Gee I didn't think it was going to be that much: a report on the issues and implications of technically sustainable and affordable bandwidth for Australian libraries

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Abstract:
This paper explores the dilemma of increased bandwidth requirements and costs in the light of stagnant or decreasing library budgets, and how one group of Australian libraries have attempted to resolve this problem by shared networking and consortia purchasing. Increasingly, library services are dependent on Internet bandwidth to deliver information services, and the bandwidth required for, as well as the cost to deliver, these on-line services is increasing. As the delivery of on-line services has become a core library business, speed and reliability have become increasingly important, as has the recurring cost of bandwidth, but library funding does not always recognise these facts. The Internet industry has become more complex and offers greater choice for delivery (terrestrial, atmospheric, satellite) as well as offering a wide array of cost structures, but these offerings are not necessarily the best solution for the libraries involved. Pricing and technical options often have hidden costs and though they may suit current needs, increased usage makes the costs prohibitive. This paper draws on practical experience in delivering sustainable cost-competitive bandwidth solutions to libraries and looks at how collaborative solutions can offer benefits to the participating libraries.

"The next generation of Internet technology will inevitably have an impact on local infrastructure and workstations, which translates into a budget impact. As the evolution takes place, administrators need to be informed of budget requirements. The same strategies that helped libraries get where they are today will be required to move ahead: networking, partnerships, grants, annual upgrades. Those who are positioned to be the experimenters and early adopters have opportunities and challenges." (Sanders-McMaster, 1997)

"How to handle the cost of becoming [our] communities' access point to the Internet… [when] we are limping along the [information] highway like a medieval pilgrim on crutches." (St. Lifer, 1997)

Introduction

The Internet offers public libraries great opportunities as well as substantial threats. In responding to the public's demand for community accessible Internet services, public libraries have been able to entice new categories of patrons to use the library services in new and exciting ways. However the demand this has generated and the rise of more and more bandwidth intensive online services have placed significant strains on library budgets and hardware, software and Internet connectivity consume more and more of the libraries budgets. For some libraries (particularly the smaller more remote libraries) the Internet is still relatively new whereas for others it is very much a fact of life. Irrespective of how long they have been connected to the Internet, libraries are still questioning the role of the Internet, trying to determine if it is a threat, and trying to work out strategies to coexist with the Internet and use information technology and telecommunications to prosper. "Many librarians see the Internet as a threat, creating competition for public libraries. While this may seem that way, the reality is that the public library exists to address gaps in the learning and information marketplace." (Roders, 2001) "Net incursions and patrons' evoking information needs have pushed the public library to redefine itself while staying true to its age-old mission of service." (St. Lifer & Oder, 2001) How libraries respond to these challenges, how they implement, maintain and budget for online connectivity is becoming increasingly important. This paper looks at how the Victorian public libraries have worked together with the frameworks of state and federal funding projects to get online and pay for bandwidth. The paper looks at the implications of ever increasing bandwidth requirements, the costing of that bandwidth and what is being done to allow libraries to plan for future growth.

Growth of the Internet in public libraries

In looking at the growth of the Internet in public libraries, it is worth considering how we have got to where we are today, particularly as the experience of Australian public libraries with the Internet is different from libraries in the research and academic sector libraries. "Community networks have been around since the 1970s when *Community Memory* in Berkeley, California installed terminals in public places for citizens to read and post material of all sorts on a centralized time-sharing system. *Community Memory* was the first known community access network." (Cisler & Polly, 1994) Yet as an exercise in networking, the *Community Memory* project is a world removed from the library networks of today with their graphic user interfaces, higher bandwidth requirements, and higher user expectations. *Community Memory* used dumb terminals and as such the bandwidth overheads were low.

Also, as the Community Network involved a centralised dedicated and directly connected network, there was not the degree of network complexity required in today's library networks.

"In 1993 a two-year experiment was commenced [in the US] to see how New Jersey people would interact with the Internet computer network. Access was via 12 public libraries through a dial-up number."(Anonymous, 1993) Meanwhile in the UK "JANET was a major online information resource for Great Britain, providing access to many library online public access catalogues, to the British Library's online search service (BLAISE-Line), and to a variety of other online services." (Kilpatrick, 1993) More recently the UK government has articulated its vision of Internet connected public libraries in two reports *New Library Network* and *Building the New Library Network* to ensure management and access to information. (Fitzgerald & Savage, 2002) In Victoria, public libraries started to use the Internet in 1995 and VICNET was instrumental in assisting these libraries get online. "Yarra Plenty Libraries (Rosanna and Diamond Valley Branch) ran a trial of the Internet through VICNET between March 29 and May 22 1995 to see how useful the Internet service would be to library patrons. They each were given access to one dedicated Internet terminal for public use. Boroondara also participated in this trial. Whitehorse-Manningham was VICNET's first ISDN customer in March 1995. Hamilton Library had an terminal installed in early 1995, Mornington had a terminal installed at the Mornington branch, with a dial-in account to VICNET (STD rate) from March 1995, and Frankston had a terminal installed on May 20 1995." (McGlinchey, 2001)

As connecting to the Internet became more affordable more libraries got online. For example, in 1995 a report from the US National Commission on Libraries and Information Science (NCLIS), on Internet Costs and Cost Models for Public Libraries found that "a public library can get single workstations, text only internet connectivity for a one-time cost of USD $ 1,475 plus a recurring annual cost of USD $ 12,635. At the high end, public libraries can get multimedia internet connectivity with multiple workstations at multiple library locations for a start up cost of USD $ 266,375 and recurring costs of USD $ 168,220." (Whiteley, 1995). Of course in 2001 no Australian public library would consider installing a text only Internet connection, and while you can now buy a lot more computing power for your dollar than in 1995 hardware is still an expensive item for libraries.

In 2001 Yarra Plenty Regional Library for example estimated that the real cost per computer is about $4,000.00 to $6,000.00. This estimation includes all the easy to identify add on costs such as set up, software, maintenance but does not include floor space, supervision or Internet bandwidth. These figures also do not include replacement costs. Yarra Plenty sets aside 1/3 of cost of the item each year on the basis that it will need to replace every three years. So while the costs of installing Internet-enabled terminals in 2001 is not as high as estimated by the NCLIS in 1995, providing Internet access in libraries remains an expensive proposition.

The 1997 *Library Journal* budget report noted that "not only are libraries having to contend with the surging costs of installing and maintaining net technology, but they are having to employ financial legerdemain to figure out how they can squeeze the additional funds from their already stretched-to-the-limit budgets…. A 1997 US Public library survey of 352 library networks found that public libraries have seen their technology related costs sky rocket by almost 85% between 1995 and 1997. (St. Lifer, 1997) This type of situation remains true of Australian public library budgets in 2001. Many Victorian public libraries have commented to VICNET staff that they are not being given the budgets necessary to keep up to date with technology required in order to meet many of their patrons' expectations.

