieter and October is the highest.
3. Even in the lowest downtime (between 3.00am and 6.00am, usage exceeds 20% of peak!).
4. The Sustained to Peak ratio is 1:3, which is the highest peak that Optus can technically offer). Given limited use by other users of the ATM network, this gives universities considerable flexibility. It would also indicate a high Latency of Demand (LOD) for the school and VET sector, whose sustained to peak ratio is often as low as 1:1.2.
5. AARNet receives discount structures contracted annually with Optus. The highest proportion of this is for the international link. Optus also have contracted to provide enforceable performance guarantees.[11] For contract balance, AVCC must provide planning data for the future.
6. Quality used to be measured using a CBR or Constant Bit Rate but this has now moved to a VBR-NRT measure (Variable Bit Rate-Non Real Time).

Given the summary information above, AVCC advises that:
1. International connections, that used to be an issue for capacity reasons, are now a costing issue. New high-bandwidth international connections are being reviewed.
2. Solutions for the five universities outside the 34Mbps net are being eagerly sought.
3. Internet II type solutions such as CANARIE are being considered.
4. New high-bandwidth applications are about to hit the network, a portent for schools.

4.1.3 Forecasted Need

The CAUDIT Report does not give a firm conclusion on the growth rate over the five years from 1999 to 2004, but does provide a table for rates at 50%, 70% and 100%. Other commentators view the university requirement as growing at 50% for the coming year, 70% for the next and at least 100% from the beginning of year three, driven mainly by streaming technologies. **The actual rate will depend highly on the pricing algorithm available to universities.**

In essence, the AARNet backbone connection speed is 155MBps with bandwidth at 68Mbps in 1999. The connection speed will need to increase to 622Mbps in 2000 and to 1.2GBps in 2002, thereafter doubling each year for the next two to allow for 100% growth rates (i.e. to 4.8Gbps in 2004.). Under current pricing, the universities could simply not afford this bandwidth; in fact, it would then become by far the most significant expense item for the entire sector.

Within this bandwidth requirement, CAUDIT estimates the following bandwidth usage (in Mbps):

	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
50% Growth	45	68	101	152	228	342	513
70% Growth	45	77	130	221	376	639	1086
100% Growth	45	90	180	360	720	1440	2880

This consultant believes that the actual path will follow the bold line through the following table, due to the growth in new application usage. Senior university managers (who don't wish to be named) have indicated that this is "highly probable".

	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
50%Growth	**45**	**68**	101	152	228	342	513
70%Growth	45	77	**130**	**221**	376	639	1086
100%Growth	45	90	180	360	**720**	1440	2880
130%Growth	45	104	239	550	1265	**2910**	**6692**

4.1.4 International Links

The capacity and pricing of our international links effects all education sectors, but particularly the universities and research groups.

Today, there are four main links across the Pacific. Details of their theoretical capacity and actual usage are difficult to obtain, but everyone agrees that they are constrained now. New links that will come on line in the next twelve months will reduce this constraint for the foreseeable future, and hopefully will lead to reduced data prices (which are still about 40% above internal Australian costs).

Links are:

?? Pac Rim East — Some 100s of Mb
?? Pac Rim West — Some 100s of Mb
?? Jasarus — A new Optus and Telstra joint project out of WA—6Gb going to 40Gb
?? Telstra Satellite — 2 by 45Mb links
?? Optus Satellite — 3 by 45Mb links

New services coming on line:

?? SEAMEWE3 Link to Europe via 43 landing ports—20Gb
?? Southern Cross LA-Hawaii-NZ-Sydney—from Q2 2000—40Gb going to 160Gb
?? Southern Cross Sydney-Fiji-Hawaii-SF (return route).

4.1.5 Quality of Service (QoS)

Bandwidth is not the only issue. Quality of Service is now being sought and contracted. All education sector representatives should endeavour to negotiate contracts with QoS components, as this may drive cost, performance and other differentiation strategies amongst carriers, to the benefit of all. QoS includes such elements as:

?? Provision of particular protocol connections for services that may be optimised. For example packet type protocols are more sensitive to interruption for streamed applications.
?? Bit rate performance measurements.
?? Guaranteed up-time of key switches and servers.
?? Preferential routing
?? Security at a variety of levels
?? Guaranteed address space
?? Virtual Private Networks.

Whilst AARNet has lead the way in the area of QoS, many other education users, particularly government agencies, could obtain significant benefits by re-negotiating some of their key carrier contracts.

A key driver for re-negotiated pricing and QoS is the potential of aggregated demand, which would provide benefits to carriers and customers together.

4.2 VET Sector—Network Status and Usage

The Vocational Education and Training Sector has seen a significant resurgence in Australia, as the key provider of "competency-based training". To the general public, this means non-degree courses teaching specific skills, which will enable them to obtain or enhance their employment. Informal research[12] in Queensland has shown that the higher levels of unemployment over the last few years, has meant that many students make a quite active decision to *not* apply to university, but to chose vocational training, with the explicit objective of obtaining ready employment in particular industries.

The major player in the VET sector is generally TAFE Colleges; however, there is growing capability in other semi government groups and commercial companies offering VET training under a Registered Training Organisation (RTO) status. For example in Queensland, QANTM Co-operative Multimedia Centre shares the teaching load for a multimedia diploma with a number of TAFE Colleges.

4.2.1 Telecommunications Impact

The combination of the VET sector's wider geographic coverage—suburban, regional and rural—and its lower-priced courses, means that the VET sector has demanding telecommunications requirements. In some states, such as NSW, networks have been built to satisfy both the schooling and TAFE requirements. Whilst this should provide significant savings in the longer term, institutions connected by minimal bandwidth connections are suffering performance degradation.

In some states, specialist organisations have been created, and supported by Government grants, so as to extend the rural reach of training programs. An example is QOLN, or Queensland Open Learning Network, which uses a mixture of technologies, including teleconference, videoconferencing and computer networks, to deliver classes to students all over the state.

4.2.2 The Role of ANTA

ANTA (the Australian National Training Authority) has a key role in co-ordination of VET activity, at the top through its CEO's Committee. ANTA approves a National Training Plan. In essence, this approves a large range of curricula, including required teaching outcomes for each certificate or diploma.

To this time, ANTA has not fostered a national VET network in the same way that the AVCC has built the AARNet network for universities. Respondents to this survey had strong views on this point, believing that such a network would be required in the near future, whether independently built, or as an overlay to AARNet. (The latter is currently constrained by legislation and was the subject of the original plan for EdNA.)

However, ANTA has made one significant step in this direction, with the release of the paper, *"Preferred Standards to Support National Co-operation in Applying Technology to VET"*. The paper was prepared under the auspices of the EdNA VET Advisory Group by CIRCIT of RMIT. CIRCIT is the Centre for International Research on Communication and Information Technologies.

The first CIRCIT report was produced in 1997 to support increased use of Flexible Delivery, with the second version conducted in 1998. The standard is not mandatory.

In brief, the report lists standards for seven key technologies, being:
- Computer Managed Learning Systems
- Data
- E-mail
- Groupware
- Internet and Intranets
- Personal Computers
- Video Conferencing.

These were developed to assist the VET sector with bulk purchasing and the national strategy for VET 1998-2003 "Bridge to the Future" agreed by VET Ministers. The paper does list a series of issues for investigation from 1999 to 2001, and one key element is noted: "The possibility of linking the VPN to the AARNet or other State Initiatives". Most respondents to this consultancy believe that this item needs increased focus and increased urgency of review and planning.

The following notes indicate the current status of TAFE colleges (and their equivalents) around the various states:

4.2.3 VET—NSW Programs

The VET network in NSW is the same as is used by the schools sector (managed by Information Technology Bureau), with additional links as required. It consists of 186 links covering 149 locations. These are spread across twelve Institutes

The initial connections were at 64Kb ISDN for each college, with 128Kb being more typical, using "On-Ramp" services. The Department of Education and Training has four Sydney locations for its

head office and computer centres, including a back up centre. The locations are at Bridge Street and Darlinghurst for the Head Office and St Leonards and Ultimo for the computer centres. The Department is experimenting with 100Mb FDDI connections for these locations, with some success.

Across the Institute locations there are fifty 128Kbps frame relay services, eleven 512Kbps ISDN services, nine 2Mbps services plus four 100Mbps services connecting state offices. Total usage on the network with 1000 of the 2600 total sites (including all centres) is 3 terabytes per annum.

TAFE have a particular issue in NSW in that the connections are not separate for administration and teaching purposes. This means that administrators are unable to do effective work over the network during core teaching hours. A method to alleviate this is being considered, both for bandwidth and for security reasons.

Connections to other locations are considered far from adequate, but have not been upgraded for simple cost reasons. TAFE officers consider that a 64Kbps link is adequate for a single class of students undertaking "light" Internet usage. Their objective, using today's applications, is 2Mbps connection for all colleges as a minimum, but concede that current carrier rates are too high to achieve this, without resorting to a private microwave network.

