Big Pipes:

Connecting Western Australia

to the Global Knowledge Economy

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Western Australian
Information and Communications
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Western Australian Information and Communications Technology Industry Development Forum

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iVEC

Big Pipes: Connecting Western Australia to the Global Knowledge Economy

April 2006

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> *"Jobs, knowledge use and economic growth will gravitate to those societies that are the most connected, with the most networks and the broadest amount of bandwidth – because these countries find it easiest to amass, deploy and share knowledge in order to design, invent, manufacture, sell, provide services, communicate, educate and entertain. Connectivity is now productivity."*
>
> T. Friedman, *The Lexus and the Olive Tree*

Foreword

Technological change has always been a key driver of economic growth and development.

It has been widely argued in recent years that broadband connectivity will be a key driver of Gross Domestic Product (GDP), jobs and wages growth. Today, it is increasingly understood that broadband technologies will be the roads and railways of the 21st century, generating the next wave of economic expansion and paving the way for productivity gains across global economies in the new century.

This study is a reflection of the globally distributed and highly dynamic value chains that determine the net flow of real jobs and capital within the Knowledge Economy.

Western Australia is fortunate to be in a time zone that is capturing most of the world's growth in productivity and is steadily moving up that value chain. We also have an ability to invest in this future, with prospects of being the first part of this time zone to have free-trade agreements with both the US and China.

This report clearly identifies a role for Western Australia as Australia's "front door" to Asia, with the leading-edge information and communications technologies that are already planned for "Big Science" within the State, able to underpin this potential expansion of our economy.

However, significant advances in "Big Science" and "Big Business" are contingent on network capacity that can support the demands of both and connectivity to the global networks that define the trade routes of the Knowledge Economy that are aligned with the opportunities presented by our time zone and our trade agreements.

This report demonstrates that current infrastructure and governance structures are unlikely to meet planned demand for "Big Science" let alone the increasing demand of "Big Business" which makes a compelling case for improving the network position of Australia. Our competitiveness within the Global Knowledge Economy may well depend upon our decisions to invest in new capacity out of Western Australia into East Asia.

The Steering Committee requests that this report be read in the context of connectivity between Western Australia's key industry sectors and between Western Australia and the Eastern States and international destinations.

I would like to thank the members of the Steering Committee for their commitment to this project. In addition, I would like to express my appreciation to Gibson Quai - AAS, in particular Mr Cliff Gibson, Project Director, and also to Mr John de Ridder, Mr John Hibbard and Professor John Houghton for the provision of consultancy services to develop the report and for their patience during this process.

Mal Bryce AO, BA, Hon PhD.
Chairman
WA ICT Industry Development Forum

Glossary

AARNet	Australian Academic Research Network (http://www.aarnet.edu.au/)
ABS	Australian Bureau of Statistics (http://www.abs.gov.au/)
ACA	Australian Communications Authority (now ACMA) (http://www.acma.gov.au/)
ACCC	Australian Competition and Consumer Commission (http://www.accc.gov.au/)
ACcESS	The Australian Computational Earth Systems Simulator
ADSL	Asymmetric Digital Subscriber Line
AJC	Australia-Japan Cable (http://www.ajcable.com/)
ANGIS	Australian National Genomic Information Service (http://www.angis.org.au)
ANU	The Australian National University (http://www.anu.edu.au/)
ANZSIC	Australia and New Zealand Standard Industry Classifications
APAC	Australian Partnership for Advanced Computing (http://www.apac.edu.au/)
APCN	Asia Pacific Cable Network (ex Indonesia to Singapore)
APEC	Asia Pacific Economic Community
APEC TEL	Asia Pacific Economic Community Telecommunications Working Group
ARRC	The Australian Resources Research Centre (http://www.arrc.net.au/)
ATM	Asynchronous Transfer Mode
b	bit; binary digit
bit/s	bits per second
Broadband	The speed of a non dial-up connection; which varies over time and by country
byte	8 bits
CANARIE	Canadian Network for the Advancement of Research, Industry and Education (http://www.canarie.ca/)
CBBC	Centre for Bioinformatics and Biological Computing (at Murdoch University) (http://cbbc.murdoch.edu.au/)
CBD	Central Business District
CERN	Centre for European Nuclear Research (French acronym) (http://public.web.cern.ch/)
CRC	Cooperative Research Centre