Libraries have also been encouraged to get online via government initiatives at a local, state, and federal level. Indeed VICNET as a business unit of the State Library of Victoria has been one of the major conduits for government funding of online initiatives aimed at connecting Victorian public libraries to the Internet as well as implementing consortium purchases of online databases. The initiatives has included subsidised Internet connections, the installation of telecommunication equipment as well as computer equipment and a considerable amount of free training and technical support. The Libraries Online (LOL) project has been funded by the Victorian state government which gave a grant towards metropolitan libraries purchasing a satellite dish and modem, and the federally funded via Networking the Nation, Rural Libraries Online (RLOL) project purchased satellite hardware (dish, modem and racks with routers) outright. These projects have a gone a long way towards enhancing Victorian public libraries' Internet connectivity. Many of these libraries (rural libraries in particular) are now able to offer Internet based services to their patrons to a level that they would not have been able to achieve with only their own funding.

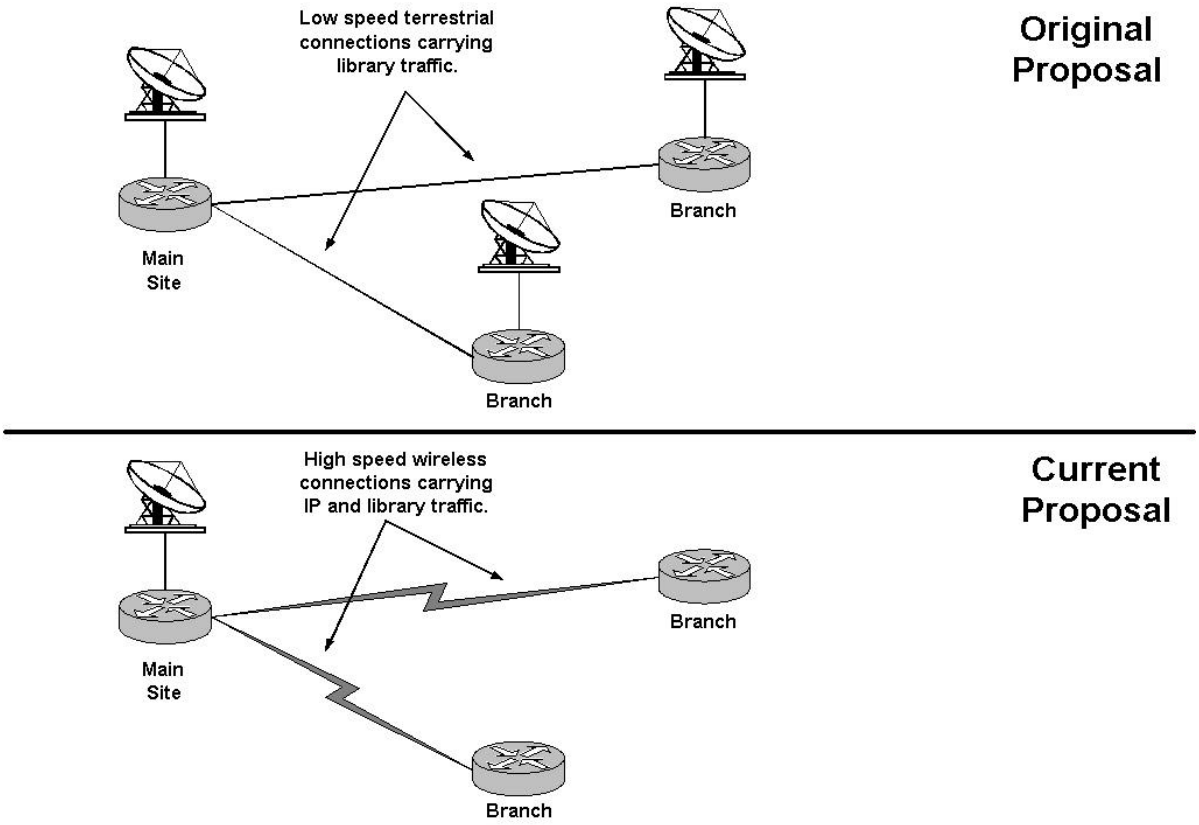
Providing Internet connectivity and cost implications

As it stands at the end of 2001 most of the Victorian public libraries receive their incoming Internet traffic via VICNET installed satellite infrastructure located at or near their main branches. However, due to the costs of two way satellite bandwidth and the concerns that the latency associated with satellite data might preclude it from being used for library system traffic a series of one way satellite connections were set up along with a variety of back channel options. Libraries also recognised that pure IP delivery was not as important as delivering their library system traffic across their WANs. In order to accommodate the library's requirements regarding system traffic VICNET was not able to install as many satellite Internet feeds as initially envisaged. (*See figure 1 for more details)*.

The Melbourne metropolitan libraries use ISDN connections to VICNET as an ISP for their back channels, whereas the rural and regional libraries use ISDN to their local ISPs for the their back channel connections. VICLINK (as the peak body representing public library co-operation in Victoria) and VICNET are working on developing a state wide back channel in order to enhance the speed and performance as well as lower the overall costs to the libraries.

The difference between what was originally proposed and what was actually built touches on the issue that what governments are prepared to fund and build may not be the same as what the library requires. This has implications for the cost of the build as well as the ongoing telecommunication costs. In order to respond to patron expectations (*see table 3 for details*) regarding speed of OPAC enquires and circulation processing, libraries need to ensure the telecommunications infrastructure accommodates their library system traffic. Rightly or wrongly, governments are more concerned with Internet connectivity to communities. For terminals used for straight Internet connectivity a low speed terrestrial connection would suffice, especially as outgoing back channel traffic tends to be 10% of the volume if incoming traffic. Under the model initially proposed in Victoria, satellites would be set up to handle the high volume incoming traffic and cheaper low speed terrestrial lines would be used for the back channel. This negated the need for establishing or leasing expensive terrestrial connections especially in the more remote parts of the state. However, the speed of the back channel was found to have a significant impact on the overall speed of the service.

Figure 1: Proposals for Victorian Public Library Internet connectivity



Furthermore, the need to provide high-speed back channels has had an impact on budgets. The metropolitan libraries have been able to reduce their back channels from 128 K to 64 K ISDN, but some of the larger metropolitan library services are finding that their back channels do get congested with request packets and domestic traffic. For some of the rural libraries, it has meant they have remained dependent on local ISPs providing more than a very basic back channel. This again has an impact on their budgets. VICNET is exploring DSL solutions for metropolitan libraries and wireless WANs for the rural libraries as a way of overcoming these back channel problems. For the rural libraries it means not being so reliant on a range of rural ISPs whose service level can vary. For the both rural and metropolitan libraries, a DSL solution would realise considerable savings, as they would not have to continue with ISDN and its associated high line charges.

If nothing else the costs of providing Internet access is forcing libraries to reassess what role they want the Internet to play within their library service. In the US, public libraries noted that "providing net access and publishing community information on the web had forced library staff to re-evaluate their fiscal priorities as well as their role in the community. (St. Lifer, 1997) Almost four out of ten respondents to a *Library Journal* survey said they would have to cut back spending in other areas to fund Internet-related initiatives. Of those having to cut back, nine out of ten public libraries are taking funds from the materials budget. (St. Lifer, 1997) In fact according to Library Journal survey virtually 50% of respondents had to rely on fund raising to cover the shortfall with the average collected being USD 143,367, a figure which speaks volumes about the difference between the culture of philanthropy between Australia and the USA.