Costs in NSW

Costs vary widely across the locations. For example a typical inner city connection costs approximately $2500 per annum, whilst a regional connection is between $16 000 and $18 000 per connection.

The effect of this is that *"80% of communications costs support 20% of our locations"*. Interestingly, this is despite the fact that 64% of student days are delivered in the less expensive connection areas of Sydney, Newcastle and Wollongong! Further, 80% of costs are in connection and recurrent costs of tails. The latter is not the case for Frame Relay connections in the city.

In aggregate (across schools and TAFE) the total installation cost was approximately $25 million and the operational cost is $2 million per annum.

These facts give a clear guidance on the areas that need focus, in providing effective price/performance solutions for this sector.

4.2.4 VET—Victorian Programs

In Victoria, there are 20 Institutions, make up of 15 TAFE colleges, five Universities offering TAFE delivery and the Driver Education College. These are spread across 147 TAFE campuses. There are also a very significant number of non-TAFE VET organisations in Victoria including AMES, six group training companies, driver education and about 600 government-funded private providers.

TAFE Victoria ran a loose network of 64Kb and dial-up links through to the end of 1998 after which VETNet was outsourced to AAPT. From June 30, 1999 VET Net became part of VicOne, the Government-wide network. Under this arrangement, funding was increased to connect all TAFE Institutions with a minimum of 2Mbps links and 128Kb links to other TAFE locations.

Eight of the rural Institutes of TAFE are connected with 2Mbps bandwidth and seven other institutes with 128Kbps bandwidth. Many TAFE locations also have private connections to ISP's but the number is not recorded. Typically they are 128Kbps links.

The recurrent cost of the Victorian TAFE network is approximately $1 million per annum.

4.2.5 VET—Queensland

Queensland and Tasmania are the only states in Australia where a majority of the population lives outside of the capital city. In addition to that, distances are huge, being second only to Western Australia. For example, Melbourne is closer to Brisbane than Cairns or Birdsville are to their capital city. The network implications are obvious.

Queensland Government Departments are set up differently to NSW. DETIR, the Department of

Employment, Training and Industrial Relations, is the portfolio to which TAFE reports. DETIR also supports independent organisations including VETEC, the state-financed Vocational Education, Training Corporation, who manages the funding for the broader VET sector.

TAFE has 62 locations in Queensland, represented by different Institutes, from Brisbane, to Moreton, Gold Coast or Tropical Queensland TAFE. Nearly all the locations are connected by a single 64Kb ISDN connection, supporting both teaching and administration functions.

While the low speed of connections between TAFE and its other locations is a concern, the largest issue is the difficulty of dial-in access, and its cost, for rural students. Many locations in Queensland, particularly stations and small rural settlements are connected by DRCS, the digital radio concentrator system, which will run a maximum of 2400 bits per second. At this speed, it is barely possible to run plain text e-mail, and then only if the connection is particularly reliable. Under the USO, Telstra is upgrading DRCS locations to HRCS, which offers 9.6Kbps connections, of little additional value for data. The solution may be offered by the new American Standard (CDMA) mobile phone stations, or by satellite connections.

Even for those in direct copper connection to the PSTN, the price of calls is at STD or other timed rates, making Internet connections expensive. This is being relieved to some extent by the provision of virtual POPs (Points of Presence) in many country towns, often as a result of the ConnectED program for schools. The result is still far from ideal.

VETEC have indicated that their preference is for a 2Mb link for all students. They would be prepared to accept an initial asymmetric service, such as ADSL, which offers up to a 2Mb downlink and 64Kb return. Training delivery via Satellite TV, with a return by landline on the POTS, may also have a place. They do, however, see this as a transitionary step to a symmetric broadband network.

VETEC also see the "Standards for National Co-operation" as being important. This is particularly so when discussions of future applications is considered. They regard planning for a network that will be a one-stop shop for streaming technologies as vital over the next three years.

4.2.6 VET—South Australia

SA TAFE is represented by eight institutes, which are spread over 56 locations in South Australia. The head office is in Flinders St, Adelaide, and is linked to the Internet by a 10Mbps connection using two pair base band cables. From that point, a star topology network links the head office of each institute. Links between institutes are ISDN channels sourced by a SA government agency, Networks Services SA.

Equipment is provided by EDS, under the whole-of-government outsourcing arrangement. There are two 512Kb links to institutes, four at 256Kb and the remainder at 128Kb. The majority of other locations are supplied by a single 64Kb link, but some smaller sites have dial-up facilities with connections as low as 14.4Kbps.

There are currently no microwave or satellite connections. Each link carries two logical networks, one being for administration and the second for education. The total network downloads on any teaching day amounts to about 4.5Gb per day.

Growth in the network has been 100% every 9 months but this has climbed to 100% every six months. There is a demonstrated high LOD and this latency would likely be satisfied by a 34Mb link from head office to the Internet, with 6Mbps links on average between Institutes. TAFE SA uses a carefully considered risk management strategy between locations, and load balancing is handled with both the network and proxy server caching.

Costs for Internet data alone amounts to $80 000 per year. Infrastructure costs are the key limitation to growth, but the trans-Pacific links are also a key factor.

4.2.7 VET—Western Australia

The VET sector in WA is made up of twelve Colleges and two Academies (Performing Arts and Kalgoorlie College). They are spread over 72 locations and almost all are linked for administration purposes. The topography is a star pattern from head office in East Perth, to each central campus and legs from there to the other locations.

The connections are 512Kb from head office to the Internet, with 128Kbps links to the central institutions and 64Kb links to the various other locations. All Colleges have additional direct links to the Internet themselves.

Rural Innovation

An innovative remote teaching program is also being developed in WA with the guidance of IMAGO Cooperative Multimedia Centre[13] and partners. Called MITE, it provides a completely self-contained pair of computer classrooms in a stand-alone building, connected to the Internet via a satellite dish. The inaugural site was one of the few surviving buildings in the area, following a major cyclone on the west coast in early 1999. This initiative is particularly important in Australia's largest state, because of the vast distances that would need to be otherwise traversed by teachers or telecommunications lines.

4.2.8 VET—Tasmania

The VET sector in Tasmania is supervised by OVET, the Office of Vocational Education and Training. As in other states, it takes advice from the local industry training board or ITAB, in this case called Tasmanian Arts, Communications, Information Technology, Printing and Recreation Industry Training Advisory Board. In late 1998, this ITAB put considerable focus on the telecommunications needs of the VET sector in the state, by releasing a report covering the key courses that would utilise higher bandwidth than then available, in particular multimedia, digital arts and film[14].

The report added credence to the Tasmanian Governments efforts to re-negotiate key aspects of its one-stop shop telecommunications agreement (of $51 million value) for all Tasmanian government telecommunications services. The contract is referred to as the NTP or Networking Tasmania Project and followed a successful all-of-government telephony agreement.

The NTP is truly unique, in that it does not guarantee either specified bandwidth, or a particular quality of service. It is actually a fee for service arrangement for services, without a comprehensive service-level agreement (SLA). Key elements are controlled under SLRs. The services were of high

value to the government because they included a range of software products designed to provide state-wide Directory Services, for example.

The lack of a tight SLA meant that performance is variable. This has resulted in the new Bacon government re-negotiating particular elements with Telstra. Components of these include:

?? The proposed upgrade of the trans-Bass Strait link from 8Mb to a 34Mb link. Two correspondents indicated that, for whole of government, it should be a 155Mb link immediately.
?? 000 emergency services
?? Capital city pricing in all rural areas of the state.

The result of the NTP arrangement is that Tasmanian TAFE colleges are connected at a variety of speeds. The four major TAFE colleges at Hobart, Launceston Devonport and Burnie are connected at 256Kb with five others at 128Kbps and the remaining eight locations being at 64Kbps. There are 17 TAFE locations in total.

4.2.9 VET—Northern Territory

The VET Sector in the NT is run by NTETA, the Northern Territory Education and Training Authority.

A current restructure has resulted in the agency reporting into the same minister as the Department of Education. NTETA is also seeking a new CEO.

The VET sector in NT consists of four Public Providers being:

?? A VET unit at NTU (Northern Territory University)
?? Centralian College in Alice Springs
?? Batchelor College
?? NT Rural College

Physical computer classroom facilities are provided by NTETA on a rental basis to these organisations. They are spread across five major locations, being Darwin, Tennant Creek, Katherine, Jabiru and Nhulunbuy (Gove).

There are also seven minor locations, making a total of eleven. There is currently no co-ordinated network, but this will be rectified by a whole-of-government networking project, being finalised this year.

4.2.10 VET—ACT

The VET sector in the ACT is primarily covered by the Canberra Institute of Technology (CIT), whose network and infrastructure is supplied under a government wide program by the in-source group, IntACT. CIT also has separate connections to the Internet specifically for educational delivery. CIT has seven campuses in the ACT, all within a few kilometres of each other.

CIT has demanding uses for telecommunications, without the distance issues that plague other states.

