Broadband: New highways for regional development in the 21st century *

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SUMMARY: *Broadband has been the subject of serial inquiries since the Broadband Services Expert Group reported in 1994. Rarely has a subject been so heavily inquired about without, apparently until recently, a great deal of action. Like transport infrastructure it is not an end in itself but a means to an end. Broadband communications is as essential infrastructure in today's economy as is road and rail: this importance is perhaps not so readily realised. The user of broadband is the economy, the digital economy, which is critically dependent on appropriate engineering of this infrastructure and in its investment. Like road and rail, broadband infrastructure has to be engineered with changing user needs in mind. This paper will explore the issues faced by engineers and engineering in the development of broadband networks, and the critical needs of the digital economy, including in the management of other (eg. utility, road and transport) infrastructure. The paper will also consider the need for connectedness of people and services, the importance of connecting information systems (including advanced computing capabilities) and the contribution to be made by broadband in addressing sustainability.*

1 INTRODUCTION

> *This 'telephone' has too many shortcomings to be seriously considered as a means of communication. The device is inherently of no value to us.* Western Union, internal memo, 1876.
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> *I think there is a world market for maybe five computers.* Thomas Watson, chairman of IBM, 1943.
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> *There is no reason anyone would want a computer in their home.* Ken Olson, President, Chairman and Founder of Digital Equipment Corporation, 1977.

At the time this paper was originally prepared, the Federal Government was considering decisions on its National Broadband Network (NBN), then specified to deliver broadband services with a minimum information speed of 12 Mbps to 98% of the Australian population. The government announcement in April 2009 necessitated a review of the document and changes have been incorporated as appropriate.

The following prediction was made prior to the government's NBN announcement and it will be apparent that fulfilment of the prediction is much closer following the announcement.

> *Most Australians in regional areas will have access to 100Mbps broadband service if required at prices comparable to capital cities by 2015 [and most are unlikely to demand more capacity for several decades].* Peter Hitchiner, Engineers Australia Regional Convention 2009.

Such a prediction seems a good deal more bullish than those previous predictions would seem today: put in context perhaps this prediction will also be an underestimate, such is the rate of development we have seen over the past 30 years in telecommunications, information technology and electronic entertainment services. In 1976, the year before Ken Olsen made his unfortunate comment, Australia was considering whether it should have a national satellite system (Commonwealth Government Task Force, 1978) to conquer the tyranny of distance. At that time many Australians in isolated areas simply wanted a telephone system that worked. In less than 30 years those living in isolated areas can now expect to have a computer in the home and maybe even broadband communications by

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satellite or terrestrial means. The "worldwide web" is just 20 years young, having been conceived by Tim Berners-Lee in March 1989, and has already had major impacts on global economies. What other developments will emerge over the coming decades? The above infamous quotations about the future have probably made people reticent about broadband embarrassment: very wise in view of the growth of the internet, broadband and consumer equipment that depends on broadband communications.

Speculations of this nature are always risky, nevertheless this paper will endeavour to show that based on previous experience my projection is not fanciful and furthermore necessary for sustaining Australia's regional economies.

2 AN HISTORICAL PERSPECTIVE

It is not feasible in a paper of this nature to provide a detailed view of the history of telecommunications, but a focus on some aspects of the development of broadband regional telecommunications is perhaps useful here. Telephone "services" have been available in regional locations since the early days of high-frequency (HF) radio and pedal power (c. 1929). Such services have never been uniformly of a standard and accessibility expected by the population living in major cities.

Until the advent of domestic satellite communications (Australia's National Satellite System, AUSSAT, commenced services in 1985) only those fortunate to be in locations passed by inter-capital links experiencing reasonable levels of telecommunications service (and generally only voice and low rate data) in regional Australia. Other infrastructure opportunities were used to provide wide-band microwave radio links (including for television bearers) to, for example, Moree in northern NSW (1968) an investment driven by the need to support the then new international satellite earth station and to Cairns (1966), as part the investment required for a submarine cable system connecting Australia with southeast Asia (SEACOM). These early investments have supported the economies of these areas and have no doubt had an important impact on the subsequent investments that provide substantial bandwidth now that they are connected by optical fibre cables. Submarine cable landings in Western Australia have also supported investment in terrestrial optical cable systems linking eastern and western Australia (WA ICT Industry Development Forum, 2006).