Technology Available

Certainly the limits on funding to create true state wide solutions for libraries has had an impact on the costs of delivering and receiving connectivity. “Decisions to create a data communications infrastructure are not always based on richness…, but on the foresight of their administrators and computer personnel…. It [is] not a matter of funding; it was a matter of priorities.” (Schuyler, 1998) There is also wide choice of technologies available to libraries each with its own implications and costs. These include the following:

A definition of “broadband”:

Broadband defines communication with data rates exceeding 1.5 Mbps. Broadband wireless is not mobile wireless, which allows users mobility while using the service. Broadband wireless is communications to buildings or a cell site that does not move.

ISDN (Integrated Services Digital Network)

ISDN was put together in 1984 primarily as an integration of voice and non-voice (data) but its key functionality was considered to be, and was designed for, voice. ISDN utilises the standard twisted copper pair from the POTS (Plain Old Telephone System) and increases its virtual bandwidth with the use of ‘channels’. These channels come in two forms, 64k ‘B’ channels for voice or data and a 16k ‘D’ channel for signalling calls for the B’s (which can also be utilised for X.28 packets, useful for EFTPOS transactions). These channels are available in differing configurations dependant upon the data requirements. In Australian library systems they are commonly found in two configurations – OnRamp (a Telstra branding) 2 (also known as Microlink or Basic Rate Interface) and OnRamp 30 (or Megalink or Primary Rate Interface). The numbers within the name refer to the number of 64k B channels that the physical line can support; therefore an OnRamp 2 has two B channels. Telstra continues to utilise and to offer this service for data that is unfortunate as ISDN does have its drawbacks in this area. As mentioned previously, this service was designed with voice primarily in mind and so its error recovery is far more stringent then pure data services such as frame relay. ISDN is also an expensive option over any distance and can prove troublesome from a setup and call establishment point of view. However for shorter distance hops where nothing greater then a 128k data service is required such as main branch to sub branch libraries, ISDN will still maintain a high level of use.

Frame Relay

Virtual Circuits in Frame Relay

Frame relay technology is based on the concept of using virtual circuits (VCs), which are two-way, software-defined data paths between two ports that act as private line replacements in the network. It is a bare bones, connection- oriented way to move bits from A to B at a reasonable speed and low cost. Frame Relay can best be thought of as a virtual leased line. The customer leases a permanent virtual circuit between two points and sends frames (packets) between them. While today there are two types of frame relay connections, switched virtual circuits (SVCs) and permanent virtual circuits (PVCs), the latter were the original service offering. As a result, PVCs were more commonly used, but SVC products and services are growing in popularity.

Using PVCs

PVCs are set up by a network operator — whether a private network or a service provider — via a network management system. PVCs are initially defined as a connection between two sites or endpoints. When a site is connected to the network, new PVCs may be added when there is a demand for new sites, additional bandwidth, alternate routing, or when new applications require existing ports to talk to one another. PVCs are fixed paths, not available on demand or on a call-by-call basis. Although the actual path taken through the network may vary from time to time, such as when automatic rerouting takes place, the beginning and end of the circuit will not change. In this way, the PVC is like a dedicated point-to-point circuit. PVCs are popular because they provide a cost-effective alternative to leased lines. Provisioning PVCs requires thorough planning, a knowledge of traffic patterns, and bandwidth utilization. There are fixed lead times for installation which limit the flexibility of adding service when required for short usage periods.

Using SVCs

Switched Virtual Circuits (SVCs) are available on a call-by-call basis. Establishing a call by using the SVC signalling protocol is comparable to normal telephone use. Users specify a destination address (an I.P number) similar to a phone number. Implementing SVCs in the network is more complex than using PVCs, but is transparent to end-users. First, the network must dynamically establish connections based on requests by many users (as opposed to PVCs where a central network operator configures the network). The network must quickly establish the connection and allocate bandwidth based on the user's requests. Finally, the network must track the calls and bill according to the amount of service provided. Although SVCs were defined in the initial frame relay specifications, they were not implemented by the first carriers or vendors of frame relay. Today, applications well-suited to SVCs are driving its deployment. While PVCs offer the statistical bandwidth gain of frame relay, SVCs deliver the any-to-any connectivity that can result in network savings and flexibility.

Frame relay is excellent for pure data connectivity. It utilises a CIR (Committed Information Rate) that is a scalable measurement dependant on the size of the circuit. For example, the channel may be a 64k channel with a CIR of 48k. This means that the Telco has supplied the user with a 64k channel on which they have guaranteed a throughput of 48k with the ability of the traffic to ‘burst’ above 48k to 64k.

DSL (Digital Subscriber Line)

Digital Subscriber Line (DSL) technology is a modem technology that uses existing twisted-pair telephone lines to transport high-bandwidth data, such as multimedia and video, to service subscribers. The term xDSL covers a number of similar yet competing forms of DSL, including ADSL, SDSL, HDSL, RADSL, and VDSL. xDSL is drawing significant attention from implementers and service providers because it promises to deliver high-bandwidth data rates to dispersed locations with relatively small changes to the existing telco infrastructure. xDSL services are dedicated, point-to-point, public network access over twisted-pair copper wire on the local loop ("last mile") between a network service provider’s (NSP's) central office and the customer site, or on local loops created either intra-building or intra-campus. Currently the primary focus in xDSL is the development and deployment of ADSL and VDSL technologies and architectures.

DSL: (digital subscriber line) a technology that exploits unused frequencies on copper telephone lines to transmit traffic typically at multi-megabit speeds. DSL can allow voice and high-speed data to be sent simultaneously over the same line. Because the service is 'always available,' end-users don't need to dial in or wait for call set-up.

ADSL: (Full Rate asynchronous DSL) ADSL offers differing upload and download speeds and can be configured to deliver up to six megabits of data per second (6000K) from the network to the customer - that is up to 120 times faster than dialup service and 100 times faster than ISDN. ADSL enables voice and high-speed data to be sent simultaneously over the existing telephone line. This type of DSL is the most predominant in commercial use for business and residential customers around the world. It is good for general Internet access and for applications where downstream speed is most important, such as video-on-demand. ITU-T Recommendation G.992.1 and ANSI Standard T1.413-1998 specify full rate ADSL. ADSL technology is asymmetric. It allows more bandwidth downstream---from an NSP's central office to the customer site---than upstream from the subscriber to the central office. This asymmetry, combined with always-on access (which eliminates call setup), makes ADSL ideal for Internet/intranet surfing, video-on-demand, and remote LAN access. Users of these applications typically download much more information than they send.

ADSL transmits more than 6 Mbps to a subscriber, and as much as 640 kbps more in both directions

HDSL: (high data rate DSL) This variety created in the late 1980s delivers symmetric service at speeds up to 2.3 Mbps in both directions. Available at 1.5 or 2.3 Mbps, this symmetric fixed rate application does not provide standard telephone service over the same line and is already standardized through ETSI and ITU (International Telecommunications Union). Seen as an economical replacement for T1 or E1, it uses one, two or three twisted copper pairs.

LMDS (Local Multipoint Distribution Service)

LMDS is a broadband wireless point-to-multipoint communication system operating above 20 GHz (depending on country of licensing) that can be used to provide digital two-way voice, data, Internet, and video services. LMDS for libraries could be used as either a last mile solution from a service provider, or within a WAN.

LMDS is a wireless technology able to transmit a large amount of data and information at a very high rate of speed using microwave radios. One microwave radio is installed onto a building at the client site and another microwave radio is installed at the LMDS base station. It can be constructed in a point to point or point to multipoint fashion. This means that the base station can use a special type of radio which allows it to have a 90 degree field of view as opposed to having a specific radio installed on the base station for each radio installed at the client site.