CSIRO	Commonwealth Scientific and Industrial Research Organisation (http://www.csiro.au/)
Cyberinfrastructure	A term describing the infrastructure supporting e-research
DCITA	Department of Communications, Information Technology and the Arts (http://www.dcita.gov.au/)
DDD	Dynamic Digital Depth (http://www.ddd.com)
DoIR	Department of Industry and Resources (http://www.doir.wa.gov.au/)
DSL	Digital Subscriber Line (of which ADSL is the main type)
DSLAM	Digital Subscriber Loop Access Multiplexer (used to aggregate customer lines acquired with unbundled local loop services at an exchange)
DWDM	Dense Wave Division Multiplexing
Exabyte	10^{18} bytes
EXPReS	A project to connect at least 16 radio telescopes globally
FDI	Foreign Direct Investment
FOC	Free of Charge
FTA	Free Trade Agreement (e.g. with the USA and soon, China)
FTP	File Transfer Protocol
Gbit/s	Gigabits per second (1,000 Mbit/s)
GLIF	Global Lambda Infrastructure Facility is an international virtual organisation that supports data-intensive scientific research and middleware development on LambdaGrids across the globe. (http://www.glif.is/)
GPT	General Purpose Technology
HFC	Hybrid Fibre Coaxial
HiBIS	Higher Bandwidth Incentive Scheme (replaced with Connect Australia)
HPC	High Performance Computer
ICT	Information and Communications Technology
IP	Internet Protocol
IPTV	IP Television (delivered over broadband ADSL services)
IRU	Indefeasible Right of Use (long term capacity)
ISP	Internet Service Provider
iVEC	The hub of advanced computing in Western Australia (http://www.ivec.org)
KE	Knowledge Economy

kbit/s	Kilobits (or thousand bits) per second
Latency	Response time (under 120 ms needed for interactive sessions like voice)
LHC	Large Hadron Collider (at CERN)
LOFAR	Low Frequency Array Telescope (in the Netherlands) (http://www.lofar.org/)
Mbit/s	Megabits (or million bits) per second (pipe capacity)
MB	Megabyte (measure of volume delivered)
MIU	Minimum Unit Investment
MOU	Memorandum of Understanding
MPEG	Motion Picture Expert Group video compression standards (e.g. mp3)
ms	Milliseconds (used to measure latency)
NCSA	National Centre for Supercomputing Applications (http://www.ncsa.uiuc.edu/)
NREN	National Research and Education Network (an international group) (http://www.nren.nasa.gov/)
NSF	National Science Foundation (USA) (http://www.nsf.gov/)
NSFNET	The original academic US Internet backbone network
O&M	Operations and Maintenance
OECD	Organisation for Economic Cooperation and Development
OPAL	Open Pool Australian Light Water (nuclear) reactor in Sydney (Lucas Heights)
PACI	Partnerships for Advanced Computational Infrastructure (http://www.paci.org/)
PAIX	Palo Alto Internet Exchange
PAS	PanAmSat
PCCW	Pacific Century Cyber Works (joint owner of Reach with Telstra)
Petabyte	10^{15} bytes
PIXe	PIXe is a software algorithm developed by Blaze in Western Australia to compress video files (http://www.blazelimited.com)
PMG	Post Master General's Department, out of which came Telecom (now Telstra)
PoA	Price on Application
PoP	Point of Presence
PSTN	Public Switched Telephone Network

