# High Bandwidth Networks for Institutions:
## Lessons from Overseas Case Studies

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*There is a crucial need in Australia's education and training sector for access to advanced telecommunications and information technology infrastructure, and particularly that delivering high bandwidth at an affordable price. However, the take-up of bandwidth is being retarded by the pricing regimes of telecommunications carriers coupled with their inflexible delivery models.*

*A large majority of Australian schools are currently starved of bandwidth, having only single line access to the Internet. Disparities in access and cost between urban and rural and regional areas also present key equity issues as well as issues for regional and industry development. Such limits on access to ICT infrastructure are a key impediment to the education and training sector's participation in the information economy.*

*This paper draws upon a study sponsored by the Commonwealth Department of Education, Training and Youth Affairs to improve our knowledge about innovative approaches to meeting the future requirements of the Australian education and training sector for high-speed online communications. Following a review of a successful case study of a group of schools in Quebec, Canada, the paper then discusses the success factors considered to be common to a number of equivalent high bandwidth initiatives examined within Canada, the USA and Sweden.*

## INTRODUCTION

In response to the Australian government's Strategic Framework for the Information Economy [NOIE, 1999 ??] and in particular to the strategic priority to "deliver the skills and education Australians need to participate in the information economy", the education and training industry developed an Action Plan, which included 'Infrastructure' as a Key Action Area:

> *All parts of the education and training industry need access to advanced telecommunications and information technology infrastructure including high bandwidth at an affordable price.* [2]

This arose from the concern that, although the education and training sector's bandwidth requirements were noted to be high and growing, the rate of growth would be determined to a significant extent by the pricing regimes of telecommunications carriers. Further, limits on access to information and communication technology infrastructure were seen to be a key impediment to the sector's participation in the information economy.

Surveys showed that whilst many Australian schools are now providing students with access to computers at a ratio of five to one or better, most schools are connected to the Internet with no more than 64 kb/s of bandwidth that is expected to be adequate for perhaps 60 or more computers. This situation is against a backdrop of sector's bandwidth requirement expected to rapidly grow as the Internet features more frequently in everyday teaching practice and as “bandwidth-hungry” real-time audio- and videoconferencing, plus the capacity to download large files, become more frequently demanded.

Concurrently, the Australian Department of Education, Training and Youth Affairs (‘the Department’) became aware of certain overseas communities who were taking greater responsibility for providing the bandwidth they need rather than depending so heavily on telecommunications carriers. The Department sought to become better informed about such innovative approaches, as they may suggest better ways of providing bandwidth to meet the future requirements of the Australian education and training sector to support its teaching and learning activities.

A project was therefore initiated to describe and review the experience in Canada, the USA and Sweden in developing such innovative approaches, and then provide a preliminary assessment of their applicability within Australia. A subsequent phase could then examine the prospect of undertaking a small-scale trial to test a potential model and identify relevant issues to be addressed.

This paper draws upon some of results of the investigation supporting the initial project. [3]

## METHODOLOGY

An initial desktop survey was made of available reports of plans, implementations and operations of relevant high bandwidth networks within Canada, the USA and Sweden, followed by confirmation of the most appropriate people and organisations to subsequently meet in those countries. A fifteen working day overseas visit was then undertaken during February and March 2001 to meet the identified people and organisations, following a structured approach in order to access and appreciate as much information of relevance as possible in the limited time. This entailed a focus on the following issues:

- Services and applications – initial/future, outcomes for education and training;
- Costs, financing and funding – imputed/real savings, long term viability;
- Challenges/barriers – technical, regulatory, competitive/market;
- Management – technical, project, operational; and
- Technology options.

Upon return to Australia, the gathered data was analysed and any new leads/unclear information or any missed persons followed up. Specific advice was also sought at this stage regarding relevant legal and regulatory, technology and macro cost issues. The study conclusions were reviewed by a 13-member steering committee that met on six occasions.

## THE INITIATIVES

The most common approach used by schools to access bandwidth is that of purchasing managed capacity from carriers, often under bulk-buying arrangements. In contrast, the high bandwidth initiatives examined in this study appear to be exceptional even in their own countries and have only come about due to a mix of opportunism, foresight and a determination to excel. Ten innovative bandwidth initiatives were taken as case studies, based on information gained through research and personal interview. They included:

- Alberta SuperNet (Alberta);
- Commission Scolaire des Affluents (Quebec);
- Public Sector Network (Ontario);
- Austin Independent School District (Texas);
- Connecting Minnesota/Minnesota Integrated Network (Minnesota);
- Iowa Communications Network (Iowa);
- Spokane Educational Metropolitan Area Network (Washington State);
- Tacoma School District (Washington State);
- Stockholm Schools (Sweden); and
- Kanal Tierp (Uppsala County, Sweden).