Depending on the implementation, LMDS offers a bandwidth of up to 1.5 Gbps downstream to users and 200 Mbps upstream from the user. A more typical data rate is 38 Mbps downstream. Some services offer both downstream and upstream service (symmetrical service); others offer downstream only (asymmetrical service) with upstream being obtained using wire connections.

Microwave

Another broadband wireless communication system similar to LMDS, microwave is point to point (unlike LMDS which is point to multipoint) and utilises radio waves that exist in the spectrums above 100 MHz. Microwave can supply a high bandwidth to users but does come with a number of downfalls. These are distance, noise and physical interference and are problems caused by the fact that microwaves travel in a straight line, do not pass through structures well and can be affected by atmospheric conditions such as rain and thick cloud, where the waves refract and so arrive at different times (known as multipath). The advantages of Microwave's remain in reduced ongoing costs though the initial ownership or construction costs can be very high.

Satellite

Satellite communication became a possibility when it was realised (by the science fiction writer, Arthur C. Clarke) that a satellite orbiting at a distance of 36000Km from the Earth would be geostationary, i.e. would have an angular orbital velocity equal to the Earth's own orbital velocity. It would thus appear to remain stationary relative to the Earth if placed in an equatorial orbit. For intercontinental communication, satellite radio links become a commercially attractive proposition. Space communication showed phenomenal growth in the 1970s, and will continue to grow for some years to come. The growth has been so rapid that there is now danger of overcrowding the geostationary orbit. Satellite communication has a number of advantages.

- The laying and maintenance of intercontinental cable is difficult and expensive.
- The heavy usage of intercontinental traffic makes the satellite commercially attractive.
- Satellites can cover large areas of the Earth. This is particularly useful for sparsely populated areas.

Satellite communication is limited by the following four factors:

- technological limitations preventing the deployment of large, high gain antennas on the satellite platform,
- over-crowding of available bandwidths due to low antenna gains,
- the high investment cost and insurance cost associated with significant probability of failure, and
- high atmospheric losses above 30GHz limit carrier frequencies.

Satellite is extremely useful to libraries for the sole purpose of international IP traffic. Here the traffic can be sent straight to a geostationary satellite down to the receiving library without any further network points or 'hops' needed. The significant problem with satellite traffic is the latency or time the signal takes to go from the ground up to the satellite (remember 36,000km above earth) and back down to the ground. While this latency isn't that disruptive to straight IP traffic, traffic such as library system traffic can be heavily affected.

VICNET initially chose one way satellite with low speed terrestrial back channel for the rural libraries as it offered us the ability to deliver high bandwidth at a lower cost into rural areas that didn't have access to terrestrial bandwidth with sufficient capacity or if this was available

it was at probative cost. As a consequence of VICNET purchasing satellite bandwidth for rural libraries, a decision was made to also provide this service to metropolitan libraries in part to deliver more cost effect economies of scale to both the rural and metropolitan libraries. It should also be stated that at the time (late 1997 for the rural libraries and mid 2000 for the metropolitan libraries) satellite infrastructure was the cheapest infrastructure and bandwidth option available for the libraries as a collective whole. The ongoing goal and objective for VICNET is to deliver affordable, stable and scaleable bandwidth to the Victorian libraries. To this end VICNET maintains a watching brief on alternative technologies and where possible runs trials to test these technologies in real day-to-day working library environments. Currently, VICNET is piloting a frame relay back channel solution with Ballarat, Bendigo and Horsham libraries. Any decision to move to alternative technologies will be made on the key criteria of cost, stability and geographical distribution as VICNET must focus on ALL the public libraries in Victoria irrespective of where they are located.

Growth of Bandwidth requirements

In the last 7 years the use and demand of the Internet in Victorian public libraries has grown from a tiny trickle to a huge flood and is now an ordinary part of life rather than a fad. Indeed at least one public library in Victoria (Yarra Plenty Regional Library Service) now treats its Internet services as another branch, and as such Internet services are staffed and budgeted accordingly. This growth has been driven by a number of factors: patron demand, the introduction and growing popularity of online library services such as full text databases, and the entrepreneurial and marketing activities of the public libraries as they introduce and promote Internet training, desk top publishing, and html courses. This growth of Internet usage has also lead to library networks growing in complexity, changes in staff skills, and of course bandwidth costs.

Though in the last 7 years the cost of providing Internet terminals and bandwidth has reduced, the overall costs of providing online services has risen as the number of terminals, and bandwidth requirements to service these terminals, has increased. Whereas a library could in the past get by with one or two Internet terminals and provide OPAC services using dumb terminals, today more and more Victorian public libraries are moving towards Web enabled PCs for Internet and OPAC services. As most of these web based OPACs use client server structures, the bandwidth required to service the newer OPACs has also risen.

Library dependency on the Internet is a of course a reflection of the overall growth of the Internet. “Over 10 million people sent messages across the network every single day in 1993, and the amount of data crossing the network more than doubles every year.” (Lawton, 1994) In Australia, by February 1998 nearly 850,000 households had access to the Internet (13% of all households) (ABS, 1998) whereas “nearly half (47%) of all Australian adults accessed the Internet during 2000, and there were 1,204 million megabytes (Mbs) of data downloaded by subscribers during the June quarter 2001. This has increased from the three previous quarters (1,052 in September 2000, 1,050 in December 2000 and 1,040 in March 2001)” (ABS, 2001). Web based E-mail remains one of the more popular Internet services supplied by libraries and in an effort to manage some of the demand and take some control over the costs, an increasing number of libraries are introducing e-mail kiosks or dedicated e-mail terminals where patrons have to pay for online connectivity. In a number (Moreland for example) Web surfing is free but e-mail incurs a cost.

Furthermore, the bandwidth required to deliver other library Internet services such as full text databases has also increased as the information now being transmitted has become richer and more varied. Using full text databases as an example, this richness has been driven by the libraries desire to ensure the online resources match the images, and layout of the original print copy. As a consequence, the Gulliver[#] databases no longer just offer text with a few black and white images in gif format. Patrons can search on ASCII text but can view the results in black and white PDF format. Some titles are now available in colour PDF. Also the various Gulliver venders have changed their editorial policies, and where allowed by copyright, have included more images. This means the volume of data being transmitted to service the same information request has increased. Using the Gulliver databases is a useful exercise when exploring the growth in bandwidth requirements as the Gulliver venders provide state-wide usage statistics.

So even if patron and staff usage of these online resources stayed the same the bandwidth requirements to service the Gulliver databases has increased. For example, a 4 page article entitled "16 ways to stay online" by John R Graham in the journal *Industrial Management* (2000) Vol 42. Issue 4, p6, which is available from one of the Gulliver vendors takes up only 18 Kb as a text file and 463 Kb as a PDF file. The PDF file is therefore 2,572% larger than the text only version! This article has only 4 small and not overly complicated images and no detailed charts and the PDF file in question is in black and white. If a library wanted a colour PDF file with high resolution the size of the full text file would increase even more. If we took the article, "16 ways to stay online", as being representative of the size and format complexity of the typical full text document, and multiplied the use of this out against the full text request statistics from the Gulliver service, we get a clearer idea of just how much more bandwidth is required. See Table 1 for more detail.