QoS	Quality of Service
R&D	Research and Development
Reach	Wholesaler of international capacity (owned by PCCW and Telstra)
RFT	Request for Tender
SCCN	Southern Cross Cable Network
SIAC	Singapore-Indonesia-Australia-Cable (proposal only)
SKA	The Square Kilometre Array; a proposed international telescope to be centred in Western Australia (not to be confused with "Sender Keeps All") (http://www.skatelescope.org/)
SLA	Service Level Agreement
SME	Small to Medium Enterprise
SMH	Sydney Morning Herald
SOC	Systems on Chip
Sohonet	A network supporting film and media providers (http://www.sohonet.co.uk/)
SONET	Synchronous Optical Network
SMW3	SEA-ME-WE3 (South East Asia–Middle East–Western Europe)
STM	Synchronous Transport Module
STM1	155 Mbit/s
STM4	4 x STM1 (622 Mbit/s)
STM64	64 x STM1 (often called 10Gbit/s since it is so close to this number)
TATA	India's largest IT consulting company (part owner of VSNL)
T3	The third and final tranche in the privatisation of Telstra
TCP/IP	Transmission Control Protocol/Internet Protocol
Tbit/s	One thousand Gbit/s (measure of data transmission (pipe) capacity)
TEIN2	Trans-Eurasia Information Network; a collaborative venture to provide research bandwidth from Asia to Europe
Terabyte	One TB is 1M Megabytes (measure of volume delivered)
Teraflop	One TFlop/s is a trillion calculations per second (www.top500.org)
TIAC	Western Australian Technology & Industry Advisory Council (http://www.wa.gov.au/tiac/)
TGN	Tyco Global Networks (acquired in 2004 by VSNL)
UCLP	User Controlled Light Path; a hybrid optical/packet infrastructure protocol

UNCTAD	United Nations Commission for Trade and Development
VoIP	Voice over Internet Protocol
VLBI	Very Long Base-line Interferometry; the signal to noise ratio and resolution of radio telescope data are improved by combining the data from different telescopes via high-speed networks
VPN	Virtual Private Network
VSNL	Indian global carrier (part-owned by TATA)
VSLI	Very Large Scale Integrated circuits
WAGER	The Western Australia Genetic Epidemiology Resource database (http://www.genepi.com.au/wager)
WAIX	The West Australian Internet Exchange (http://www.waia.asn.au)
xDSL	Generic acronym for digital subscriber line systems
xNTD	The Extended New Technology Demonstrator

Key Findings

This report was sponsored by the Western Australian ICT Industry Development Forum, the Office of Science and Innovation (OSI), the hub of advanced computing in Western Australia, iVEC, and the Department of Industry and Resources (DoIR) to recommend policies and development options for Western Australia's international communications infrastructure.

Most recent policy focus in Australia has been concerned with local access to broadband infrastructure ("Small Pipes"). This has been important, since the local loop remains the main bottleneck. However, this is changing as the broad-banding of local access accelerates. Currently, local access speeds of 1.5 Mbit/s or more are considered good. Soon, "true broadband" with speeds of 10 Mbit/s or more will become the new standard, as it has in other countries. With improvements in local loop infrastructure, attention is shifting to the other parts of the knowledge economy infrastructure.

The current report is specifically concerned with the capability of Western Australia's international communications infrastructure to support a knowledge economy. Our focus on "Big Pipes" reflects the emerging needs of "Big Science", which is now a global activity, and the need for affordable international connections in a global knowledge economy. "Big Science" will inevitably involve "Big Business".

We find that Western Australia is not well served in terms of its international communications links. Western Australia is Australia's "front-door" to the fast growing economies of Asia and yet most Australians communicate with Asia by the "back-door"; via the USA and/or Japan. Worse still, the direct links to Asia from Western Australia are expensive to commercial users and researchers cannot get the same bandwidth as they can on the East Coast.

With demand for international capacity increasing considerably over the last 18 months, and the development of applications requiring low latency and greater interactive collaboration between Australia and Asia, the time is ripe for the development of a new cable system out of Western Australia.

