Fibre Infrastructure for Schools of Tomorrow

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Abstract

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.

1. 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.* (DETYA, 2000)

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. (Kelso, 2001)

2. 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.

3. 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:

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.

One of the better documented initiatives, that of the Commission Scolaire des Affluents (the school board of Affluents) is examined here more closely as it epitomises the classic approach of deploying dark optical fibre for educational

application in Canada. Dark optical fibre is 'unlit' and enables the controlling party to carry any type of traffic and terminate the fibre any way it chooses, rather than accept managed services from a carrier.

4. A Case Study: Commission Scolaire des Affluents

The school board of Affluents was formed from merging the two school boards of des Manoirs and le Gardeur. The amalgamated board administers 75 education centres housed in 70 buildings, encompassing 54 primary, 15 secondary, 2 adult, 2 professional schools and 2 administrative centres. In all, there are some 3000 PCs of which 80% are used for teaching purposes. Affluents serves 40,000 students across 10 municipalities. The area is on the mainland immediately north of the island city of Montreal, in the province of Quebec, Canada.

Apart from a single fibre optic link and a small microwave radio network between a few schools, existing telecommunications service was being met with managed services from a carrier.

The new 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 was to support multiple transmission types (video, voice and data) including distributed video transmission that called for bandwidth capacity of at least 10 Mb/s accessible by each user. Above all, the one network had to support rapidly increasing throughput, be easily upgradeable and support multiple physical connections by interfacing with local area networks.

The Affluents School Board decided that optical fibre was the only medium without capacity limitations, and that Fast Ethernet was the least expensive technology in terms of maintenance and upgradability. All network installation and management costs were shared with three other partners, viz. the municipalities of Terrebone and Repentigny, plus a post-secondary college. QuebecTel, a CRTC-approved carrier, technically owns the street-laid cable that was provided as 'dark' fibre.

CDN$1.5 million was committed to network capital and CDN$1.3 million in operating costs for the school board's share of the dark fibre network. By means of an Indefeasible Right to Use (IRU) agreement, it now controls 179 km of fibre (six strands) linking the 70 school sites, with 20% underground and 80% installed on power poles. LAN access within each school is now to Ethernet 10Base-T standard, reticulated via twisted copper pairs with a capacity of 10 Mb/s. The schools are linked by fibre operating under Ethernet 100Base-F standard with a capacity of 100 Mb/s and connected to two administration centres. These centres then connect to the Internet via a 1 Gb/s (1000 Mb/s) capacity link.

A post implementation review of this dark fibre network was based on the following assumptions: (SECOR, 2000)

- All costs are shared four ways;
- Individual school LANs are pre-existing and their costs are 'sunk'; and

- Eight of the 40 LAN technician positions were surplus to requirement.

Based upon carrier offerings, the best available alternative technology considered was ADSL, however the cost benefit analysis also scoped a “wait and switch” alternative strategy. The fibre optic solution was found to have an absolute benefit advantage over ADSL and break even after 44 months or just under four years. After that time, the school board would have fully paid for the fibre network and it would be in control of a private optical fibre network with effectively unlimited transmission capacity.

5. The Strategic Decision

The ten initiatives focussed on accessing increasingly higher bandwidth telecommunication service at a cost considered to be attractive over a period of time. In all but the instance of the Minnesota Integrated Network, this has been achieved through arrangements that avoided direct payment to carriers for bandwidth-managed services.

Upon closer examination, it was evident that in each instance the relevant sponsor was willing to act in a manner that was exceptional even in the state or country of origin. These actions were strategic in that they were designed to pre-emptively address future needs both technically and economically, rather than incrementally satisfying only current needs. Five primary factors were found to be common to the success of all initiatives.

5.1 Rapidly Increasing Telecommunication Demand

The initial driver is invariably the need to cope with a rapidly increasing demand from students and teachers for access to the Internet (typically the World Wide Web) as well as material containing moving images that are as near as possible to real-time presentations (which may or may not be accessed via the Web or even the Internet). In addition to traditional video material of a broadcast nature, the requirement for interactive video (including video conferencing) greatly increases the demand for bandwidth as the application moves from group (i.e. classroom) to individual student access. Collaborative studies and distance education can be large consumers of telecommunication bandwidth.