Table 1: Victorian Public Library / State Library use of full text from Gulliver databases

	Gulliver full text document requests #	Text only version @ 18Kb	PDF version @ 463 Kb
First half 2000	58,550	0.13 Gb	3.23 Gb
Second half 2000	56,089	0.12 Gb	3.10 Gb
First half 2001	68,723	0.15 Gb	3.79 Gb

Patron / staff full text requests as recognised by most popular Gulliver full text databases admin utilities. Includes information from EBSCOhost, Electric Library, Infotrac, and ProQuest databases.

The impact on the bandwidth required by the Gulliver databases due to information being delivered in richer formats is the difference between 0.15 Gb and 3.79 Gb assuming the average increase in file size has risen from 18 Kb to 463 Kb per full text article. The introduction of even richer full text with more graphics as well as more and more multimedia applications, data streaming, and video on demand, means that any saving on the per megabyte costs of bandwidth will be in all likelihood by negated by the need to provide even greater amounts of bandwidth to support these richer forms of information.

To get an idea of just how much bandwidth may be required in the future it is worth considering the recommendations of the US government's Internet 2 project where speeds of 622 megabits per second are planned for the Very-High-Speed Backbone Network Service, or BNS operating under a five-year agreement between the US National Science Foundation (NSF) and MCI Telecommunications Corporation. (Sanders-McMaster, 1997) This is over 10 times the capacity of the fastest standard Internet connection.

VICNET in comparison supplies bandwidth to most of the Victorian public libraries, the State Library of Victoria, and all of its commercial customers using a 3 Mb satellite connection and 2 times 2 Mb terrestrial links. During the middle of 2001, the Victorian public libraries incoming satellite usage averaged just under 900 kilobytes per second or 0.9 megabits per second, so what then is the relevance of the Internet2 project to public libraries? The Internet 2 connections are designed to provide "high-speed capability… necessary for researchers who work with complex computer models, exchange multimedia files, collaborate live over the network" (Sanders-McMaster, 1997) Though public library requirements would take many years to match these specifications, any growth in video streaming, exchanging multimedia files, and collaborative interaction (for example using public library patron terminals for web based gaming or certain chat based net software under an ASP arrangement offer co-browsing) is going to have a large impact on the bandwidth required and the associated costs. Already sites such as the ABC are offering broadband video downloads. According to the Australian Broadcasting Corporation web site, ABC "video is encoded at 33 Kbps for the dial up version, and 200 Kbps for the broadband version. Graphics, text and in some cases flash files add to the total amount of data". (ABCbroadband, 2001)

The speed and therefore cost of bandwidth is also becoming critical for libraries wanting to maintain and enhance patron expectations and satisfaction. Fast reliable Internet bandwidth is obviously important to libraries offering services to the public, especially given the research that demonstrates people do not persist with an Internet service if it is slow.

Table 2: Terminal speed and Patron use (from Puetz, 2001 B)

- 7 percent abandon with 7-second delays.
- 30 percent abandon with 8-second delays.
- 70 percent abandon with 12 seconds or more in delay.

Library staff on the 'coal face' are only too aware that slow Internet connections do not enhance user satisfaction. Patron perceptions of the quality of the overall library service can also be damaged by slow Internet connections. Using the above formula, unless managed in some other way, anything more than an 8-second delay has the potential to damage the end users' perception of the libraries services. In other words, there can be a real budget cost if libraries want to provide bandwidth with less than 8-second delays. However, what VICNET is finding is that even when libraries are provided with 4 Mb satellite bandwidth, Internet speeds on library terminals can be very slow.

"There are two basic approaches in solving the many Internet performance issues that are prevalent today. The first approach adds more infrastructure, increasing the overall capacity, performance and reliability. The second provides an overlay network that bypasses the Internet bottlenecks, which is the approach used by content delivery networks (CDNs)." (Puetz, 2001 B) However even a CDN cannot help in regards to performance if the bottleneck

is local. Library LANs, council or regional library WANs, local firewalls, end bandwidth routing can all contribute to delays. Unfortunately slow bandwidth is not always the fault of the Internet Service Provider, so one of the challenges facing libraries is to train up enough staff that when there is a problem they can readily do a number of simple tests, pinging and trace routes for example, in order to identify where the delay is occurring in order to expedite a fix and manage patron expectations.

Paying for Bandwidth

As mentioned, while the cost of bandwidth has been steadily decreasing library use of bandwidth has been increasing at a faster rate with the net impact that bandwidth charges are rising. Unlike other utilities such as electricity and water, libraries are particularly sensitive to increases in bandwidth charges because for many it is still a relatively new line item on their budgets. Unlike other utilities, libraries are pulling down more and more bandwidth to perform the same tasks because the data is becoming richer and more varied. Controlling the costs of bandwidth has therefore become critical.

> "Controlling costs has been a compelling, consuming concern of libraries for some time now. Administrators who manage libraries and the politicians and appointees who fund them are intrigued with how network technologies, resources, and services will innovate their service and product offerings. At the same time, they are particularly interested in how to measure the payoffs on investments in modern information technologies and eager to learn what those measurements will show. If benefit was the handle they grasped when they first extended networked resources and services to their patrons, cost will be the handle they grasp to raise those services to the next level of development." (Peters, 1995)

One of the great challenges facing libraries, as their use of the Internet increases, is to be able to identify Internet costs in terms of services provided to patrons. "Charles McClure, professor at the School of Information Studies, Syracuse University, NY, and primary author of the study, Internet Costs and Cost Models for Public Libraries, found that during the course of his first study, Public Libraries and the Internet (1994), a large number of libraries were unable to articulate specific Internet-related costs. Several librarians expressed to McClure the need for more cost information to help them plan their Internet connectivity."(St. Lifer & Rodgers, 1995) Seven years later Internet cost information can still be difficult for libraries to articulate especially where the usage and therefore the charges are being shared by other parts of the library's host organisation. For example, a number of the Victorian public libraries share their Internet access with council. It is also difficult for the libraries to determine how the Internet charges should be costed back to various library services. Many councils and libraries are concerned about the growth in communications charges.

In the US these concerns have been meet by introducing subsidies to libraries. "Thanks to an obscure provision in the 1996 Telecommunications Act, Americans can expect to see an increase in their phone bills after the first of the year. The revenues are intended to pay for a little-known federal program called the "Universal Service Fund" (USF), which is being expanded to subsidize, among other things, Internet access for schools, health-care facilities and libraries." (Anonymous, 1997) About 30,000 schools and libraries applied for

approximately USD $2.02 billion in e-rate funding (Margolis, 1998) in 1998 alone. This amounts to a subsidy of USD $6,700 per school and library.

However not all has gone to plan in regards to this subsidy programs. “Less than five percent of E-rate telecomm discounts have gone to public libraries under the federal government's Universal Service provisions. In Year 1 of the program, public libraries represented 18.06 percent of funded applications and 3.93 percent of funding dollars. In Year 2, the figures sank to 16.14 percent of funded applications and 3.08 percent of funding dollars.” (Rogers & Order, 2000) Not surprisingly there has been considerable comment in the library literature on the effectiveness of specific subsidy programs.