The initiatives shared the following common goal and strategic approach:

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|---|---|
| **Goal** | To access low-cost but high bandwidth telecommunications service. |
| **Strategy** | To create an arrangement that avoids the need to pay tariffs to telecommunication carriers for managed bandwidth services. |

Beyond that common aspect, each initiative varied according to the local circumstances and this is reflected by whoever was the relevant sponsor and the nature of access permitted. The sponsor was either:

- A state government desirous of creating a network that shares traffic either with a number of other public and/or non-profit agencies, or with a number of public and private users or user groups; the government typically acts as the anchor tenant in terms of telecommunication traffic levels, with schools and other educational institutions being the most significant component; or

- A municipal government or group of schools (belonging to a school district) which pools its resources, typically by converting their ongoing operational expenditure on tariffed services from carriers into once-off capital expenditure that buys long-term access to 'dark optical fibre' which is then operated for the enjoyment of just that user group.

## CASE STUDY CHARACTERISTICS

### Network Aspects

Local Area Networks

A precondition for any higher bandwidth telecommunications service delivery to school users, whether they are students, teachers or administrators, is a pre-existing local area network or LAN of adequate bandwidth capacity operating within each school site. These aggregate data traffic within individual schools to a single point for offering to an outside service provider.

Wide Area Networks

It is becoming increasingly common for LANs to be interconnected between schools to form a wide area network or WAN by means of data lines leased from carriers. However, due to the high tariffs, only low bandwidth capacities have generally been affordable (e.g. usually just 64 or 128 kb/s) with the result that, whilst individual LANs can be operating at design speeds of 10, 100 or even 1000 Mb/s, overall WAN performance can be substantially worse. As larger capacity leased data lines become more affordable for interconnecting LANs, the improved WAN performance causes end users to experience better response times and encourages the adoption of new applications which in turn are typically more bandwidth hungry. The case studies of Affluents, AISD, Spokane and Tacoma all demonstrate effective educational WANs.

Dark Fibre

Affordable dark fibre to interconnect LANs removes all capacity constraints and enables transparent Ethernet transmission throughout the whole WAN. The dark fibre-enabled WAN then becomes an aggregated LAN. IT support staff can readily upgrade their skills to manage the new LAN/WAN Ethernet configuration and thereby reduce operations and maintenance complexity.

Future increases in LAN/WAN traffic levels can be handled for exceedingly low additional network cost and possibly even some of the spare fibres can be swapped for equivalent fibres within an adjacent cable network.

Condominium or Shared Approach

By themselves, server rationalisation and traffic aggregation savings are unlikely to be sufficient to justify the capital outlay to gain access to dark fibre. The more significant saving arises from adopting the ‘condominium’ approach to fibre cable construction. In like manner to a multi-storey apartment building, separate parties who own or otherwise control groups of fibre strands can exercise sole discretion on how to use their fibre assets. The condominium parties pay for maintenance undertaken by a specialist company.

Figure 1 illustrates that, in the case where four parties share the total fibre capacity, four individual LAN/WANs can operate with total electrical separation. Sharing a common cable route, each WAN would also tend to cover much the same geographical spread. With fibre cable manufacturing costs only loosely related to the number of fibre strands and the cost of installation almost independent of the cable size, it follows that an arrangement to share costs across, say four entities, must reduce capital expenditure for each by close to one-quarter. The case studies of Affluents and the Peel PSN ably demonstrate the condominium advantages.