Australia seems to have neglected many such infrastructure opportunities in the intervening periods including co-construction of telecommunications infrastructure with gas pipelines (eg. Eastern Gas pipeline) and railways (eg. Darwin to Alice Springs). There are engineering challenges associated with such opportunities, not only in coordinating construction, but perhaps more especially for subsequent access and maintenance. Many opportunities to exploit road infrastructure work are often not attractive because of the access restrictions in a hazardous environment.

Inter-capital telecommunications links are not useful to regional locations they pass through unless there are suitable access points, in the same way that roads and railways require access points. Technical solutions for telecommunications services access have been costly. Optical fibre technologies now available allow more affordable drop off access to broadband optical fibre systems. Once access points are available, incremental costs of providing capacity should generally be relatively low. While in case of roads, access is available to any vehicle suitably registered; such open access has not been available for telecommunications until relatively recently. Such access is not gained easily and is the subject of ongoing commercial disputes in relation to trade practices. Such issues need to be resolved to allow regional locations access to affordable broadband services. The NBN as announced acknowledges this issue and is intended to deliver an open access wholesale broadband service.

While inter-capital links can be costly, the volume of telecommunications traffic carried generally means that the cost of carrying individual connections is relatively low. The high cost of providing telecommunications services has traditionally been in the cost of the customer access network (providing the links to the individual customers). Recent developments in wireless broadband and in passive optical fibre networks have resulted in technology solutions that bring broadband services within affordable reach of the majority of the Australian population, with only the remotest potentially not being served. The main impediments to providing such services are generally the availability of resources that are typically focused on the higher demand and therefore higher revenue areas.

3 THE ECONOMIC SIGNIFICANCE OF BROADBAND

Broadband is increasingly recognised as an important enabler in advanced, as well as emerging, economies. Broadband has taken on an economic role much as waterways, roads, rail and electricity transmission have done in the past (and continue to do). With the increased need for immediate and effective communication in commerce, the need for broadband extends throughout the economy.

The Organisation for Economic Co-operation and Development (OECD) has undertaken studies of the impact of broadband on the economy, among the latest being for the OECD Ministerial Meeting on the Future of the Digital Economy (OECD, 2008). Other studies have been undertaken in Australia (DCITA, 2007; DBCDE, 2008). The topic is beyond the scope of this paper: the importance is nevertheless illustrated

by the commitment not only by the Australian government but also by governments including Singapore, South Korea and New Zealand to assist in the funding of broadband infrastructure.

Broadband now plays an important role in engineering projects with their increased dependence on information and communication technologies, and the dispersion of engineering teams among offices and field locations. Operation of infrastructure (including utilities) and transport networks requires increasingly sophisticated systems, including those required to monitor infrastructure to support timely maintenance and minimise life cycle cost of the investment.

In commerce and government, electronic services are becoming increasingly important both for operations as well as in interacting with customers and delivering services. eHealth and eEducation are becoming essential services to support traditional health and education services. In health, the availability of timely information about patients and the management of treatment including use of telehealth leads to improved health outcomes and lower patient costs for the community (especially in regional and remote areas), and to address the growing demand from an ageing population. In education, the ability to apply resources to multiple locations through the use of telecommunications, whether for live lectures, one-on-one tutorials or for access to information sources, is essential in meeting demands with fewer resources per student, and for efficient delivery of vocational training and in service courses. Increasing globalisation of economies means that access to good broadband services is necessary in order to remain competitive, and deliver an acceptable level of service and support.

Increasingly commerce and governments need to be connected to computing (including supercomputing process capabilities) and information sources such as spatial/mapping, financial, educational and health information. Innovation and productivity benefits can be gained through access to information from various sources and the ability to process data: modelling and access to engineering resources can be made possible even in remote areas through the provision of a good broadband service. In trade, the tracking of goods is facilitated by radio frequency identification devise (RFID) and intelligent location systems require an increased use of broadband.