Communications between campuses are generally 2Mbps, usually via ISDN links. These support about 1000 seats across the system, ranging from 50 seats to 300. The higher bandwidth has enabled a computing component to be included in almost every course, even if only at the general literacy level. The courses with the highest usage are Information Technology and Business.

Interestingly, there has not been a large increase in the number of seats across CIT, but there has still been a significant increase in both Internet usage and online learning. Current estimates for broadband increase are 100% compound per year (two magnitudes per year).

The major limitation is modem connections from home. This is likely to be altered dramatically in the ACT because of the implementation of the production TransACT Program (see below). Other limitations are Government Policy and cost escalation.

Costs for the ACT are $2 million for leased computers plus network charges. CIT wish to upgrade the entire network to full ATM, but the cost of $3 million per year is outside their conceivable budget.

4.2.11 TransACT—A Broadband CAN for All ACT Residents?

ACTEW (ACT Electricity and Water) is in the process of developing a particularly innovative program, to enable all Canberra residents to have very high-speed access to the Internet and other data services.

The concept is to provide a very high-speed link, plus a full range of services to any and every household in the ACT. This connection is being provided using much of ACTEW's power pole network, currently to the one suburb of Aranda in the inner north west of the city.

The program is called TransACT, and provides an optical fibre connection to within 300 metres of each home, and a copper link for the tail. The protocol being used is VDSL, which is quite a different proposition from ADSL proposed by other carriers.

TransACT offers up to 52Mbs of potential capacity to every household or small business. The first trials have been particularly successful, and a roll-out to all other suburbs has been under increasing discussion by the press and residents. This has resulted in international interest in the overall concept. ACTEW was reported on 24 July to be prepared to invest $35 million in the project, and was also looking for commercial partners.

TransACT is proposed as a "Full Service Network" where customers pay for the services that they desire. For example a simple service will offer:

- Local telephony, multiple lines
- High-speed Internet connection (minimum 512Kbps)
- Free-to-Air television
- Pay TV
- International feeds as chosen such as Reuters or CNN News.

The fee structure is interesting. At $15 per month for a basic connection plus $25 per month for a very high-speed Internet link, the rates are very competitive. Carriers were originally asked to become involved, but have taken differing positions, according to their views on the degree of competition that TransACT may offer to their traditional services, particularly standard telephony. Private investors are now being considered.

The potential impact to the schools, VET and university sectors, is huge. As more students are able to connect from home, "distance learning", assessment and discussions between parents, teachers, managers and students will all be available online.

A similar community connection project, us being progressively developed by the Springfield Land Corporation, in conjunction with Optus and Apple Computer, to the east of Ipswich in Queensland.

4.3 Schools—Network Programs, Status and Usage

Australian State Governments have universally considered that the connection of public schools to the Internet, and the provision of computing capability and LANs as a key priority. The general target has been one computer per five students, an aggressive target, and one not met by many non-government schools and colleges to date.

Queensland and Victoria are currently leading the way, with 100% rollout of their permanent connection program, with others close behind. Usually, 64Kb ISDN has been considered satisfactory, but ***every*** school correspondent to this consultant's survey indicated that it was wholly insufficient for any but the very smallest schools (viewed as those with 40 students or less). The most universal question was why, when two ISDN channels were connected, was the incremental cost of the second channel so high?

4.3.1 Schools—NSW

There are 2224 schools in NSW, of which 900 are connected with 64Kbps ISDN links, on the same network as the TAFE colleges. Approximately 200 of these schools will need to be connected via a non-terrestrial system and there is one Telstra VSAT trial being currently undertaken at Broken Hill.

Originally, suburban schools developed their own networks. Country Schools were given a boost via the "Country On-Line" Program one year ago, which connected 200 rural schools via On-Ramp ISDN at 64Kbps.

The next program was called SchoolsNET, a name which has been dropped, as it is that of a private company.

The current program is simply termed The Education WAN. The new title is designed to give overall focus to education networks in the state.

ETSI On-Ramp connection of most schools is expected by December 1999. It is supported by the supply of 77 000 computers to-date, with a total of 90 000 expected across all schools. There is no specific software support program. Some resources are available to teachers via the "Network for Education" website[15].

Teachers are also supported by the TILT (Technology in Learning and Teaching) Program, plus 40 technology advisers based in different districts.

Bandwidth will later be expanded according to student numbers in particular schools, to a maximum of two channels per school for larger schools.

4.3.2 Schools—Victoria

VicOne is a Whole-of-Government initiative to provide network services to more than 3000 Government agencies throughout Victoria. The Department of Education is the largest customer to VicOne. The network links 1900 education sites across Victoria including all schools, TAFEs and Departmental administrative centres.

VicOne consists of a core high-capacity telecommunications network linking Melbourne and 42 regional Points of Presence around Victoria. From these Points of Presence lower-speed links (64Kbps, 128Kbps, etc) run to schools and TAFEs.

Education Victoria is centrally funding a core VicOne service to schools and TAFEs. Schools and TAFEs are able to purchase additional bandwidth. VicOne is currently providing schools with bandwidth ranging from 64Kbps to 448Kbps.

Currently 1663 sites are being delivered by ISDN, 56 sites are being delivered by radio and approximately 21 sites are being supplied by satellite.

Features of the VicOne network include:

?? Provision of a high bandwidth backbone infrastructure.
?? "Anywhere-to-anywhere" core network capability, allowing any school, TAFE, etc, to communicate directly with other schools, TAFEs, Internet Service Providers, EduMail, etc.., within a secure environment and at no cost.
?? Secure Virtual Private Networks (VPNs) to schools and TAFEs.

VicOne provides significant benefits for schools and TAFEs, including:

?? Improved learning outcomes for students through improved access to educational resources, either directly over VicOne or via the Internet over VicOne.
?? The opportunity to significantly re-engineer the business processes of schools and the Department, monetary savings and automation of business processes.
?? Significantly enhanced electronic communications between schools, TAFE and Departmental administrative centres.
?? Electronic distribution of and access to Departmental documentation.
?? Provision of an enabling infrastructure over which additional services can be provided, at little additional costs, including videoconferencing (EduConf), video streaming (EduVideo), etc.
?? Helping to remove many of the disadvantages faced by remote schools.

VicOne is enabling Education Victoria to very significantly re-engineer the way in which curriculum and administration is delivered.

A range of services have been made available to schools over VicOne including:

EduNet and other Internet Services

EduNet provides high quality Internet Services to schools particularly orientated towards providing a "safe" Internet environment for students and at minimising Internet costs.

The Education Selected Cache consists of over 13 000 websites selected by Victorian teachers as being applicable to a particular area of study. These sites are fully catalogued (Year Level, KLA, etc…) and checked for inappropriate content. Schools can have their students access these sites only; they are thus accessing a safe place on the Internet. Access to these sites by schools is also largely free of cost.

Shortly the EduNet service will block 8.5 million porn, bomb and hate sites. It also provides individual reporting of Internet usage as required by Education Victoria's new Internet Guidelines for schools.

Victorian schools are performing up to 8 million Internet requests per day across VicOne. The majority of these are through EduNet.

EduMail

Edumail presently provides electronic mail services for 53 000 staff. Up to 90 000 messages are being sent and received daily. There are currently over 2000 Distribution Lists and Special Interest Groups

in the system. Edumail is also accessible via the web, providing staff with access from home or any location worldwide. The benefits include improved communications, productivity and reduced business costs.

EduLibrary

EduLibrary is an on-line electronic library of Education Victoria publications, and is available to staff who have access to the EduMail Service. The documents contained in EduLibrary include Executive Memoranda, guidelines, manuals, quick-guides, Curriculum and Standards Frameworks, Study Designs and forms.

EduLibrary can be used to search for information, view documents, save and print documents. EduLibrary provides on-line access to over 1500 Departmental documents by Principals, teachers and staff.

EduConf

EduConf is an IP-based videoconferencing service enabled by the VicOne network. Videoconferencing will be available in all schools and classrooms, enabling them to collaborate with other schools in Victoria, Australia or internationally. Central conference servers enable one-to-one or many-to-many conferences.

EduConf is building on the Department's successful (H320) videoconferencing services.

SOFWeb

SOFWeb is Education Victoria's intelligent signpost to the Internet and learning technologies for students, teachers, school leaders, school administrators, parents and the school community.

Schools are able to get direct access to SOFWeb via VicOne without going through the Internet. Access is thus quicker and also is achieved at no cost for schools.

HRMS

The Department's new Human Resource Management System (HRMS) is being introduced to Victorian Government schools to replace CASES Personnel Administration and School Level Payroll.

The HRMS central system is already in operation, processing personnel and payroll records of staff working in schools and other Department of Education locations.

HRMS software, to be installed in schools, will provide direct on-line access to personnel information in a more efficient, simple and secure service than currently available.

The following services will also be accessed via VicOne in the future:

VSAM

The Victorian Student Achievement Monitor (VSAM) is a computer-managed assessment program being developed by the Board of Studies and trialled in Victorian schools in 1997 and 1998 for implementation in 1999.