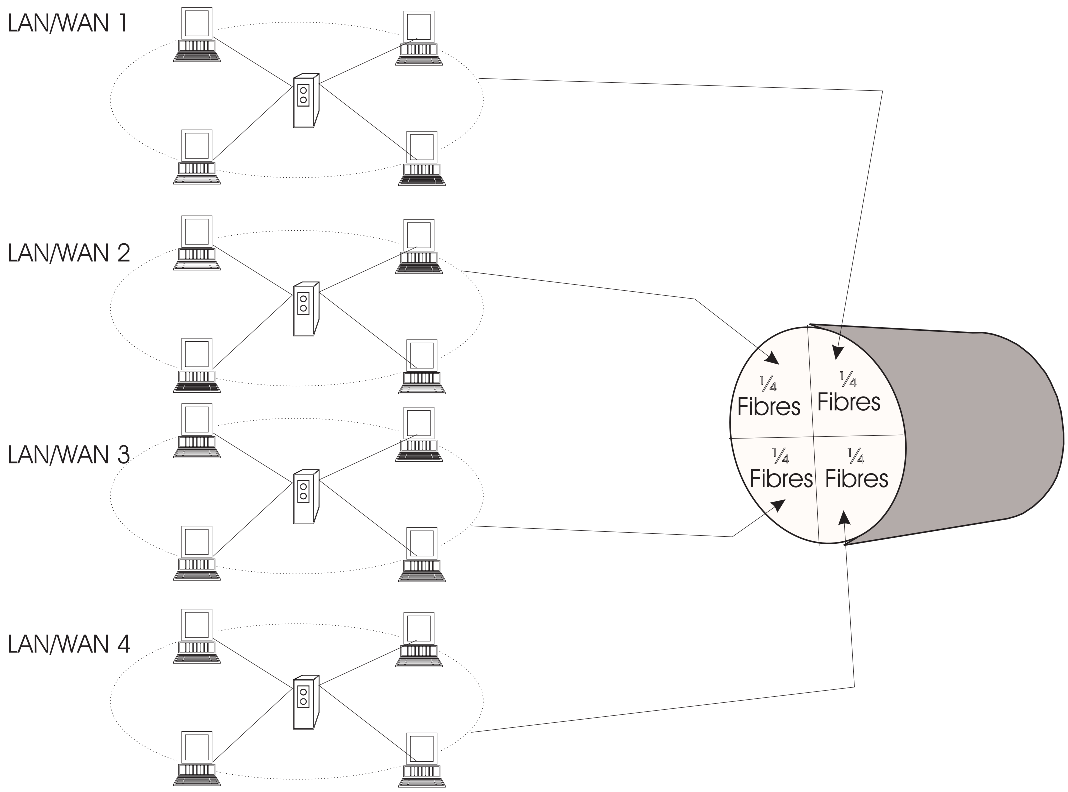


Figure 1: Condominium LAN/WAN Approach

Telephony

Voice over IP technology removes the need for separate telephony and data circuits. By way of illustration, the Spokane school district can now afford to provide a telephone in each classroom for teachers.

**High Bandwidth Applications**

All of the initiatives examined were structured to avoid direct payment to carriers for additional bandwidth on a pro-rata or tariffed basis. Typical 'break-points' imposed by carrier technology are 64 kb/s, 128 kb/s, 256 kb/s, 512 kb/s, 1024 kb/s, 2048 kb/s, etc. As traffic saturates at one level, a conscious decision must be made to upgrade to a higher access network bandwidth for an increased tariff – otherwise LAN/WAN performance degrades. Increased usage of existing applications, not to mention the adoption of new applications, is inhibited by typical tariff regimes.

Initiatives employing Ethernet LAN/WAN technology exploit bandwidths of 10, 100 or 1000 Mb/s. Although such bandwidths could be under-utilised from time to time, the scalability inherent in the technology implies that increased bandwidth demands can be met for minimal additional cost. The communication services exploited by schools include telephony, data, Internet and video.

Telephony

For a mix of historical and technical reasons, some of the initiatives continue to deploy separate lines between school sites for telephony services. However telephony can be integrated by Voice over IP technology with other data-like services once economies permit.

Data

Data transport, employed for school administrative functions directed to and from a central management site (such as the School District office), continues to assume greater importance as student-related data, such as individual class attendance, is required to be provided by teachers in real time from their PCs at the head of each classroom.

Internet

Officials associated with all of the initiatives reported rapidly growing levels of Internet traffic – often doubling every 12 months or so. The need to address such high growth levels was a key requirement to be met by each new initiative.