In the residential community, demand for broadband is being driven by the entertainment (including electronic games) market, with an increasing number of people using the internet for electronic communication, including email and video conferencing (such as Skype).

There is a growing desire to be connected, to be able to contact people and/or leave messages, which will receive prompt response wherever the people are in the world. Social networking and presence services (including unified communications) are also experiencing substantial demand. Teleworking on a part-time basis is becoming commonplace, assisted by the availability of improved broadband services.

In the early 1990s, in regional locations (the Shoalhaven/Nowra area of NSW was a particular case in point), businesses have been frustrated by the inadequate and expensive telecommunications services required to undertake commercial activities: remember ISDN (Integrated Services Digital Network)? Many businesses have on occasions been effectively forced to relocate to capital cities simply due to inadequate telecommunications services. Such relocations today should be rarely necessary even for very high bandwidth requirements. However, cases of inadequacy of telecommunications services continue to be reported even where improved services have been introduced (NSW Legislative Assembly Standing Committee on Broadband in Rural and Regional Communities, 2009): hopefully the NBN will effectively eliminate the future occurrence of such cases.

The "digital economy" is increasingly being recognised as an essential part of the environment in which we live. The Department of Broadband, Communications and the Digital Economy has recognised this and is currently undertaking broad consultation on the matter. Engineers Australia recently made a submission to those consultations (Engineers Australia, 2009). In other economies, the "digital economy" issue is also receiving high profile attention (Department for Business Enterprise and Regulatory Reform, 2009). One of the biggest challenges in regard to the digital economy is in increasing the awareness of the population as a whole to the benefits of operating in the digital economy. It requires significant change in the way the economy functions efficiently and those economies making the changes effectively will gain substantial advantage. It is particularly important that this change occurs through education. Australia's regional areas have much to gain from making a transition to the digital economy and broadband is an essential enabler for that.

4 SERVICE DEMAND

Broadband has widely been defined (OECD, 2008) in recent years as a minimum network access speed of 256 kbps. This is generally regarded as unacceptably low in any economy, even though some users with relatively undemanding needs remain able to conduct business at those data rates. The demand for high bandwidth is being driven mainly from the very large residential market.

Table 1 provides an estimate of residential broadband demand that is likely to be common in 3 to 5 years (based on OECD typical household demand). Some users will require more, many will require less. Constraints will apply not on the technology

Table 1: Service demand and associated data rate.

Service	Residential[a] (Mbps)
Telephony (VoIP)	0.4
Web browsing, etc.	2
Electronic services (including email, messaging, smart home, home office, eHealth)	2
Videoconferencing	4
IPTV (assume 2 x HDTV) and video on demand	10-20 per channel
MP3, radio/audio streaming and podcasts	1
Interactive gaming and online education	4
Home surveillance (CCTV) and security	0.5
Average peak demand per household	~50
[a] aggregate of inbound and outbound	

capability, more due to the cost of downloads (capping of download is likely to continue albeit at higher levels and lower per megabyte cost, but nevertheless will act as a constraint on utilisation). Perhaps more significant though will be the constraint of suitable content: many users may find limited content in areas of interest will constrain their use of internet data.

The service that dominates demand as summarised in table 1 is IPTV. IPTV is in addition to digital free to air (DFTA) television (TV) and cable TV (Pay TV). Where DFTA and cable TV are available, this can be readily incorporated into passive optical network systems (PONs). Wireless broadband on the other hand would need to carry DFTA TV and IPTV or at a lower quality digital stream. In locations where PON delivery of services is not economically feasible (eg. in many rural locations), the demand on wireless broadband may be greater. The capping of download volumes would place an additional burden on rural users even where access to the limited range of DFTA TV is available.

There will always be some users with even higher bandwidth requirements (in excess of tens of Gbps). These will need to be considered on a case-by-case basis, and often the location of such entities requires consideration of access to broadband in the same way as roads and rail corridors are also part of planning criteria. Some facilities (such as the proposed Square Kilometre Array (SKA)) require very high bandwidths in very isolated locations necessitating the provision of extensive new telecommunications transmission systems. These are opportunities to provide improved broadband to other communities through which those systems are constructed.