Victoria Education Channel

The Victorian Education Channel is being developed to integrate the range of educational online initiatives, including the provision of online quality educational content to schools, TAFE Institutes, and the vocational education and training sector.

EduVideo—on-line distributed video

EduVideo service will make available streaming video and video on demand to schools.

On-line access cultural institutions

Giving students direct access to cultural institutions such as State Library, State Museum and National Art Gallery.

EduLink

EduLink is a service which allows the sending of data between school systems and central computer systems.

Performance Measurement over VicOne[17]

Victoria is in the excellent position of being able to accurately measure network usage because of its single VicOne government network. The number of Internet requests over EduNet in the month of December 1998 was just over 10 million, but this had grown to over 70 million by March 1999 and showed no signs of slowing.

In a similar period from November 1998 to March 1999, the number of megabytes of data sourced per month, had increased from 50 000 to almost 320 000 million bytes. Similarly, e-mail accounts had grown from 22 000 to 70 000, with more than a third of the network still to be connected.

4.3.3 Schools—Queensland

In 1997, the Director-General of the Department of Education, made a fundamental decision to connect every public school in Queensland to the Internet. The project was called "ConnectED" and the project tender was won by Telstra.

The Project was preceded by delivery of a computer server to every school, for use solely as an administrative machine, a smart move which increased awareness of computing among teaching staff in many schools.

The Numbers in Queensland

The result was the connection of 1298 public schools to ConnectED, a number that increased to 1330 with the inclusion of a number of environmental education centres, outdoor education centres and children's correctional institutions.

Of those schools connected, 64 were connected by a 64Kb VSAT link. To this date, no other carrier has been able to make a similar link work effectively. (Optus is trialling, at the moment without reliable success, a similar system for West Australian Police.) A Telstra VSAT asymmetric service is also being trialled in Queensland at 400+Kbs for a particular school, to determine its effectiveness.

Amongst other schools, there are approximately 700 schools with 300 to 800 students, who are finding the single channel link of varying usefulness. There are also about 130 schools, usually with more than 800 enrolments, which are connected at the higher speed of 128Kbps. Current data measurement for schools indicates that about 30 of these need to go to 256Kb urgently. One of these

schools in suburban Brisbane, Ferny Grove State High School, is being used as a special test case and would be a good contender as a "Lighthouse School". Ferny Grove has approximately 300 computer seats in the school, with about 3Gb of data incoming each month. As a result, they are being used as a test case for a 256Kb Frame Relay site. Ferny Grove, in addition to having a large student population, has increased its application focus and allows Internet Relay Chat (IRC) and other applications.

Head Office in Brisbane and the Managed Internet Service Office are connected with 34Mbps and 100Mbps links.

A Driver, the LAN IT Project

Data measurements indicate that requirement is (naturally) a matter of the number of users. The other immediate driver is the degree of sophistication of internal LAN setups. Those schools with an active computer program and efficient LANs are experiencing measured growth of 100% usage every three months.

This is assisted by a separate "LAN IT Project" in Queensland. Four hundred schools have received funding for this project, and some have put that into additional bandwidth. Four hundred more schools will complete their LAN projects in the 1999–2000 FY and another 400 in the 2000–2001 year.

Teachers are supported by the "Connecting Teachers to the Future" Program, which includes notebook computers, Internet accounts and vacation training.

One correspondent for the Queensland section indicated that the maximum number of students undertaking standard Internet usage that could be supported by a single ISDN channel was currently 40. He indicated that this would reduce to one per channel average within five years.

Costs of ConnectED

Following the initial infrastructure costs, routers for ConnectED cost $3 million. Other single-year capital costs about $300 000 once the initial set up is complete, with the recurring bill being $14.8 million per annum at current rates. The cost of a single ISDN line in a major city is about $5000 with a further $3000 for the second channel.

Private Schools in Queensland

One school deserves special mention in this report, because it has been used around the world as an example of best practise use of IT for primary and secondary education. John Paul College has a mandatory computer usage program for all students at all levels.

The program provides maintained notebook computers, supplied by Toshiba under a rental program charged to individual parents, and all classes from music to maths utilise the service. All classrooms and desks are connected to the campus LAN. Technical support, both for hardware service and software updates, is provided by contractors permanently stationed on the school site.

John Paul College is connected to the Internet via a 2Mb link, which is soon to be upgraded. This is probably a useful benchmark for 2000, for the larger public schools.

Catholic Education does not have an integrated schools network in Queensland and other private schools are installing classrooms and LAN's to meet computing teaching needs, but not regular education needs, in the main.

4.3.4 Schools—Western Australia

There are 772 public schools in Western Australia, all connected to the government network via EdNet, except for 22, which are remote. A further 30 locations are being considered, in the same group as schools. A range of different satellite options, from different carriers, are being tested for the 22 remote schools:

?? Telstra's VSAT service

?? Optus proposing a Hughes asymmetric solution.

The WA Education Department was the first in Australia to propose 128Kb as the minimum connection speed for any school; however most are still connected at 64Kb. This program commenced as "EdNet" in 1955 with the first 85 schools, and today some 50 schools are still connected by dial-up to the PSTN. More recently, schools are being connected into the state-wide government network called STEP (State-wide Telecommunications Enhancement Program).

Cash grants are being made to schools, to achieve a 1:5 ratio of computers to students in all schools. However, WA has a vision for electronic classroom capability for all schools within three years. They view a 256Kb connection as the minimum for videoconferencing in the short term and 2Mb for the full virtual classroom capability.

Social Equity Considerations

Social Equity groups have not yet prepared comparative costing models for remote schools and students, and therefore are finding it difficult to argue a case for equivalent cost and performance networks for their locations.

They do, however, have the strongest interest in WA. However, they are progressively getting their story prepared in all states. The most active group, apart from the Parents and Citizens Associations, is the ICPA (Isolated Children's Parents Association).

4.3.5 Schools—South Australia

South Australian schools are currently relating to over 45 ISPs for city, rural and remote connections to the Internet and associated services. Currently schools are responsible for contracting to and purchasing services from an ISP.

There are 630 public schools in South Australia, plus 350 preschools. Of these approximately 100 are currently connected by ISDN links at 64Kbps with only one site having a 128Kbps connection. The remainder of schools sites are connected through dial-up modem services averaging 28.8Kbps. Of the 100 ISDN-connected sites, approximately 30 are managing some degree of video conferencing over the 64Kb link, where the audio is reported to be satisfactory but the vision is very poor. (High-quality compression may assist with this, but compression cards and software are an additional expense to a standard computer purchase.) To date approximately 30% of schools have a LAN for curriculum purposes. This will increase rapidly as all schools have recently received grants totalling $5.5 million in June 1999 and further $5.4 million in August 2000 for the installation of passive cabling infrastructure from the DECS*tech* 2001 Project.

To provide all schools with a consistent, high-speed, high-quality services and connection to the Internet, the State Government, through the five-year $85.6 million DECS*tech* 2001 strategy, will contract with a single ISP. At the date of gathering information from states, the single ISP contract for South Australia is currently before State Cabinet for approval and Ministerial signature.

All schools will be provided with broad-bandwidth telecommunication services. 90% of schools will be connected within six months of the contract being signed, with the remainder (10%) in the following three months. There are 13 schools that will require satellite services with a 128Kb shared service proposed. A rapid connection of services to schools is planned once Cabinet approval is gained with the majority of schools connected by the end of 1999. The program will be managed by the Internet Online Services Project (IOSP) in the Department of Education Training and Employment.

The plan is for country schools and preschools to have the same Internet access speed as that available in Adelaide specifically to ensure equity in the delivery of high-quality services regardless of location in the state.

IOSP will offer a range of connections provided under an "Express One Service" utilising a committed information rate (CIR) of 64Kbps depending on school student enrolment, as follows:

ISDN Channels	Connected Data Rate	School Student Enrolment
1 Channel	64Kbps	13 remote schools
2 Channel	128Kbps	Up to 675 students
4 Channel	256Kbps	Greater than 676 students

The South Australian Test School

As in other states, one school leads the pack in usage. Aberfoyle Park High School was selected after a survey showed the following general usage patterns from 364 responding schools:

Survey Results from 364 Responding SA Schools	
No Student Use of the Internet	27%
Limited Student Use	47%
Moderate Student Use	22%
Extensive Student Use	4%

These results appear to match estimates of early usage by schools in other states, but as experienced elsewhere, SA officers believe that this will change very rapidly, particularly as LAN's are implemented in a majority of schools. SA also allows high-bandwidth applications, such as IRC, streaming and video conferencing. Officers believe that they can meet the bandwidth requirements provided that prices continue to drop at a rate that leaves their annual expenditure at about the same rate, but with much increased bandwidth.

4.3.6 Schools—Tasmania

Despite Hobart being a capital city, carriers tend to view all of Tasmania as "regional" with correspondingly poor bandwidth. The advent of the Social Bonus Fund, allocated across all states as a result of the partial sale of Telstra, has given Tasmania an opportunity to increase the quality and capability of its telecommunications on a large scale. Ten million dollars will be applied across the Bass Strait islands for example. The Bacon government has reviewed the NTP and is negotiating key elements of the contract, including the application of considerable pressure for Telstra to upgrade the Bass Strait link from about 8Mbps to 34Mbps.