Video

Both streaming and full-motion video capabilities are being increasingly delivered to classrooms and individual students over broadband LAN/WANs. In the case of the Stockholm Public Schools, a video-on-demand capability is now available at individual student PCs via a 100 Mb/s LAN design and centralised video storage facility. The Iowa Communications Network delivers full-motion bi-directional interactive video at a rate of 45 Mb/s to each of over 700 sites, as well as a mix of full-motion and compressed video to more than 85 sites for telemedicine application. Teachers report that the fast response time offered by the high speed Internet access has a significant impact on reducing class time allocated to students searching for information on the Internet.

**Funding Sources**

Loans

Seemingly unique amongst the initiatives studied, the Austin Independent School District borrowed the required capital funds to construct their portion of GAATN from a finance company that was introduced to them by the company that undertook the network construction – the incumbent telco, South Western Bell. The loan is being paid off over time from expenditure otherwise earmarked for payments for tariffed carrier services prior to GAATN.

Municipal Bonds

Within many US states, depending on legislative arrangements, school districts are allowed to borrow money from public investors through the vehicle of a municipal bond. The bonds are repaid after a specified time period at a specific interest rate. For example, a municipal bond funded the US$400,000 cost of connecting each site within Tacoma School District 10 by fibre to the I-Net backbone, i.e. covering the ‘last quarter mile’ gap.

Grants and Subsidies

Within the US, the Telecommunications Act of 1996 created the federal E-Rate program that makes available discounts of between 20 and 90 per cent for telecommunication services from carriers in addition to the cost of constructing school-based LANs. Many states in the US also employ arrangements for providing direct grants of money to school districts. Within Sweden, the new municipal broadband infrastructure is to be funded by the national government according to the nature of the new infrastructure:

- Between villages – direct funding contribution on a percentage basis;
- Within villages of fewer than 3,000 people – a tax subsidy applies; and
- Local access and internal cabling – a tax subsidy applies.

Budget Appropriation

The Government of Alberta is making a one-time appropriation from budget of CDN$193 million (about A$240 million) to specifically pay for new fibre construction in those parts of the province considered by the carriers and service providers to be uneconomic, and to partly contribute to construction in other areas.

Levy

A form of taxation on local residents, levies can raise funds for small capital projects such as school LAN upgrades and to supplement monies raised via bonds for larger cabling works.

**Application of Funds**

Recurring Lease Charges or Other Fees

Each of Stockholm's 174 City Schools gains open access to two fibre pairs from the municipally-owned agency Stokab AB, who charges back the total fibre cost utilised by the schools on the basis of the number of students. This charge is understood to be in the region of 250SEK (about A$50) per student per year. Another example is that of the Commission Scolaire des Affluents which is required to pay CDN$131,330 each year for maintenance plus the right-of-way costs of its dark fibre network.

One-time Capital Expenditure

Leasing a network on favourable terms, particularly one composed of dark fibres is only possible through a strategically friendly body. Where such cooperative bodies are not available, the school district must directly outlay capital expenditure and thereby accept full risk that the investment may not be successful. The capital may be sourced from any of the means previously discussed.

The Austin school district directly paid for construction of its share of the dark fibre network, as did the Commission Scolaire des Affluents. As with all condominium fibre arrangements, it is highly desirable for a school board to share construction costs with as many other bodies as possible that have a similar strategic intent. In the case of Affluents, the total cost was shared four ways.

**Contra-Deals**

The Austin Independent School District was the originator of GAATN which subsequently grew with six other partners. The City of Austin, through its municipal utility (Austin Energy), was granted 12 optical fibre strands free of charge in lieu of payment by AISD for the right-of-way access to the utility poles.

The swapping of dark fibre strands represents another form of contra-dealing that can, if the appropriate partners with alignment of strategic intent exist, significantly lessen the need for direct capital expenditure. When one party is in possession of more fibre strands than required, surplus strands can be swapped for an agreed number of fibres in another party's cable. Both parties can then extend their overall physical networks by lessening the number of fibres they initially owned or controlled.

The best-known example is that of the Reseau Interordinateurs Scientifique Quebecois or RISQ, which is a high-speed communication network connecting universities, research organisations and government agencies mainly throughout Quebec. In addition to construction of 813 km of fibre cabling,[1] RISQ managed to exchange 1470 km of fibres with parties such as telecommunication carriers and cable television companies, i.e. 64 per cent of the total route length of the resultant RISQ fibre network was gained through the swapping of fibres for no added outlay of capital.