In Australia, money from the Networking the Nation fund has gone to building infrastructure and this has allowed libraries to suck down more bandwidth resulting in hikes in bandwidth charges. Ironically in the US where a lot of money went into providing subsidised bandwidth, libraries complained they couldn’t take advantage of the subsidies if they did not have the infrastructure in place. “…schools [and public libraries] across the country began to complain that they couldn't take advantage of the Internet because they didn't have their communications infrastructure in place. So they wanted money to fix that part of their operations up as well. But they weren't content to get their telephone bill slashed in half and apply that windfall to their infrastructure. No, they wanted money from the fund to pay for the infrastructure as well. So we're not talking telephone discounts anymore, we're talking in-house wiring contracts.”(Schuyler, 1998)

In Victoria the state government set up VICONE in part to get schools online. To encourage schools to use VICNET the service was heavily subsidised. As Victorian public libraries are the responsibility of local government and not the state they were not able to take advantage of the VICONE subsidies. VICNET of course is not funded to provide subsidised Internet bandwidth to public libraries. As a result the pricing models that VICNET has developed in co-operation with VICLINK has had to cover costs. Where it differs from commercial models is that the libraries were directly involved in the development of the pricing model. This partnership approach was seen as important if the pricing model was to meet the needs of the libraries involved.

Consortia have emerged as a popular topic of library debate in the last 5 years. Consortia are invariably driven by the desire to save money. The success of consortia among Australian libraries has been mixed. Consortia work best when the libraries involved are natural partners and preferably not competitors, where the consortium is organised in a way that is open, transparent, accountable and inclusive and most importantly of all where the libraries involved actively acknowledge that in order to gain as a group they have to give up some individual control and authority. (Lowe & Feighan, 1999) In the case of the VICNET / VICLINK model, library bandwidth pricing was devised by VICNET staff and reviewed by a VICLINK subcommittee.

Pricing Bandwidth

Working with VICLINK it became clear that libraries wanted fixed pricing for bandwidth in order to protect themselves from budget blowouts. While it is possible to provide fixed bandwidth for a fixed price the libraries also required a service fast enough to meet the expectations and needs of their patrons. It is not possible to offer fixed pricing for unlimited growth and guaranteed service -something has to give, as detailed in table 3.

Table 3: Relationship between Bandwidth Costs, Growth in Bandwidth, and Performance

Costs	Growth	Performance
Fixed	Up	Down

Cost	Growth	Performance
Up	Up	Stable

Cost	Growth	Performance
Stable	Fixed	Stable

As the library and in many cases council use of the Internet was steadily increasing, fixed bandwidth would have led to a gradual degradation of service. It became clear that price stability and flexibility to increase bandwidth was the main objective of the VICNET public library pricing exercise. As the model had to be sustainable, the pricing also had to cover VICNET's costs in providing access to the bandwidth. As a result of this the following three factors were agreed upon as the critical success criteria for the project.

1. A technical model, addressing the proportion of the total current cost of bandwidth to VICNET used by the satellite project as a whole,
2. The infrastructure and the administration necessary to deliver the bandwidth,
3. A growth model, taking into account factors influencing individual differences in library network size during the financial year.

As a result a model was developed where charges were fixed within tiers of usage. This gave the libraries some assurance of billing stability without the need to factor in a significant pad to protect against loses. Under the 2000 – 2001 FY pricing model libraries were charged according to population. This proved unsatisfactory because population did not reflect actual Internet usage. Socio-economic factors, the number of branches and their opening hours, the number of terminals, and the Internet usage policies of the respective libraries together have a more significant impact on bandwidth than the resident populations. The population model also did not factor in growth in usage, and as a consequence if the population model had been used in the 2001 – 2002 FY VICNET would have incurred considerable losses.

The model that was developed also had to take into consideration the following issues:

- The model had to rely on user pays principles, as VICNET is not receiving funding to subsided library bandwidth.
- The pricing model had to be fair and equitable to both large and small users of bandwidth. It was not considered desirable that larger or metropolitan libraries subsidise smaller or rural libraries or vice versa.
- Libraries should have the ability to spike their usage without incurring excess charges.

- Diagnostics and quarterly reports were considered important so libraries were aware of trends in their bandwidth usage and could plan accordingly for future growth or changes in that usage.
- VICNET also had to provide a 24-hour paging service and back up support.

As a result, a pricing model was developed where libraries are billed according to the range (or tiers) of bandwidth they used. Initially, 64 kilobytes per second units were considered. However, it was found that 64 kbps bands were too large and libraries in the low range of each band would end up paying for bandwidth they would never use during the billing period. As a result bands of 32 kbps were introduced and finally approved by VICNET and VICLINK. The cost of each 32 Kbps unit of bandwidth ($388.41) was determined by working out the total circuit and bandwidth costs to support the libraries. VICNET knew the amount of bandwidth used by each library rounded up to the closest 32kbps unit. So the total dollar amount required to provide library bandwidth capacity was then divided by the number of 32kpbs units needed to deliver bandwidth to the libraries and this determined the cost of each 32kbps unit. Therefore if a library were using 79.43 kbps on average this would be rounded up to the next 32 kbps unit in this case 96 kbps. The cost would therefore be 3 * $ 388.41 or $1,165.23 per month. Overall, the per megabyte cost to the libraries has worked out at roughly $0.12 per Mb. As long as this library's AVERAGE usage stayed within this third tier their cost would not change. In this case, if the average usage went below 64kbps they would pay less, and if it went above 96 kbps they would pay more. An example of a typical metropolitan library's billing is given in table 4. It is also important to note that VICNET only considered incoming traffic when billing the libraries.

The smaller rural libraries proved to be more difficult. During the development of the pricing it was found that even with 32 kilobit tiers rather than 64 kilobits the smaller rural library usage was so low that these small users would be paying for bandwidth they could never hope to use. As a result a separate rural library model was developed based on various SOHO pricing models. Under the rural library pricinglibraries paid $60.00 for the first Megabyte of data per month and then $0.24 for every Megabyte thereafter. This touches on one of the main challenges when developing the public library pricing in that the pricing had to be fair and equitable for a very disparate group of users. This is a very different philosophy to normal commercial models that are designed around maximising profit and market share.

Table 4: VICNET satellite pricing model for FY 2001 - 2002

Tier	Average Kilobits per second	Cost per month	1st quarter	2nd quarter	3rd quarter	4th quarter
10	320	$ 3,384.10				
9	288	$ 3,045.69				
8	256	$ 2,707.28				
7	224	$ 2,368.87				
6	192	$ 2,030.46				
5	160	$ 1,692.05				
4	128	$ 1,353.64				
3	96	$ 1,015.23				
2	64	$ 676.82				
1	32	$ 338.41				

Using this example the library in question pays $ 1,353.64 per month during the first, second and fourth quarter and $4,060.92 per month during the third quarter. The change in the billing in the 3rd quarter is due to the fact that the average incoming bandwidth use for this quarter rose above 128 kbps. As the usage dropped below 128 kbps in the 4th quarter so the pricing also dropped back. This then comes to a yearly total of $13,197.99 per annum plus GST. Most of the metropolitan libraries fell within the 4th, 5th, or 6th tiers. Only one library service used 9 tiers and this was due in large part to the fact that the council was also getting its Internet from the library.

To ensure the VICNET pricing was competitive, VICNET then compared the pricing against a state-wide cable option and a state-wide satellite option. In both cases the VICNET pricing delivered better value for money than the commercial alternatives.