There are 221 government schools in Tasmania, plus about 50 public libraries on the same network, with other government agencies.

As in SA, Tasmania has all schools connected, but two thirds use BigPond dialup, via an inefficient and not readily available 56Kb service. The contract with Telstra has offered the bonus of widely located virtual POPs, making dial-in costs more competitive. Of the total, 85 have ISDN, all with a single 64Kb channel.

In the last week of July 1999, it was decided to connect all remaining schools in the State to ISDN. About half the schools will have 64Kbps links, with the remainder scaled up to 512Kbps, depending on student numbers in the school. The majority of these upgrades are expected to be in place by year end 1999.

Tasmania's Test School

As in other states, Tasmania has a test school for higher bandwidth. Tasmania's test school, Hobart College, is now supported by a Telstra-sponsored 640Kb Frame Relay link. The school has 800 students and 200 to 300 computers. Capacity planning indicates that schools of this size require about 500Kb to operate efficiently, a fact borne out in other states.

Of particular note is Launceston College in northern Tasmania, with about 2000 students, making it one of the largest public schools in Australia. Launceston College has a single 64Kb ISDN connection, which teachers describe as "almost unusable". They indicate strongly, that the failure of the technology "has become a distraction from the learning" and that "content hosted in the USA is almost unusable in Tasmania and becoming more so over time".

Correspondents indicated their desire to achieve bandwidth of equivalence to "small primary schools in Canada, who are using 1Mbps links for education" within 18 months.

Bandwidth Growth Drivers

Correspondents in Tasmania have clearly thought through the ramifications of current technology use, and listed the following drivers, currently and in the immediate future:

- Professional development for staff
- Increased use of streaming applications
- Desire to use videoconferencing
- Increased web page sizes generally
- New streaming and video services coming online.

Estimates by these people indicate that "growth by a factor of 10 every 18 months for the next five years is highly probable, thus requiring three magnitudes of increased bandwidth". This tallies with feedback from other schools across Australia.

4.3.7 Schools—Northern Territory

The new Northern Territory program for schools is known as the Education 2000 Strategy. This program is linked with a whole-of-government networking tender, which closed in July 1999, but has yet to be finalised.

There are 155 schools in the Northern Territory, plus about 50 preschools and 25 non-government schools. Approximately 80% of these have connection to the Internet via modem. Fourteen senior schools and eight primary schools, most located in Darwin, have ISDN access, all at 64Kbps. Direct connections are limited to Darwin, Palmerston, Katherine, Nhulunbuy and Alice Springs.

NTDE Staff believe that genuine improved teaching capability, using computers and networks would require 1MB connections to smaller schools and 2Mb connections to larger schools. This is their longer-term objective.

The USO in the Northern Territory

Under the USO, Telstra is obliged to provide digital telephone coverage to 96% of the Australian population. Due to its remote location and small population, NT has more than a quarter of Australian residents in the remaining 4% who are "un-connected". A tender process run by DEETYA in the early 1990s, under EdNA auspices, was designed to obtain a single contract for the connection of all education institutions around the country (who wished it), which would have been of considerable benefit to the NT. Unfortunately, irregularities in the tender process saw it cancelled. As a result, NT is unable to afford the necessary infrastructure to reach all schools.

Of the 180 schools (including non-government) over 100 are not currently reachable by a Telstra landline, and will require relatively expensive satellite or microwave equipment to obtain connection in the longer term.

4.3.8 Schools—ACT

There are 98 public schools in the ACT (plus 81 pre-schools), whose computing systems are supported by the whole-of-government unit, IntACT. IntACT utilises whole-of-Government suppliers and partners which include GE, Fujitsu and Telstra.

Originally, the project was simply called "Canberra Schools on the Net" (CSN) but now goes under the title "EduNet". CSN commenced as a dial-up service to access content, but now all schools are connected to EduNet for Internet access (although not for active content), except one at Uriarra and one at Jervis Bay. The latter is serviced by the Commonwealth under contract. CSN remains for out-of-hours access for schools. EduNet was built primarily as an administrative network, with secondary use for curriculum purposes.

All schools are connected at 64Kbps with two of 18 high schools connected at 128Kbs. All eight colleges will be connected to 128Kbps this year, with Hawker College already complete. Hawker has 1000 students, and the 64Kbps line proved to be unworkable in the first instance. A separate proposal to upgrade all school connections to 128Kbps has been made.

Costing in the ACT

Pricing for ISDN lines in the ACT is interesting, as it comes under a "whole-of-government" contract, in the same way as Tasmania, but with widely varying rates.

The cost for a single channel is:

- $10 000 for establishment (including the first year's ongoing fee). This is a full "end-to-end" service, including infrastructure.
- $5000 thereafter.
- 19 cents per megabyte, with a small service charge on top.
- Only a $700 fee (approximately) for the second channel.

This pricing demonstrates the different approaches taken in differing locations, plus the opportunity for collective negotiation.

4.3.9 Non-Government Schools

A brief telephone survey of non-government schools in Queensland and ACT indicated that, in general, they are (perhaps surprisingly) behind the public sector in providing permanent connections to the Internet. There are, however, some notable exceptions that are leaders across Australia.

Catholic Schools

Non-Government Schools make up approximately one-third of the student population around the country. Their computing and networking needs mirror those in public schools. The following is sample information for Catholic schools in two states.

In Victoria, there are 490 Catholic schools of which 386 are primary, 98 are secondary and six are special.

Connection of 64Kb ISDN has commenced with a planned completion of late 1999, but currently, most schools have dial-up access. All secondary schools will be connected at 128Kbps or higher.

In SA, there are 109 Catholic Schools, of which 30 are secondary and 79 are primary. 75 of these schools have dial-up capacity. The majority of secondary schools (25) have 64Kbps ISDN and two have 128Kbps. Radio links are being considered for on-campus links in some schools.

Radio and Microwave

Representatives from a number of non-government schools see ISDN as being an old and limiting technology and are exploring radio and microwave links of at least 2Mbps for their initial links to the larger Internet. Cost comparisons make this solution increasingly attractive.

5 Factors driving increased use of Broadband Networks

In summary, factors that are driving increased use of data networks across Australian Educational Institutions include:

1. Availability of new Internet connection services to more homes, schools, businesses and government agencies.
2. Improved and increased LAN and desktop equipment in schools.
3. Latent demand (up to three times by volume) from those who have poor or limited access on current networks.
4. Lack of substantial disk mirroring in Australia, forcing higher international traffic.
5. Lack of clarity regarding the use of high volume, computer memory cache systems, from a copyright viewpoint, thereby driving use of cache down to acceptable legal levels and increasing use of bandwidth.
6. Increase in the use of more complex e-mail, in particular the increased use (to about 40%) of attachments to e-mail including larger documents and digital photography.
7. Increase in general complexity and size of web sites, impacting on telecommunications because of complex graphics, audio and other features.
8. Increase in the sheer quantity of material on the WWW.
9. Increased awareness and capability of teachers and administrators
10. Improved use and capability of streaming technologies, particularly for video and audio.
11. Increased interest in Virtual Classrooms, and related virtual libraries and other holders of digital materials such as galleries and museums.
12. Increased use of other virtual and related services such as GSD, telemedicine, simulators and virtual laboratory testing (amongst many others).
13. Increase in regular academic research.
14. Increase in applied research from collaborative ventures between universities and commercial enterprises.
15. Increased competition in global markets, driving foreign educators on-shore with flexible learning materials.
16. Reducing prices for computer equipment, telecommunications costs and other infrastructure.

6 Restraints to Increased Use of Networks by the Education Sector

Naturally, almost every respondent to this consultancy mentioned price as the key restraining factor for the increased use of telecommunications bandwidth. But it is not as simple as that, even for pricing. Constraints include:

1. lack of any reasonable connection capability, especially in rural and remote areas
2. lack of teachers and administrators with enough training to effectively use the technology
3. lack of teaching materials in electronic format to cover all subjects in the curricula
4. lack of competitors in the carrier business with enough financial muscle to effectively compete with the established players
5. restrictive actions of the ACCC using the *Telecommunications Act 1997* as the basis in law
6. differentially higher pricing for trans-Pacific links, and
7. specifically, lack of competitors supplying ISDN connections (or similar technology).

6.1 Pricing Issues

Pricing of telecommunications deserves an entire consultancy of its own.

1. To commence, there are so many components and variations to pricing schedules, that it is very difficult for a small user to reasonably and accurately compare offerings from different carriers.
2. Secondly, each service requires payments around multiple different components, such as connection, CPE equipment, monthly charges and data charges. The major concern for most users, is accurately estimating re-current or ongoing charges for data downloads. Those who have visibility to wholesale prices, wonder why there are such high differences between the wholesale and retail costs of services.
3. Small businesses and schools need to count in the cost of internal LAN hardware and software, a point often overlooked by state agencies preparing their first networks. Ditto for training.