**Economic and Other Evaluation**

Some information could be obtained, mainly on a financial basis, for three of the high bandwidth initiatives although the degree of detail varies somewhat. The evaluation techniques hinge on parameters that can be interrelated:

Break-even Period; Payback Period – Example 1: CS des Affluents
Industry Canada and CANARIE Inc. commissioned a cost-benefit analysis of the dark fibre network created by the School Board of des Affluents. (SECOR, 2000) The report, summarised in Appendix 3, was based on an assessment of costs and benefits prior to construction, as post-construction costs were then unavailable. It followed a framework for dealing with uncertainties as well as intangible costs and benefits, and provided criteria for assisting a decision recommendation. The school board comprises 75 educational centres housed in 70 buildings with some 3,000 PCs.

The pedagogical requirement was for Internet access to all schools, sharing of software and databases plus online access to the pedagogical software and applications. Administratively, all schools needed to be networked – with emphasis on provision of an e-mail system plus a variety of human resources management systems.

The technical requirement called for:

Support of multiple transmission types (video, voice and data);

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1 Some of this construction was also in collaboration with a carrier and some other lengths were constructed with school boards, i.e. via condominium arrangements.

High bandwidth (> 10 Mb/s) for the support of distributed video transmission;
Support of multiple physical connections by interfacing with local area networks; and
Easy upgradability – particularly noting the need to cope with future educational applications of increasing throughput.

Optical fibre was the only medium without capacity limitations and Fast Ethernet was the least expensive technology in terms of maintenance and upgradability. A total of 170 km of fibre (6 strands) now links the 70 buildings, with 80 per cent installed on power poles. Costs of the transceivers and switches at the Access level (i.e. in individual schools) were regarded as sunk. Before moving to a fibre solution, 40 technicians were employed mainly on LAN support. The net effect of adopting a single Virtual LAN or VLAN solution was estimated to entail a 20 per cent reduction in technician support.

On further considering the administrative, pedagogical and technical requirements of the School Board, the study concluded that the Dark Fibre solution illustrated:

an absolute benefit over the ADSL alternative offered by a carrier; and
a break-even point of 44 months in comparison to the Wait & Switch strategy – thereafter, the School Board would be financially ahead of all considered alternatives and would be in control of a private optical fibre network with effectively unlimited transmission capacity.
Break-even Period; Payback Period – Example 2: The Peel Region Public Sector Network (PSN)
Commencing in 1993, the PSN was constructed by three partners, the Region of Peel, the City of Brampton and the City of Mississauga, for the purpose of reducing communication costs and improving the service offerings by their various public sector agencies. The Town of Caledon subsequently joined. It comprises some 200 route km of municipally owned dark fibre with a 96-strand backbone plus smaller fibre rings. Each partner to the PSN constructs its portion, retains ownership of what it builds and must grant access (via separate control of fibre strands) to all other partners and subscribers. The PSN can also serve non-partner, public sector subscribers such as hospitals, schools, colleges and universities. (Wiseman, 2000)

The PSN management has only undertaken a rough savings calculation based on the original partners, which involved over 125 sites. Without the PSN, each site was deemed to require on average one T-1 (1.5 Mb/s) digital connection from the local carrier to serve both telephony and data needs. Their calculation was as follows:

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| Initial construction costs for the dark fibre PSN: | CDN$7,500,000 |
| Alternative carrier charge for T-1 services | |
| (125 x CDN$20,000 per year) | CDN$2,500,00 |

Hence the initial investment would be paid back in three years (7.5 ÷ 2.5), with additional subscribers only improving the situation.
Rate of Return on Investment; Rate of Return on Assets – the example of the Iowa Communications Network (ICN)

A traditional return on total assets calculation may be expressed as the net income divided by the average total assets. However, since ICN is disallowed by law to have a net income, a different method of calculation was adopted. Net income is represented by three savings and benefits criteria:

Communication cost savings, in so far as ICN provides services to its authorised users at a rate less than the cost that would be charged by private providers;
Other savings reported by state agencies through use of the network; and
Actual federal investments secured because of the existence of the ICN.

By dividing the Gross State Investment in ICN to date into the Total Annual Savings and Benefits, the State of Iowa has recognised a 25 per cent rate of return on investment for each of the last four fiscal years. In other words, the State has totally recovered its investment in the network during that four-year period. (Fujinaka, 2001)

Additional savings and benefits considered but not quantified in the above calculation include:

Savings in travel and expenses associated with the provision of more than one million citizen training/education hours over the network in the last year;
Value to the state arising from added investment by private telecommunications providers to counter any expanded state effort to use the ICN in bringing high-speed telecommunications capability to rural Iowa.