Recent attempts to remedy poor Western Australian international connectivity have failed, and current proposals may suffer a similar fate without government support. This is due to the cost of a new submarine cable being relatively high (around USD100 million), the currently "thin" demand on international routes out of Western Australia and the "supply overhang" that exists. The various "externalities" that apply to the provision of international capacity off Western Australia justify public intervention due to the presence of market failure in the provision of international capacity which is inhibiting the State's economic development.

If there is not immediate prospect of new capacity (two cables have been announced but are not certain), the State Government must expedite its provision to secure Western Australia's position in the global knowledge economy.

Chapter 1

There are powerful forces for globalisation which are being enabled by the Internet and improved global communications. Big Pipes go both ways. There is a risk of weaker peripheral regions in the global economy being "hollowed out"; a risk earlier TIAC reports have discussed. But, no economy can or should insulate itself from the rest of the world.

Despite the risks, Western Australia must "play on or be preyed on".

- The risks of marginalisation and being pushed down the global value chain are reduced by developing and enhancing a region's competitive strengths. Through the various TIAC reports, these have been identified as engineering, biotechnology, education, health and technical services. These sectors can provide a platform for successful participation in this new form of global services production. Importantly, they are areas with particular dependence upon information and communications infrastructure.
- Another advantage that Western Australia has is its geo-political position at a time when the balance of economic strength is shifting to Asia. China and India are leading the pack in terms of growth and opportunity and the communications gateway to these markets is Singapore; which also means Western Australia will become more important to all Australians.

Western Australia must leverage its position as the "front door to Asia".

- The "main artery" of Western Australia's globalising knowledge economy is international communications links. Communications infrastructure is to the knowledge economy what roads and rail were to the industrial economy. It is prone to some of the same "externalities" that can lead to sub-optimal investment in road and rail without public intervention.

Given Western Australia's isolation and its desire to develop its knowledge economy, the State Government needs to support investment in international links.

Given the State Government's Cabinet Decision of December 2004 to develop Western Australia's knowledge economy, "Big Pipes" and other parts of the knowledge economy infrastructure should be supported.

- While the communications infrastructure is probably the most important, there are other "building blocks" which make up the "Cyberinfrastructure" supporting a knowledge economy. Many of these can be enhanced with government policy and support. Western Australia already has a good track record in attracting key talent to the State. Current thinking is that regions with "technology, talent and tolerance" will prosper in the global knowledge economy.

Chapter 2

This chapter finds a lack of affordable capacity off the West Coast of Australia.

The lack of affordable connectivity is due to the lack of effective competition.

- The problem is not physical scarcity; the principal cable off the West Coast, SEA-ME-WE3 has so much spare capacity and could be easily expanded further. The alternative cable, Jasuraus, although much smaller, could also be expanded.
- The complexity and difficulties associated with the multiple owners and the half-circuit capacity regime make it difficult to access this "spare" capacity. Consequently, the two cables do not exert the same competitive pressure on price that can be observed between the rival cables on the East Coast.

Regulated prices are a poor substitute for real price competition

- Another possible response to a lack of competition which has been exercised with respect to domestic transmission facilities is "declaration", which provides the ACCC with the power to arbitrate prices. But, regulated prices would be counter-productive as they will "chill" investment in international capacity. Investment will be needed.

- Once adequate connectivity is established to Singapore, then onward connection to China, India, Europe, Africa, other Asian destinations and North America is readily possible.

Chapter 3

Chapter 3 shows that "Big Science" alone, will stretch the limits of what can be provided with existing international capacity. Taking into consideration the future needs and demand of industry; "Big Business" will almost certainly ensure that requirements will exceed bandwidth.

Greater efforts must be made to include Perth in the upgrade of the network backbone that underpins the APAC National Grid.