As more carriers come to the market, they are offering attractive deals based around a CIR service, which is well worth consideration. For example, a user can obtain and pay for a 128Kb Frame Relay or ATM service, but actually have access to any bandwidth available on the connection they use, enabling them to obtain very high capacity without initial high costs. The restriction of course is if the network becomes overloaded with other users, or if the customer consistently uses more than the CIR in capacity, when they are then asked to pay the additional rate.

A Comparison of ISDN Pricing

The table below shows comparative ISDN pricing in the USA and UK. The rates are in international currency, but clearly show a wide variety of rates that are less expensive than most services in Australia.

Supplier	Bandwidth	Connection Fee	Monthly Rental	Monthly Data or Call Rate	Addition for Internet or internal wiring
BT UK	128Kb	UKP149	UKP44.58	UKP 19.10	
Bell South	64Kb	$US140	$US38	additional	$15 one-time for Internet
Ameritech	64Kb or 128Kb	$US122	$US41.31	Nil	$90 internal wiring
Bell Atlantic	64Kb or 128Kb	$US85 to 200	$US35	Nil	$90 for wiring
GTE California	64Kb or 128Kb	$US172	$US50 to $66.38	Nil	$85 for wiring
Nynex	64Kb or 128Kb	$US312	$US36.23	Nil	$142.76 for wiring

In the US, a T1 link (about 1.3Mbps) is disproportionately cheaper, particularly over longer distances. A 2MB link today could cost at least $80 000 intra-state, and some hundreds of thousands where it crosses a state border, and is dependent on the supplier and capacity used.

Of course, the data charges for the trans-Pacific connection are additional for Australian users.

7 Related (and Special) Issues for Bandwidth in Education

More bandwidth is not always the only solution to education telecommunications needs.

7.1 Mirroring, Caching and Digital Copyright

Educational institutions have quickly found that schools with high needs from a limited number of standard websites can increase their effective bandwidth by caching, or storing in the memory of their computer servers, the most popular sites and data. Caches can be set to any amount that the school can supply, and 2Gb is not uncommon. This raises a question of copyright, because a larger cache will hold material for a longer time. The question is whether this amounts to "copying".

The general view is that a cache of 20Gb would be very useful but questionably legal. The new Copyright Act is not clear on this point but seems to view cache as a transitory copy.

Mirroring is a more formal method of copying digital materials, usually under a license. The data is then held on disk, rather than in memory, and in its simplest form, allows connection over shorter distances. AARNet members developed a Super Mirror, which currently costs over $700 000 per annum in trans-Pacific carriage costs, but has now been limited to Australian users. Naturally, international users complained that the excellent service was no longer available, but backflow costs were too much for AARNet to carry.

7.2 Government Programs

A range of current Federal programs have the potential to support increased use of networks and online teaching. These include:

- Networking the Nation ($250m from July 1997)
- RTIF (Regional Telecommunications Infrastructure Fund)
- BITS (Building on IT Strengths)
- Information Industries R&D Test Bed Infrastructure Program
- Telstra Social Bonus Schemes such as:
  - Building Additional Rural Networks
  - Rural Transaction Centres.

8 International Programs and Innovations

8.1 US Internet Programs for Education

The USA has a comprehensive focus on IT for schools and educational institutions. This is driven from the President down, and is based around **The Four Pillars of the Technology Literacy Challenge**[21], which are:

1. **Modern Computers** will be accessible by every student.
2. **Classrooms will be connected** to one another and to the outside world.
3. **Educational software** will be an integral part of the curriculum.
4. **Teachers will be ready** to use and teach with technology.

US Government Programs to support this strategy are extensive. Those of significance and worth our consideration include:

1. the E-RATE program, which offers deep telecommunications discounts to educational institutions
2. the Technology Challenge grants for Professional Development, which assist teachers in utilising technology, and
3. The President's Life-Long Learning Program.

8.2 International High-Speed Networks Compared

Planners in Australia should be cognisant of the following programs and opportunities overseas:

- CANARIE's CA*net3, building on the high-speed academic network, using optical fibres and DWDM (Dense Wave Digital Multiplexing) technology. Members of CANARIE, a private not-for-profit company, include Bell Canada, JDS Fitel, Newbridge, Networks Corp, Nortel and Cisco.
- Internet2, which is being constructed as a very high-speed academic network, sponsored by UCAID and 150 other universities who are each investing in a "GigaPOP" at their locations.
- International Partner Programs (often in conjunction with Internet2), including the following subnetworks and agencies, amongst which is APAN the Asia Pacific link from Australia to Japan.

Each has its own website for details and all are significant contributors to the net.

- UKERNA who supports the UK Janet networks
- CANARIE from Canada
- APAN—Asia Pacific
- SURFnet from Netherlands
- SingAREN from Singapore
- NORDUNET for the Nordic countries and some eastern European partners.
- DFN-Verein—Germany
- RENATER from France
- JAIRC from Japan
- CUDI from Mexico
- Terena—Europe
- IFN-GARIL from Italy
- IUICC from Israel.

?? NGI sponsored by the US Federal Government with commercial partners, to be 100 to 1000 times faster than today's Internet.

9 Key Findings

9.1 Summary of Findings

1. The 37 AVCC University members are well advanced in the use of Internet technology, via AARNet, with today's needs being largely met for all but five universities.
2. Whilst growth in University usage is at about 50%, the growth rate is expected to increase in about 18 months, and the current networks, particularly the current international links will be inadequate by about one magnitude, due to the drivers listed above.
3. All Australian State Governments are advanced in rolling out basic ISDN and equivalent services to their school sector, but still have about a third of connections to make.
4. However, for larger schools, the bandwidth of 64Kb is totally inadequate in almost every case.
5. Latent demand in most schools is running at about three to one, as measured by base demand, versus theoretical peak demand (only measured in a limited number of schools).
6. All schools should be connected at a minimum of 128Kb as soon as practicable, simply to meet this year's needs.
7. In the larger third of schools, growth by one magnitude (10 times today's level) can be expected in an 18-month to two-year timeframe and two magnitudes at least, within the two-to-five-year timeframe (i.e. at least 100 times today's general capacity.)
8. A few schools are highly advanced in use of broad bandwidth telecommunications, and should be encouraged, provided that the resulting materials are eventually available to all.
9. State Governments have generally not (with a few notable exceptions) allowed sufficient funding for allied needs, such as:
10. Computers in schools
11. In-school LAN infrastructure
12. Educational software and multimedia tools
13. Teacher training.
14. Non-Government schools face the same challenges as their public sector cousins.
15. Current TAFE or VET networks are the poor cousins of the sector, except within major capital cities.
16. Co-ordination of the national VET network, possibly as an overlay to AARNet, would see significant pricing and management benefits.
17. The current Telecommunications Act and therefore its overseer, the ACA, is restricting growth of high speed networks, particularly for academic research.
18. A very high bandwidth research network in Australia, would likely foster development of new industry applications enabling Australia to maintain a competitive position in global e-commerce.
19. Proposed international links are likely to be adequate for the foreseeable future, however, pricing remains unreasonably high.

9.2 Bandwidth summary for the School Sector

The following table is designed to provide indicative data, for future comparison. In reality, the numbers depend on a range of assumptions and change day by day.

State/ Territory	Number of public Schools (+ other connected centres.)	Number of schools connected (excluding dial-up) to network	Percentage on ISDN or VSAT or frame relay	Number connected via satellite	Number on Dial-up only	Number of schools with 128K or higher bandwidth	Approx. Total Connect Bandwidth
NSW	2224	900	40%	0	1324	0	65.0Mb
Victoria	1740	1740	100%	21	0	358	80.2Mb
Queensland	1298(+32)[22]	1330	100%	64	0	130 @128K, 1 @ 256Kb	106.1Mb
South Australia	630(+350[23])	100	16%	13	530	1 @ 128Kb	7.3Mb
Western Australia	772(+30)	750	97%	22	50	Nil, want all at 128K	49.4Mb
Tasmania	221(+50)	85	38%	0	146	1 @ 640Kb	6.1Mb
Northern Territory	155	22	14%	0	124	Nil	1.4Mb
ACT	98(+81)	98	100%	0	0	2 @ 128Kb	6.3Mb
TOTAL Australia	**7138**	**5025**	**63.1% av.**	**120**	**2174**	**493**	**321.8Mb[24]**

9.3 Bandwidth summary for the University Sector

Comprehensive data on all bandwidth connections for AARNet is available from the AVCC. In summary, they believe that the following international demands will happen over the next two years.

The table shows the previous years' data for comparison.