**Other Considerations**

Although section 3.2 noted that all of the high bandwidth initiatives shared a common goal and strategic approach, in practice each arrangement was planned and implemented according to the local circumstances. These involved a mix of legal, regulatory, commercial and other environmental factors.

Regulatory Environment

In Canada, cable television companies were recognised as common carriers in 1996 and thereby gained access rights to the poles and conduits of the incumbent telco at that time, Bell Canada, and the electricity distribution companies or 'hydros'. The CRTC set down a series of rules, procedures, costs and processes. By 1997, various school boards, universities, municipalities and small carriers began to realise that they (or a broker acting on their behalf) could register as a non-dominant carriers and thereby gain the right to build their own fibre networks. All the CRTC requires for a non-dominant carrier licence is demonstration of Canadian ownership plus evidence of plans for creating telecommunications facilities – a relatively small administrative task plus a small application fee. In practice, many of the Quebec condominium dark fibre networks have been created under the umbrella of a cooperative telco or cable television company. Ownership of the fibre cable stays with the telecommunications carrier whilst each of the multiple parties sharing the costs of construction is granted an IRU to a number of fibre strands in the cable. (Cook, 2001)

Within the United States, the regulatory scene is considerably more complex: apart from national rules and regulations set by the FCC, every state has its own public utilities commission and most cities and towns also exert a degree of local control. The result is a decided lack of uniformity across the country in regulatory approach and a plethora of legal judgements within many jurisdictions that are being constantly challenged and re-interpreted. Of the five high bandwidth initiatives identified in this study, three (Spokane, Tacoma and

Austin) were facilitated through the cooperation of the local electricity utility. In the instances of Tacoma and Austin, the utilities were municipally owned. The other two initiatives involved direct state intervention, with one (Iowa: ICN) totally successful and the other (Minnesota: Connecting Minnesota) only partly completed. Both initiatives confronted extreme hostility from incumbent telecommunications carriers and cable television companies who feared erosion of their market share, resulting in appeals to the FCC, court cases and lobbying to state politicians.

Whilst the United States has a long history of community-owned telecommunication and cable television companies (which interestingly are most prolific in the state of Iowa), political lobbying by the major telcos has been successful in banning or severely curtailing municipalities from entering into these domains within many states. As a result, dark fibre initiatives that are plentiful in the Canadian province of Quebec are less likely to arise in the United States. Masud (2000) gives a graphic account of the power of major telco lobbying. Nevertheless, within the federal domain of the US Communications Act and related legal precedence, dark fibre networks serving schools, other educational institutions and public sector agencies would be generally exempt from common carrier regulation provided they are closed to the external public. (Thorne, 1995: p.127)

Since the Swedish telecommunications market was fully de-regulated in 1993, Sweden has adopted the most liberal regulatory regime of the three countries examined, and perhaps of any country in the world. As an example of the low barrier to new entrants, all that is required for a company, or local government for that matter, to deploy a telecommunications network is for that organisation to declare its intention to operate as a non-dominant carrier.

Whole-of-State Strategies

There is circumstantial evidence that the school board dark fibre initiatives so extensively adopted throughout Quebec in Canada could be less viable propositions in areas of lower population due to the longer distances involved, lower aggregated traffic levels and fewer opportunities for co-construction partners. However, for two of the initiatives studied (Iowa and Alberta), state or provincial governments have decided to address inequalities that may be experienced by schools in rural and remote areas of their jurisdictions.

Commencing in 1987, a request for proposal (RFP) was issued for a state-wide microwave-based educational network to connect community colleges for distance learning throughout the state of Iowa. The only proposals received were for a fibre network, and subsequent RFPs allowed vendors to submit proposals to either lease capacity or construct new fibre cables – this time to address both educational and administrative needs. The telephone carrier and cable television companies decided to snub the RFP and the only bids received were just for construction of a fibre network. In this manner, the state became the owner and administrator of the Iowa Communications Network or ICN – understood to be the only state-owned network of its kind in the US. The full-motion video capability of ICN came into being from 1995. Whereas Alberta's SuperNet is a public/private partnership, ICN is purely a public venture. It grew from the political will of the then state Governor Branstad who urged his fellow citizens to support the project thus (Sawhney, 2001):

Almost 150 years ago, the frontier leaders of Iowa decided that the most important thing to the future development of our state was education. They made certain that there was a school within two miles of every schoolchild. The one-room township schoolhouses initiated the continuous commitments to quality education that have made Iowa a national and world leader in education … Just as our great-great-grandparents had the foresight to build the country schools … so too we in Iowa today build a future through the information superhighway.