5 BROADBAND AND SUSTAINABILITY

Broadband is increasingly recognised as an important contributor to sustainability and more efficient use of carbon resources. One particular and widely-noted advantage is the ability to substitute some travel by teleconferencing. Apart from substitution for meetings, travel can also be avoided where information can be provided electronically rather than in a physical form. Increasing sources of data are becoming available online, including geospatial data and mapping, enabling work to be conducted at locations remote from the source of information where such information is made available.

The possibilities of demand-side management of the electricity power system will become increasingly important as nations endeavour to use their supply-side infrastructure more efficiently. The ability to shed targeted loads that are not instantaneously required (eg. a well insulated refrigerator stopped running for a short period will not damage food or adjust air-conditioning temperatures by a few degrees temporarily during peak demand) will allow supply to be maintained for other requirements and reduce the need for additional infrastructure to supply peak demands by smoothing the peaks in demand.

The ability to collect, process and respond to a range of environmental and user data facilitated by the availability of broadband will have profound implications on the ability to support increasing population and expectations for improving living standards. The design and modelling of the built environment to optimise the use of resources will have dramatic impacts on the ability to implement sustainable solutions. This is covered particularly well in the 2008 Brunel Lecturer by Peter Head (Head, 2008).

6 CURRENT REGIONAL BROADBAND SERVICES

Broadband services in regional Australia are generally regarded as inadequate. As previously noted, some locations benefit from the fact that inter-

capital telecommunications systems pass through and provide access points for reasonable quality services, but aside from that the services cannot be regarded as adequate and affordable.

In 2007 Engineers Australia added a *Telecommunications Infrastructure Report Card* (Engineers Australia, 2007) to its suite of infrastructure report cards. This report card addressed the state of fixed and mobile telecommunications infrastructure (as distinct from the services which that supports) and concluded that in regional Australia the infrastructure rated at best poor and in many cases inadequate. It should be noted that the very thin population in some areas makes the commercial provision of services difficult. The report card recommended that:

1. Australia needs an ongoing, regularly reviewed and updated strategic plan for telecommunications infrastructure development.
2. Government should ensure that regulations and subsidies (if appropriate) are regularly reviewed and adapted as needed.
3. Unnecessary duplication of infrastructure should be avoided, particularly where government subsidies are given. Where there are no government subsidies, policies should encourage carriers to avoid duplications through appropriate access regimes.
4. A requirement to support inter-carrier roaming on any mobile infrastructure funded by government.

The Commonwealth Government initiated the Regional Telecommunications Review (Glasson, 2008), which addressed deficiencies in regional telecommunications. It was tabled in September 2008 and the government recently announced its response involving an additional $60 million investment in regional communications. The government deferred decisions in relation to broadband pending the announcements in relation to the NBN.

Should regional areas now expect standards comparable with those of the city when they always seem to have lagged by a considerable margin?

It is probably not reasonable to expect that it will be feasible to deliver services at the upper extremes of what is provided in urban areas or at the same cost, nevertheless it should be possible to provide them affordably and with sufficient capability that regional Australia can experience the same type of services as is experienced by urban dwellers. It may take some time to achieve this outcome, but opportunities for investment should be used efficiently by avoiding duplication and implementing access regimes that promote competition and deliver improved services.

The technologies are available to deliver the services required across regional Australia using optical fibre (including especially passive optical networks), wireless broadband (including 3G cellular mobile with high speed packet access and WiMax, which was the technology proposed for the now abandoned OPEL project) and satellite systems (eg. IPStar and Optus). The challenge is to create a commercial environment and network access regime that allows the services to be provided as required universally. The ability for carriers to access a competitor's infrastructure (on reasonable commercial terms) has probably been the greatest inhibitor to the take up of broadband and other services throughout Australia, and in particular regional Australia, where competition exists only in limited locations. To overcome this issue, the NBN is planned to be a wholesale open access network.

Opportunities to leverage other infrastructure investments (such as the provision of telecommunications to the hoped for SKA radio telescope facility in WA) will gradually provide infrastructure that can be used to deliver high capacity broadband to currently underserved locations.