Year	Download
1995	12 Terabytes
1996	27 Terabytes
1997	52 Terabytes
1998	95 Terabytes
1999	150 Terabytes
2000	220 Terabytes

9.4 Bandwidth Summary for the VET Sector.

STATE	# Inst's	# Loc's	#64Kb	#128Kb	#256Kb	#512Kb	#2-10Mb	#34 -100Mb
NSW	12	149	180	50	0	11	9	4
Victoria	15+5	147	140	7	0	0	8	0

Qld	14	62	55	0	0	0	0	0
SA	8	56	48	2	4	2	0	0
WA	12+2	N/A	60	12	0	1	0	0
Tas	4	17	8	5	4	0	0	0
NT	4	11	4	0	0	0	0	0
ACT	1	7	0	0	0	0	7	0
TOTAL	**70+7**	**449**	**495**	**76**	**8**	**14**	**24**	**4**

10 Recommendations

10.1 Policy Recommendations

The consultant recommends that DETYA and NOIE determine the most appropriate timing for consideration of these policy recommendations, in particular their juxtaposition to the Telstra 2 share float.

?? That the EdNA Schools Advisory Committee (ESAG) and EVAG prepare a proposal to the Commonwealth (MCEETYA), to instigate a national telecommunications discount program for the schools and VET education sectors. (This might be named AUS-E-RATE and benefit from the lessons learnt in the USA, both positive and negative, via its E-RATE Program.) It is further recommended that DETYA (in conjunction with the States), on obtaining the costs comparison for each state, should negotiate with Telstra and DCITA for consistent education pricing across Australia, especially for regional locations.

?? That AUS-E-RATE be financed by the relevant deliverer of the Universal Service Obligations (USO), from its service margin.

?? That the Commonwealth should modify policy, and legislation if necessary, to allow AARNet to develop AARNet 3, with the inclusion of any other legitimate member of the education community including schools, research organisations and members of the VET sector, both public and private.

?? That, at an appropriate time, the Commonwealth put the USO to public tender and reconsider inclusion of data components in that tender, such that regional users may obtain parity pricing for data services, with their city counterparts.

?? That the Commonwealth, through continuation of its program of de-regulation of the Telecommunications Sector, encourage increased competition in the telecommunications sector, particularly for "last mile" telecommunications services, with the objective of allowing market forces to determine broader telecommunication pricing regimes and delivery protocols.

?? That the Commonwealth defines a policy of not supporting transitionary telecommunications technologies such as asymmetric data delivery, where they may discriminate against remote, rural or other disadvantaged groups or individuals.

10.2 Recommendations for Action

?? That the EdNA Reference Committee, with assistance from DETYA, allocate resources to regularly (and at least annually) survey:

- ?? the network structures and their maximum theoretical capacity for the education sector
- ?? the proportion of this bandwidth used, by each State
- ?? the monthly growth rate in that usage, and
- ?? comparative costs of equivalent data services, by regional location.

And publish the results to the entire sector. Further, that DETYA encourage the EdNA SAG to utilise the information to better negotiate and bargain for appropriate services, on a national and collaborative basis. Estimated cost is one salary, or equivalent, at $50 000 per annum.

?? That, in 1999 MCEETYA set a new National Education Data Standard (NEDS), for the provision of **minimum** bandwidth for every school and VET teaching location, in Australia of **at least** 128Kbps in 2000, 256Kbps in 2001 and moving to 2Mbps by 2004[25]. Further, that the standard

recognises an increased bandwidth requirement for every institution where the number of students exceeds a total of 200.

?? That the EdNA Reference Committee prepares a proposal to MCEETYA to develop a national strategy to ensure that all schools and VET providers in Australia are able affordably to gain access to bandwidth to at least the minimum benchmark levels.

?? That States give consideration to the provision of regional POP services from selected institutions, to enable cost effective dial-in Internet services for teachers and all students, thus enabling flexible learning and some distance delivery. Limitations should be to educational domains or material, rather than to particular student groups.

?? That DETYA consider developing a program of one-off funding of sixteen "Lighthouse Schools" (such as the Special Schools listed in the section below) across all states and territories, to specifically fund high performance networks for key teaching applications, to the value of $80 000 per school. Schools must apply for the grants, and as quid pro quo, supply digital teaching materials in return, with the IP made freely available to any school in Australia.

?? That the Commonwealth co-sponsor a joint industry/AARNet/government proposal for an ultra-high-capacity (at least 5Gbps) commercial network, to be paid for by users, similar to the Internet II Project in the USA. This project should be cost neutral to Government over five years.

?? That the ERC and DETYA consider annually, the likely new applications to be used on education networks, and make an estimate of the increased bandwidth that may be required on a macro level to Australia and across the sector, for the planning benefit of DETYA, DCITA and other Commonwealth agencies.

?? That, should the NBI be unable to provide precise comparisons of pricing for standard data services in the international education sector, DETYA commission a separate consultancy to obtain this data for equivalent education organisations in the USA and other appropriate countries. The estimated cost is $25 000.

10.3 Related Observations and Implied Recommendations

The following items were mentioned by a number of respondents, but are peripheral to the Scope of this consultancy. To provide a complete teaching and training capability, they should be considered by DETYA and NOIE.

?? That DETYA consider supporting and promoting programs that not only assist States with rollout of telecommunications infrastructure but also support critical related capabilities:
  ?? Computers in Schools and TAFE colleges, with a target of one computer for every two students by 2003.
  ?? LAN infrastructure including servers, NOS, routers and cabling.
  ?? Education and learning software (with a target of 50% Australian digital content) that supports teaching across ALL subjects disciplines.
  ?? Specialised instructional programs for teachers and parents.

?? That, in conjunction with the States, DETYA investigates the most appropriate and cost-effective way to either acquire or develop Australian digital teaching materials for school students, which will eventually be available for all subjects in the school curricula. Such materials should include:
  ?? Face-to-face teaching materials
  ?? Online, flexible learning materials
  ?? Centrally held resources.

?? That the Commonwealth continues to develop ways to stimulate tertiary skills development amongst Australians in areas of telecommunications and information technology.

Notes

1. *"The Emerging Economy II* "—US Department of Commerce—June 1999.
2. Pers Comm. Frank Blount ex CEO Telstra, 1998.
3. AVCC Presentation by AARNet Manager, July 1999.
4. International Data Corporation—http://www.idc.com/
5. Australian Bureau of Statistics—Household survey, 1998.
6. Note that this refers to a standard for connection of "institutions", not connection to "students", as it is not possible to guarantee high-bandwidth access to every home in Australia at this time. The consultant's assessment is that many correspondents to his survey desired far stronger action from both state and federal governments, particularly in terms of alleged monopolistic practices from a number of carriers. However, the current Telecommunications Act 1997 does not allow some of these proposed actions, which may also be counter to the current National Competition Policy and the view of the ACCC.
7. Largely from a speech by Vinton Cerf, Chairman of the Internet Society, April 1999.
8. "Being Digital" Nicholas Negroponte, First Vintage Books 1996.
9. The new Canadian network (CA*Net3) will utilise 32 different colours of laser light on their fibre, representing 32 different frequencies on a single fibre, yet still only utilising 1% of the total fibre capacity.
10. National Bandwidth Inquiry—A Submission to the Department of Communications, Information Technology and the Arts by CAUDIT, the Committee of Australian University Director's of Information Technology, 1999.
11. Costing details for these arrangements are confidential to AVCC, but are exceptional, when compared to public pricing regimes for commercial users.
12. Telephone surveys by the Queensland Information Industries Branch and Australian Silicon Studio Training Centre of graduating diploma students' employment prospects, 90 days after graduation 1998 and 1999.
13. http://www.imago.com.au/
14. "Multimedia Training Needs Analysis" November 1998, TACITPR ITAB.
15. http://www.det.nsw.edu.au
16. http://www.sofweb.vic.edu.au/itb/vicone/
17. Source, Charts from Education Victoria June 1999.
18. BT UK http://www.isdn.bt.com/pricesum/2epriceo.htm
19. Bellsouth in Houston http://www.uh.edu/~wrice/cost.htm
20. Following data came from http://www.orderisdn.com/isdncost.html, which lists many other examples.
21. http://www.ed.gov/technology/
22. Environmental Education Centres etc.
23. Pre-schools in SA, ACT and Tas.
24. This is a very approximate estimate and does not include dial-in or private lines leased by some schools. It is also not 100% useable, but will give an approximate sizing for future comparison.
25. Note that this refers to a standard for connection of "institutions", not connection to "students" as it is not possible to guarantee high bandwidth access to every home in Australia at this time.

Appendix 1: Bibliography

Australia—Australian Communications Authority *Digital Data Enquiry August 1998*. http://www.aca.gov.au/

Australia—Department of Education, Training and Youth Affairs—*State and Territory Based Initiatives—Schools.*—DETYA Online Education Group June 1999.

Australia—Department of Education, Training and Youth Affairs—*Infrastructure Issues for the Education and Training Sector*—DETYA Internal Paper June 1999.

Australia—Department of Foreign Affairs and Trade—*Putting Australia on the New Silk Road*—1998.
http://www.dfat.gov.au/nsr/nsr_hobart.html

Australia –National Office of the Information Economy (NOIE)- *National Bandwidth Inquiry* Information Paper—1999.