The services now provided by ICN to Iowan schools and colleges are tariffed independent of distance, with some at one-fifth of market rates or even better.

Through the SuperNet initiative, the Government of Alberta is implementing a public/ private partnership to construct a backbone telecommunications network that will deliver high bandwidth services to schools and other public agencies in rural and remote areas. It will charge on a distant-independent basis and is benchmarked against urban rates for similar services. The government's bargaining power was to invest CDN$193 million and also commit all government-related traffic to the new network. This investment was justified on the grounds of uniform economic development throughout the whole province and is to commence in 2001.

Opportunism

For most investment decisions, there is a real or perceived 'window of opportunity'. If creation of the initiatives in question had been deferred, would they have been less successful or perhaps even prevented from occurring by other circumstances? Compared to the private sector, decision making by public organisations is much more transparent. The longer plans to invest in innovative networks are in the public domain, the greater opportunity there is for more nimble private sector carriers to lobby against such proposals or to re-price their services.

The Iowa Communications Network was the outcome of political will by the state government and the poorly crafted tactics of telecommunications carriers and cable companies in hoping to derail a series of the RFPs around 1989-1990. There is now no comparable network within the US. However, nowadays telecommunications carriers and cable companies are considerably more sophisticated in lobbying to achieve their commercial ends and new national broadband providers have criss-crossed the state with independent fibre backbone networks. In the current political and commercial climate, it is unlikely that a similar whole-of-state initiative could be undertaken anywhere within the US.

Both the Peel Region Public Sector Network and the Greater Austin Area Network were created only a few years ago when the incumbent carriers dominated broadband telecommunications infrastructure. Since then, a number of competing national backbone networks have arisen (although not necessarily dark fibre providers, let alone at acceptable rates) so nowadays a decision to lease major capacity would perhaps be more likely – presuming that the price was right. Nevertheless, those new backbone networks do not bridge the 'last mile' gap remaining to connect with most high bandwidth public sector users. This is particularly a problem for schools that by nature are located in residential areas.

Agreements to Cooperate

The basis of 'condominium' dark fibre is for separate customer or user groups to exclusively control their portion of fibres that are together contained within a common cable sheath.

Agreements must be reached on the terms under which such control is obtained, for example is it perpetual or only for a number of years, can fibre capacity be sub-let? Such conditions can be prescribed in an Indefeasible Right of Use or IRU, but other forms of agreement are possible.

The Peel Region PSN operates under an 'Exchange of Access Agreement' by which each party is totally responsible for all fibres within its particular cable route, but agrees to share fibre capacity with other parties via connected cables. AISD and the other members of GAATN operate as parties to an agreement formed under the Texan Interlocal and Cooperation Act. The state government of Minnesota shares capacity in the new Minnesota Integrated Network via a Joint Powers Agreement with the colleges and universities, whose central purpose is to take mutual advantage from leveraged purchasing and operational activities.

Depending upon the nature of the agreement, acceptable condominium parties can be either restricted to different public agencies or otherwise a mix of public agencies and private users. Where the agreements grant complete control over the fate of individual fibre strands, they may be traded or swapped for equivalent lengths of fibre within separate cables. By this means, a party can gain access to a greatly increased network reach merely by diluting its share of unused fibre capacity.

Commodification of Dark Fibre

In the three countries studied, dark optical fibre has become a commodity item – a situation about to develop in Australia. The requirements for commodification appear to be:
The relative ease of becoming a telecommunications carrier, particularly in Canada (where the category of 'non-dominant carrier' is exploited for these purposes) and in Sweden (where apparently the process for becoming a carrier is tantamount to self-nomination);

The willingness of some of these carriers to profit merely from the installation of fibre cables and not from the sale of derived telecommunications services; and
A substantial degree of over-cabling whereby multiple carriers have installed optical fibre cables along the same routes.