In many education and training jurisdictions there is also a focus on steadily improving the number of computers that students can access, which underpins the growth in bandwidth demand.

5.2 Technical Suitability

A necessary pre-condition is the pervasive deployment within schools of a widely accepted LAN transmission protocol such as Ethernet, and LANs designed to readily handle increasing bandwidth demands. LAN expenditure should not be part of the business plan for creating a high bandwidth wide area network or WAN. The emphasis on a protocol such as Ethernet is important as it maximises acceptance by IT staff who require less re-training. Also it minimises the adoption of traditional carrier technology and the associated mode of business thinking that can inhibit

innovation.[2] Each school LAN acts as an aggregator of telecommunication traffic.[3] The exercise is then one of interconnecting a number of similar campuses to achieve greater traffic aggregation through creation of a WAN. The traffic may comprise a mix of data, Internet and telephony services.

Access to affordable optical fibre is the most common factor for a successful WAN. This can be realised in two ways:

- Access to an unlit or 'dark' fibre network offering limitless capacity to cater for future bandwidth-hungry applications; or
- Truly open access to a managed bandwidth service that does not favour vertically integrated carriers.

Both avenues rely on an industry environment in which bandwidth is regarded as a commodity.

5.3 Financial Underpinning

Sufficient funds are required for either upfront capital expenditure to purchase access to dark fibre or to make annual lease payments. Depending on the jurisdiction and local circumstances, fund sources are variously loan borrowings, budget appropriations, non-repayable grants or specific tax raisings. Whilst lease payments may appear to be less demanding, they do rely on the munificence of a third party that in turn must make the upfront expenditure.

Despite the attractiveness of a short payback period, it is essential to identify and capture the savings and present them in a business case format acceptable to the practice of each local jurisdiction. Such exercises are complicated by the fact that each initiative delivers greater bandwidth than the arrangement it replaces, and dark fibre presents opportunities for new applications that may not be conceivable in the previous bandwidth-constrained environment. It can therefore be quite difficult to make 'before' and 'after' cost and capability comparisons on an equal basis.

5.4 Third Party Involvement

A pivotal third party is generally required to facilitate access to affordable high bandwidth network capacity. In many instances in the three countries visited, these involved governments at one level or another – often a local or municipal government, but sometimes a state government. These entities can directly intervene as one or more of:

- Implementers of a strategic vision favouring entities such as education and training institutions;
- Providers of capital expenditure, either directly for a particular private network or communally for a public open-access network;
- Controllers of rights-of-way underground along highways and/or aerially via electricity utility poles;
- Licensed owners of network infrastructure.

Although not common, a privately owned utility or carrier may decide to favour the education and training sector, either in the public good or for a perceived strategic advantage. Other partners in any dark fibre condominium are also facilitating third parties since their involvement in sharing expenditure directly improves any business case justification for each entity.

Regardless of the avenue made available, all these third parties serve to reduce the financial risk to the benefiting party and in some cases are pivotal to the very creation of the high bandwidth network.

5.5 Further Beneficial Elements (Regulatory, Fibre Swapping, etc.)

Depending on local circumstances, there can be a number of other elements that lessen barriers to success and/or improve the overall business case justification. However, they must generally be identified at the time of business planning and actively exploited for maximum advantage. They include factors such as:

- A telecommunication regulatory regime that doesn't discourage the creation of private fibre networks or inhibit who may comprise the users of a shared public/private network;
- The ability to swap fibres with other parties so that the reach of a network can be extended;
- Access to affordable rights-of-way (underground or aerial) or to affordable radio spectrum;
- Access to a contra-deal, particularly one involving fibre swapping or forbearance of a right-of-way charge in lieu of fibre capacity;
- Lack of interest by incumbent carriers in making attractive counter offers; and
- The ability to access or install aerial cabling, which incurs a lower cost of construction.

6. 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.

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Endnotes

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[2] For a thought-provoking article on such issues, refer to Denton, 1999.

[3] In these terms there is a close parallel between each school campus and a multi-storey office building – for equivalent traffic levels, one could perhaps imagine two classrooms per storey. The LAN then concentrates all external traffic to one point at the ground floor or basement, from which the WAN connection out into the neighbourhood is made.