Australia—Telstra Social Bonus Scheme—http://www.dcita.gov.au/graphics_welcome.html

Australian National Training Authority—*Preferred Standards to Support National Co-operation in Applying Technology to VET*—February 1999 http://www.vicnet.net.au/neptune/

CAUDIT—Committee of Australian University Director's Information Technology *National Bandwidth Inquiry Submission*— September 1999.

HREOC Human Rights and Equal Opportunity Commission—Rural and Remote Education Inquiry Briefing Paper—http://www.hreoc.gov.au/news_inf…./n1_9_8.htm

Maher. W—APC Newswire—Report on Rural Australia Missing our on Data Services – http://www.newswire.com.au/9908/datare.htm

Moon. O.—The Needs, Capabilities and Opportunities for the Multimedia Industry Development in Tasmania: Final Report. Department of State Development—August 1998.

Queensland Department of Education—ConnectED Project. http://www.qed.qld.gov.au/tal/2001/snip/

Tasmania—Department of Education *Bandwidth Measurement for Schools*—Personal Comm to DETYA from Peter Croger.

Tasmania—Tasmanian Arts, Communications, IT, Printing and Recreational Industries ITAB – *Multimedia Training Needs Analysis* November 1998.

US Department of Commerce—*The Emerging Digital Economy II*, June 1999.
http://www.ecommerce.gov/

Victoria—Education Victoria—*Victorian Edunet Data Requests*—June 1999.

Australia—Department of Communications and the Arts—*Networking Australia's Future*—The Final Report of the Broad Band Services Expert Group 1994.

Appendix 2: Contacts and Interviewees for this Consultancy

The following list of names is useful and relevant to the matters of this consultancy. Most were contacted in one form or another, during the course of the consultancy.

SCHOOLS

NSW Schools
Garth Newton, Wolfgang Purucker, Peter Eldershaw

VICTORIA Schools
Bruce Rigby*, Paul Doherty

Queensland Schools
Gary Barnes, Henk Vullers

SA Schools
Peter Simmonds, Allen Bevan, Garry Putland

WA Schools
Neil Jarvis, Bevan Doyle, Hazel Day

ACT Schools
Carol McKenny, Narelle Hargreaves, Mike Brown

TASMANIA Schools
Peter Croger, Max Gentle, Martyn Forrest

NT Schools
Vic Czernezkyi, Francis Kong, Andrew Luke, Clint Andrews, John Preswell, Mark Pettifor, Mike Forster

VET

NSW VET
John Banham, Allen Ibbitts, Janine Hourigan

Victoria VET
Rodney Stark, Jack Gilding, Julie Harris, Mark Bevelander, Meredith Sussex

Queensland VET
Jon Henry, Cran McLean, Noela Eddington, Charles Henderson

SA VET
Neil Strong

WA VET
Stuart Young, Linda Bryant, Marion Seboa, Gillian Werner

NT VET
Lee Upton, Greg Flanaghan, Noelleen McCormack (Education), Rita Harvey (Education)

Tasmania VET
Col Hollingworth, Michael Bennet, Tony Lohrey, Grant Hearps, Mike Brough

ACT VET
Peter LeCornu

DETYA

Evan Arthur, Jan Gough-Watson, Gabrielle Onitiri, Murray Judd, Louise Wells, Bruce Edwards

Appendix 3: Acromania

The following abbreviations are used within this report. Please note that a number have alternate meanings such as those for ABC or ATM.

AAIREP	Australian Advanced Internet Research and Education Program
AARNet	Australian Academic Research Network
ABC	Australian Broadcasting Corporation
ACCC	Australian Competition and Consumers Commission
ACT	Australian Capital Territory
ACTEW	ACT Electricity and Water
ADSL	Asynchronous, Data Service Link
AIIA	Australian Information Industries Association
AIMIA	Australian Interactive Multimedia Industry Association
AIMS	Australian Institute of Marine Science
AMC	Australian Maritime College
ANSTO	Australian National Scientific Technology Organisation
APAC	Australian Partnership for Advanced Computing
APAN	Asia Pacific Advanced Network
ASSTC	Australian Silicon Studio Training Centre
ASTEC	Australian Science, Technology Expert Committee
ATM	Asynchronous Transfer Mode
AVCC	Australian Vice Chancellor's Committee
BSEG	Broadband Services Expert Group
CAN	Customer Access Network
CAUDIT	Committee of Australian University Directors of Information Technology
CBR	Constant Bit Rate
CDMA	Code Division Multiplier Access
CD-ROM	Compact Disk-Read Only Memory
CG	Computer Graphics
CIR	Committed Information Rate
CIRCIT	Centre for International Research on Communications and Information Technology RMIT
CLRC	Copyright Law Reform Committee
CMC	Co-operative Multimedia Centre
CPE	Customer Premises Equipment

CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCITA	Department of Communications, Information Technology and the Arts
DEC	Distance Education Centre
DETIR	(Queensland) Department of Employment, Training and Industrial Relations
DETYA	Department of Education, Training and Youth Affairs
DIST	Department of Industry Science and Tourism
DMO	Telstra's Data Mode of Operations
DRCS	Digital Radio Concentrator System
DVD	Digital Versatile Disk
DWDM	Dense Wave Digital Multiplexing
EC	Electronic commerce
EdNA	Education Network of Australia
EDI	Electronic Data Interchange
ESD	Electronic Service Delivery (Government)
ETI	Eligible Tertiary Institution
ETSI	European Telecommunications Standard Interface
FMO	Telstra's Future Mode of Operations (Analogue to Digital)
GB	Giga Byte
Gbps	Giga bits per second
GSD	Government Service Delivery (Electronic)
HTML	Hypertext Markup Language
HFC	Hybrid Fibre Co-axial
IBM	International Business Machines
ICPA	Isolated Children's Parents Association
ICT	Information and Communication Technology (European term)
IDC	International Data Corporation
IEEE	Institute of Electrical and Electronic Engineers
IMM	Interactive Multimedia
IP	Intellectual Property
IRC	Internet Relay Chat
ISDN	Integrated Service Digital Network
ISP	Internet Service Provider
IT and AT	Information Technology and Advanced Technology
IVR	Integrated Voice Response System
Kbps	kilobits per second

LAN	Local Area Network
Mbps	Megabits per second
MCEETYA	Ministerial Committee on Employment Education Training and Youth Affairs
MITE	Moveable Interactive Teaching Environment
MM	Multimedia
MOU	Memorandum of Understanding
MPEG	Motion Picture Expert Group
MS	Microsoft Corporation
NASA	(USA) National Air and Space Administration
NBI	(USA) National Broadband Initiative
NDA	Non Disclosure Agreement
NEDS	National Education Data Standard
NOIE	National Office of the Information Economy
NSW	New South Wales
NTP	Network Tasmania Project
NUSP	National Universal Service Provider (Telstra)
OECD	Organisation for Economic Co-operation and Development
OS	Operating System (of a computer)
OVET	Office of Vocational Education and Training (Tasmania)
POP	Point of Presence
POTS	Plain Old Telephone Service
PSTN	Public Switched Telephone Network
PVC	Permanent Virtual Circuit
PVP	Permanent Virtual Path (may include many PVCs)
QANTM	Queensland and Northern Territory Multimedia
QOLN	Queensland Open Learning Network
QoS	Quality of Service
QUT	Queensland University of Technology
RMIT	Royal Melbourne Institute of Technology
RNO	Regional Network Organisation
RTIF	Regional Telecommunications Infrastructure Fund
RTP	Registered (VET) Training Provider
SATCOM	Satellite Communications (Telstra)
SEAMEWE	South East Asia Middle East Western Europe
SLA	Service Level Agreement

SME	Small and Medium Enterprise
STEP	State-wide Telecommunication Enhancement Program (WA)
SVC	Switched Virtual Circuit
TAFE	Technical and Further Education
TCP/IP	Transfer Communications Protocol / Internet Protocol
USO	Universal Service Obligations
UTAS	University of Tasmania
VBR-NT	Variable Bit Rate—Non Real Time
VCR	Video Cassette Recorder
VETEC	Vocational Education and Training Corporation (Qld)
VFX	Virtual Effects (in films)
VOD	Video on Demand
VR	Virtual Reality
VRML	Virtual Reality Markup Language
VSAT	Very Small Aperture Transmitter
WAN	Wide Area Network
WWW	World Wide Web (graphical version of the Internet)

Notice

This report was prepared as a private communication to the Department of Education Training and Youth Affairs pursuant to the Consultancy Agreement. Whilst this report is based on information from sources which Wildtwo Consulting considers reliable, its accuracy and completeness cannot be warranted. Any opinions expressed or recommendations made are based upon the information provided to the Consultant during the compilation of this report. Such opinions and recommendations are fairly based and fair comment on the facts as provided to the Consultants. Wildtwo Consulting Pty Ltd, its directors and employees do not accept any liability for the results of any actions taken or not taken on the basis of information in this report, or for any negligent mis-statements, errors or omissions. This report is made pursuant to the agreement with the Commonwealth of Australia—Department of Education, Training and Youth Affairs.