The long-term objective should be to deliver fibre optics as close to all premises as possible because fibre does have the capability to deliver the greatest bandwidth to every premise. Wireless broadband is a very effective means of delivering the first mile access from the fibre into premises, especially in less populated areas where the cost of provisioning optical fibre per premise is relatively high. Wireless broadband typically provides a lower bandwidth (up to 100 Mbps is being planned) compared to optical fibre (passive optical networks are being deployed with 10 Gbps) in each case typically shared among multiple users. Clearly optical fibre can deliver several orders of magnitude higher capacity if required, and although multiple broadband wireless systems can overlay to deliver greater capacity, this can become costly in providing a uniform service over a wide coverage area. Furthermore, broadband wireless systems typically require optical fibre to deliver the backhaul to the base stations. Such optical fibre systems could be placed to deliver improved services to premises which they pass.

7 ENGINEERING ISSUES

Construction and capital cost represents the single biggest barrier to providing services, particularly in thinly populated areas where the potential revenues for recovery are much lower. There are also maintenance costs to consider, which can be significant for considerable distances of optical fibre. Reliability is an important feature of any telecommunications service and can be designed into networks by using redundant architectures that do not need to add significantly to overall costs.

Wireless broadband is more readily rolled out for the first mile and is generally lower cost per premise served compared to fibre, especially in areas where the user density is much lower; although new and innovative techniques for constructing fibre

networks underground and overhead are being used to more efficiently deliver optical fibre services. Lower density of users reduces the level of contention in shared use wireless broadband, and therefore wireless broadband provides a more enduring solution for regional and rural areas. Wireless broadband does nevertheless require fibre cable systems for backhaul connection to the networks.

Telecommunications infrastructure is often invisible in an engineering context, in part necessary for physical security reasons and also for visibility reasons. More tangible infrastructure such as roads, bridges and railways, water, electricity, gas, etc., are recognised as engineering challenges, not often the silent infrastructure of ICT/telecommunications. Apart from the need for innovation in implementing telecommunications systems, specific engineering challenges need to be considered especially in remote and regional areas:

- selection of the technology and architectures, including attention to reliability, scalability and maintainability, to meet current and future needs
- power supply, necessitating attention to reducing overall power budgets, which must include the ability to keep remote sites running for periods in excess of 4 hours following the loss of primary power (which may include local renewable energy sources)
- equipment enclosures, including passive cooling where electrical power resources are costly, and appropriate enclosure ratings (protecting against vermin, dust, etc.)
- planning approvals and access provisions (for construction and subsequent maintenance)
- physical and electronic security
- access provision for service delivery in the first mile.

8 CONCLUSIONS

Broadband will provide new highways for commerce and other services in regional Australia. Regional Australia will become increasingly dependent on broadband and its availability will stem the need for people to migrate to the capital cities. Indeed the availability of broadband may encourage urban dwellers to seek the sea change while not being cut from many of the services available in capital cities.

To most people in regional Australia, 100 Mbps is possible at prices comparable with those in capital cities in the foreseeable future. Unfortunately such capabilities will not be available to all at those comparable prices, nevertheless lower speeds, much greater than those available today, will be available at prices well within affordability.

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Peter Hitchiner has over 30 years of experience in the telecommunications industry, including roles as Director and State Manager for six years with a leading telecommunications consulting business and as General Manager for four years with a telecommunications project management business.

During much of his career Peter has been engaged in infrastructure engineering (including radio, satellite and optical fibre systems) in both strategic and tactical roles. He has consulted extensively to Commonwealth and state governments, including on mobile/wireless and cellular radio matters. Peter has particular skills in strategic and business planning of public carrier and private telecommunications systems, including project funding, project and contract management, and communications networks planning and design.

Peter's recent experience includes planning of a major fibre optic infrastructure investment in Australia; commercialisation of research for Smart Internet Technology Cooperative Research Centre and commercial support in the formation of Smart Services CRC for research, and its commercialisation, in electronic services for the finance, government and media sectors; and implementing a new procurement model for telecommunications services for a state government to provide a more competitive environment (including legal and technical issues).

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