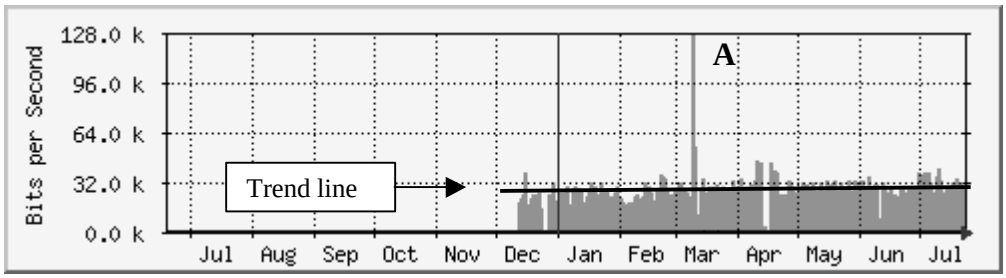
Impact of Library Use and Bandwidth Pricing

As it stands most of the metropolitan and rural libraries have experienced reasonably stable or a slight growth in bandwidth requirements over the last 12 months. (*See table 5 for details*.) VICNET bases it pricing on AVERAGE usage so as long as the libraries remain within their bandwidth tier they have price stability. Spikes in usage (See A and B in the table 5) do not have an impact on pricing unless of course they are ongoing and sustained. Most of the libraries have been able to monitor their usage and plan their budgets accordingly. Where there have been some concerns is when a library's average bandwidth usage has been close to the top of a tier and it has not taken much increased use to put them in the next pricing bracket. There has also been one or two library / council users where the growth in bandwidth use has been very significant and they have found it difficult to control their usage and therefore their costs. VICNET has offered assistance by including supplemental information with usage graphs and information on how to take control of bandwidth use. (*See Appendix A for details*.) Unfortunately where the IT is controlled by the council the library is somewhat constrained about implementing any of these control methods.

As mentioned early to help libraries monitor and take control of their bandwidth usage and therefore costs VICNET provided detailed historical usage information for each library. This is available online at http://noc.vicnet.net.au. The following graphs are taken from the VICNET Network Operations Centre (NOC) site.

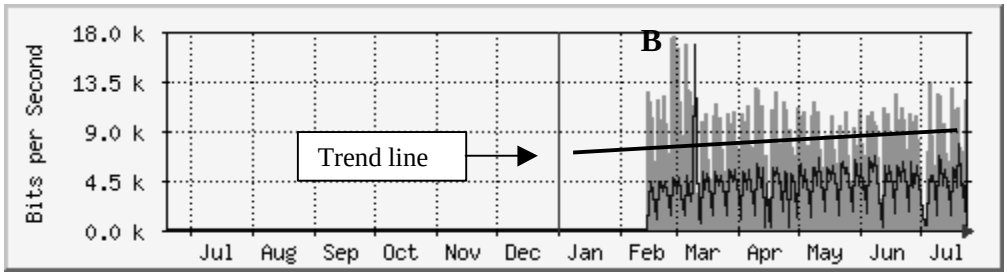
Figure 2: Typical metropolitan library usage

Satellite `Yearly' Graph (1 Day Average) with trend line



NOTE: Outgoing Internet traffic only as there is no satellite back channel. Back channel traffic is graphed separately. See following graph.

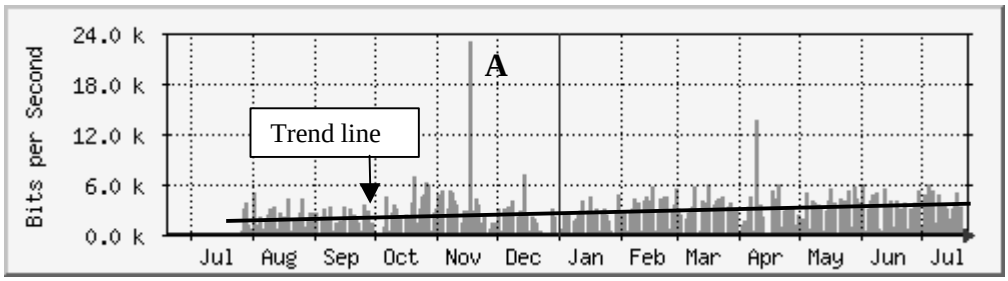
Back channel `Yearly' Graph (1 Day Average) with trend line



NOTE: Shading represents incoming Internet traffic on the back channel. The single dark line (not the trend line) represents outgoing Internet traffic on the back channel. Where it delivers better response times, incoming Australian domestic traffic is routed via the back channel.

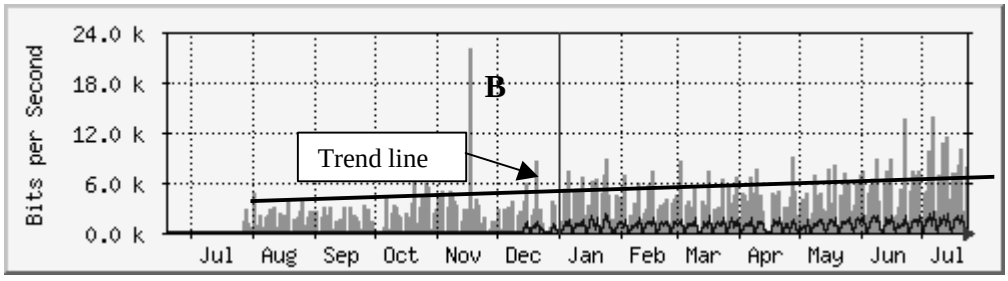
Rural library pricing has also tended to be stable with overall slight growth in Internet usage over the last 12 months. (*See figure 3 for details*.) The rural library pattern of usage is similar to the metropolitan libraries except that it is coming from a lower base. All of the larger rural and regional library services have been charged according to the metropolitan pricing model as their usage is typical of the smaller metropolitan libraries and in these cases the VICNET metropolitan pricing gives them better pricing. In fact over the last 12 months only 7 of the 19 rural libraries remain on VICNET rural pricing. As with the metropolitan pricing VICNET charges on AVERAGE usage so spikes in usage do not incur additional costs.

Figure 3: Small rural library usage



NOTE: Outgoing Internet traffic only as there is no satellite back channel. Back channel traffic is graphed separately. See following graph.

Back channel `Yearly' Graph (1 Day Average) with trend line



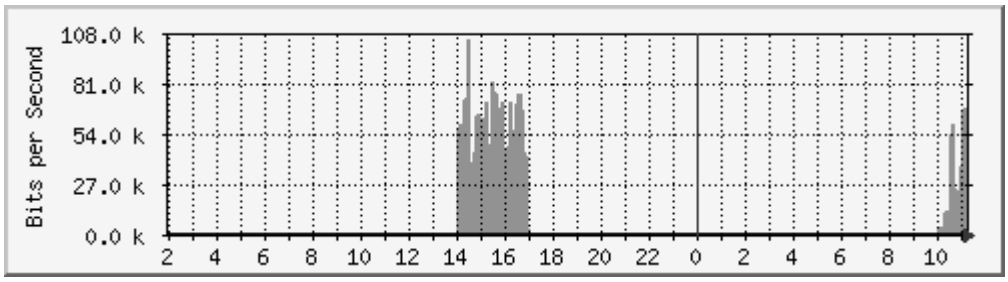
NOTE: Shading represents incoming Internet traffic on the back channel. The single dark line (not the trend line) represents outgoing Internet traffic on the back channel. Where it delivers better response times, incoming Australian domestic traffic is routed via the back channel.