Aerial or Underground Cabling; Right-of-Way

Aerial cabling, strung between power utility poles, can be perhaps one-quarter of the cost of underground cabling and hence becomes a significant economic factor. However, the sample of high bandwidth initiatives studied here uses both modes for the following reasons:

| **Dominant Construction Mode** | Initiative | Commentary |
|---|---|---|
| Aerial cabling | Typical Quebec school board dark fibre network | The rights-of-way of power utilities were often exploited; partners were typically cable companies and other carriers who likewise accessed power poles. |
| | Public Service Network, Peel Region | The rights-of-way of power utilities were exploited and some of the utilities were initially municipality-owned. |

| **Dominant Construction Mode** | Initiative | Commentary |
|---|---|---|
| | Austin Independent School District/GAATN | In lieu of paying the city-owned power utility for right-of-way access, AISD provided the City of Austin a proportion of the fibres at no charge. Wherever the power lines go underground, the fibre cables do likewise. |
| | Tacoma I-Net (which serves the Tacoma School District dark fibre network) | Right-of-way access from the city-owned power utility was granted to the operator of the *Click! Network* (which happens to be owned by the utility) through which I-Net arose as a condition of its cable television franchise. |
| Underground cabling | Iowa Communications Network | All fibre cable was ploughed into the ground statewide for increased security (noting that the Iowa National Guard is also a user). |
| | Connecting Minnesota (Version 1) | Exclusive right-of-way to the state highways was originally granted to the fibre installer; it was mainly installed in ducts. |
| | Stokab and other Swedish municipal networks | With the exception of high transmission power lines, it is the norm for Swedish utility services to be installed underground. |

## CONCLUSIONS

Optical fibre constitutes infrastructure of the most basic type and one that provides unparalleled capacity for innovative applications. Direct control of fibres, through ownership or perhaps a lease agreement, offers the key to affordable high bandwidth in the future. The cost of bandwidth for the carriage of additional education and training traffic is then almost zero into the foreseeable future.

Unfortunately, the market will not offer tariffs that reflect such costs. Success with the first demonstration business case in Australia has the potential to markedly change the perceptions of all stakeholders.

Provided cable construction and operation costs are shared with, say, three other parties under a condominium-type arrangement, economic evaluations indicate payback periods of between three and four years for education sector dark fibre networks within the countries examined.

Traffic aggregation is the key to economic viability of any wide area network initiative. The exercise is a trade-off between the increased cost of fibre cabling as more traffic sites are captured, and the increased savings resulting from such sites no longer having to pay individual service tariffs to a carrier.

A payback period that is acceptable for Australian conditions will be required and the risks quantified as much as practicable. Nevertheless, the first implementation may encounter greater barriers than subsequent projects due to increased difficulty in attracting a minimum of two to three other partners and likely higher costs of a pioneering exercise. Initial allowance should be made for this.

A commitment of upfront capital expenditure will clearly constitute the major component of the risk taking and, at least for demonstration networks, federal government seed funding could overcome any initial reticence of educational and training bodies to commence to deploy their own optical fibre infrastructure.

**REFERENCES**

1. Denton, T., Menard, F. & Isenberg D. 1999 Netheads versus Bellheads, report to the Federal Department of Industry, Telecom Policy Branch, 31 March 1999. At: http://www.tmdenton.com/netheads3.htm

2. DETYA 2000 Learning for the knowledge society: An education and training action plan for the information economy, Canberra: Commonwealth Department of Education, Training and Youth Affairs. At: http://www.detya.gov.au/edu/edactplan.htm

3. Kelso, R. 2001 Innovative Bandwidth Arrangements for the Australian Education and Training Sector – Stage 1: Assessment of Overseas Approaches. Commonwealth Department of Education, Training and Youth Affairs. August 2001. At http://www.detya.gov.au/schools/publications/2001/bandwidth/index.htm or http://www.detya.gov.au/schools/publications/2001/bandwidth/finalrep.pdf (A hard copy of the report can also be ordered from the CIRCIT publications section at http://www.circit.rmit.edu.au/publics/SEARCH/SearchPublication.asp?FromListPublicationID=200)

4. SECOR 2000 Canadian School Board Investments in Private Fiber Optic Networks: An Assessment of the cost and benefits of building high speed fiber optic networks to link schools in Canada, CANARIE's 6th Advanced Networks Workshop, Montreal, 28-29 November 2000. At http://www.canarie.ca/advnet/workshop_2000/presentations/waldron.pdf

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