The MRTG graphs have not only given the libraries a feel for the ongoing bandwidth requirements, they have also provided valuable information on daily and weekly Internet use which the libraries can use to match against hours of opening and information on what staff

and patrons tend to be doing online at different times of the day. (*See Figure 4 for details*.) For the most part these graphs have only confirmed what libraries already know and suspect. For example that there is often an afternoon / early evening spike in usage as school students use their local public libraries. Internet usage also tends to be heavier on certain days of the week and less heavy on other days. Again this information can assist the libraries in taking control of their bandwidth requirements and budgets by giving them valuable information on patron and staff usage patterns.

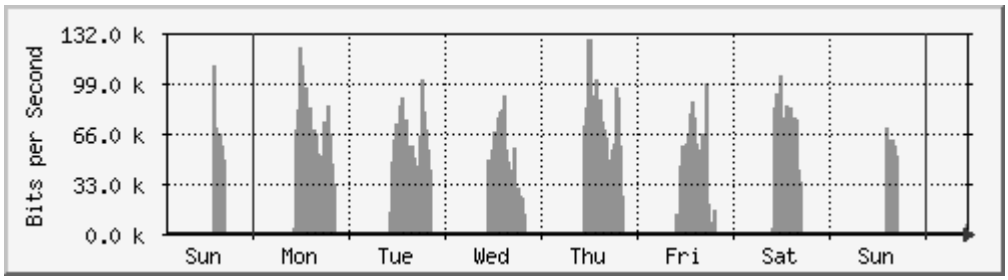
Figure 4: Typical daily and weekly usage

`Daily' Graph (5 Minute Average)



NOTE: Outgoing Internet traffic only as there is no satellite back channel. Back channel traffic is graphed separately. See following graph.

`Weekly' Graph (30 Minute Average)



NOTE: Shading represents incoming Internet traffic on the back channel. The single dark line (not the trend line) represents outgoing Internet traffic on the back channel. Where it delivers better response times, incoming Australian domestic traffic is routed via the back channel.

Conclusions

The rollout of satellite and back channel infrastructure, the collaboration of public libraries with VICNET as an ISP, and the access to diagnostic tools on the VICNET NOC site has assisted libraries and VICNET provide a level of Internet connectivity to the Victorian public that would not be possible if the libraries (particularly the smaller and more remote libraries) were to proceed independently. Both VICNET and the public libraries have gained considerable skills and developed in-house expertise in the areas of routing, bandwidth pricing, and project management. This has created a strong basis of intellectual capital which can be utilised to assist Victorian public libraries develop in response to future growth and demands for online services.

However as expertise has been developed and lessons learnt, more questions have been raised. As a result of monitoring the growth in Victorian public library bandwidth usage, VICNET and the public libraries have realised that more needs to be done to understand what impact various online library services and programs have on the libraries' IT and budgets. VICNET has been able to supply information on total satellite and back channel usage but at this stage we can't provide detailed information on what specific programs and services are driving this increase in bandwidth use. To provide this type of information VICNET requires the close involvement and co-operation of the libraries and in a number of cases the council IT departments.

To this end VICNET and the State Library of Victoria, along with a number of rural and metropolitan libraries, are exploring options to pilot a bandwidth mapping exercise in early 2002. This pilot will monitor different types of bandwidth usage across a number of different types of library services. In working with the Victorian public libraries VICNET has been made aware that there is growing interest in the impact that web based e-mail, chat sessions, Kinetica, multimedia applications, and collaborative computing all have a bandwidth requirements. Having a clearer understanding of what impact these and other services have on bandwidth utilisation will assist libraries priorities their services and plan for future demands and growth as well as take control of their bandwidth and IT costs. VICNET is also keeping a watch on emerging technologies particularly where they offer flexibility and savings to Victorian libraries. However, bandwidth and the associated technology costs should be treated no differently to any other utility (power, water) that libraries require to provide services to patrons. This sort of collaborative work and the sharing of intellectual capital, as well as working in concert to develop bandwidth pricing models and cost effective infrastructure roll out programs, will continue to ensure that libraries are best placed to take advantage of the ongoing online revolution.

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Appendix A

Bandwidth usage and minimisation

Here are the issues that people can look for or change to assist with bandwidth usage.

1. The first and most important is point all PC's, staff and public, at a local proxy and if possible have the local proxy parent off one further upstream (ie; Vicnet).

2. Block access to port 6667 (if possible) on your PC's. This is the port that chat sessions use.

3. Be cognisant of web free-email services. Do not equate these with standard email as these services download full web pages and as such, utilise a higher level of bandwidth (see again point 1).

4. Kinetica. Will route up and down the back-channel as it is a domestic site. This is also another heavy bandwidth site as the web page and the information within it is fairly dense. Proxies will help with the initial pages but as soon as you start sending pages with differing information, the proxy becomes moot.

5. Internal LAN Design and firewall's have an issue with traffic speed but NOT bandwidth.

6. A bad (not clear) back-channel and/or ISP will affect both traffic speed and to a lesser extent, bandwidth. This is due to dropped packets, timeouts, re-transmits, etc.

Cache Memory

In simplest terms, cache memory is a special type of super fast memory built onto or next to the processor. Your processor moves and works with a lot of data. Sometimes, your processor works on a problem then needs to set it aside and work on another before picking up the original problem. Without cache, your processor would have to store the set aside data into conventional memory (RAM). While there is no particular reason your processor cannot do this, setting data aside in conventional memory subjects the data movement to the limitations of your motherboard and how fast it can move memory. It’s nowhere near as fast as your processor. Designers figured out that there had to be a much faster and more efficient way for this to happen. Enter cache memory.

Types

L1 Cache:

L1 cache is also known as onboard or primary cache and is built into the CPU itself. L1 cache is typically very small in size (for most computers it is 16KB although this is changing rapidly) but it is very fast.

L2 Cache:

L2 cache is also known as external or secondary cache. It is built into a separate chip, but it is still much faster than conventional memory because it, too, is not subject to the speed limitations of the motherboard. Typically ranges for L2 cache are 128KB – 1MB.

Important

Depending on what you do, the amount of cache your system has can greatly increase or decrease the overall speed of the system. For example a 450MHz Pentium III has far more cache than a 450MHz Celeron. Even though both chips have the same clock speed, they do not perform at the same level in all situations. For data-intensive applications like complex spreadsheets or graphic design, the Pentium III will outperform the Celeron any day. The lesson here is to know what you will be doing with your computer before you settle on a processor. If you are into CAD design, and buy a Celeron, you may be sorely disappointed. If, on the other hand, you just write letters and surf the Internet, you may not want to spend the extra money on the Pentium III

Endnotes

[#] Gulliver was part of the Libraries Online projects funded from Multimedia Victoria to provide access to full text resources to the Victorian community. The full text databases on Gulliver were chosen by a group of librarians from Victorian public libraries and the State Library of Victoria. Since March 2001 Gulliver has been self funded by the member libraries with most Victorian public libraries participating. Databases currently include resources from EBSCO Publishing, Gale Corporation and provide access to over 6000 full-text journals, books, newspapers and pictures.