- The science community in Western Australia is generally well served by AARNet. However, AARNet cannot afford to re-equip the long Adelaide-Perth circuits to carry multiple wavelengths at this time. South Australia provided a grant to make the enhanced APAC Grid available to its own researchers. Until the Western Australian Government provides a similar grant, researchers in Western Australia will not have the same bandwidth as those in South Australia and the eastern states for moving around very large amounts of data. This may constrain access to the new OPAL and synchrotron facilities on the other side of Australia (see Section 1.2.2) that Western Australians will need to use.
- Such an upgrade works both ways. Researchers on the other side of Australia and the other side of the Pacific Ocean will need to access the new radio telescopes (xNTD and possibly the SKA) planned for Western Australia.

Telescope communications infrastructure should factor-in regional development.

- If Australia is fortunate enough to be chosen in 2006 as the site for the SKA telescope, there may be the possibility of using the infrastructure linking SKA sites to provide improved access to business and people in remote areas. Most of the SKA sites are in Western Australia.
- Even without the SKA, the xNTD telescope (which is proceeding) will provide significant opportunities. The "correlator" will compare data across 20 antennae (190 correlations) and the resulting product will need global connectivity of 1Gbit/s allowing for bursts up to 10Gbit/s. This represents a significant level of demand for global connectivity out of Western Australia.

Business needs more affordable international connectivity.

- Business can require large volumes of data to be shifted over communications links. But, the main requirement for business is for more affordable international connectivity. Demand is artificially constrained, despite the abundance of physical capacity, because of current retail pricing models that do not cater for the short, bursty requirements of some customers.

Chapter 4

"Small Pipes" feed the demand for "Big Pipes".

- The demand for international connectivity is accelerating. The weakest link in the Internet delivery chain has been the local loop. Broadband local access loop connections have doubled in a year and will keep increasing as customers migrate from dial-up services. The "Small Pipes" (local connectivity) are getting bigger not only because of the migration to broadband from dial-up but also because of the increasing bandwidth available on broadband connections.

Wild cards may bring their own funding to help augment international capacity.

- While there is adequate near term international capacity out of Western Australia, either via the Indian Ocean or across Australia to the Pacific Ocean cables, there are significant drivers increasing the demand for international capacity even before "wild cards" such as the needs of radio telescopes and defense are taken into account. Major users like Defence have a direct interest in improved international connectivity.

International communications links on the West Coast need to be strengthened.

- Australia is too reliant on the East Coast which accounts for 90 per cent of Australian international capacity. Historically, the development of international connectivity has reflected the status of the US as the centre of economic gravity and the Internet. But, this is changing with, particularly, China and India emerging as super powers in their own right. Australia has strong business and research links with countries to our north. For connection to Japan and the USA, the East Coast routing can be superior both on price and performance. However for South East Asia and Europe, direct access from WesternAustralia offers better performance.
- Another important argument for improved West Coast connectivity is security. Perth as Australia's second international gateway can provide route diversity for all Australian traffic.

While upgrades to existing cables to service near-term needs are quite possible, the commercial arrangements surrounding Western Australian cables and the motives of the owners both create significant obstacles to achieving upgrades (and improved pricing). Consequently, there are initiatives periodically announced to implement a new cable to overcome these commercial handicaps. Currently, two cables are mooted (SIAC and Ochre). It is hoped that they will fare better than earlier planned cables (i.e. NAVA and A2A), which did not proceed.

Chapter 5

At first sight, there may not appear to be a capacity problem. The West Coast cables are under-utilised and can easily be expanded. However, while it would be cheaper to upgrade SMW3 than build a new cable (USD20 million versus USD100 million), it does not solve the problem of the lack of effective competition, which results in the current high prices (relative to the East Coast). A new cable would certainly have a capacity extension capability several orders of magnitude greater than the upgrade option, and consequently a much greater lifetime.

There is clearly a case for a new cable out of Western Australia.

- This case is based on continuing rapid growth in demand, the need for effective competition in West Coast international capacity, the shift in the balance of power in the global economy to Asia and national security. For these reasons, a new cable is important, not only to Western Australia, but also to the whole of Australia.

The State Government needs to support new cable investment.

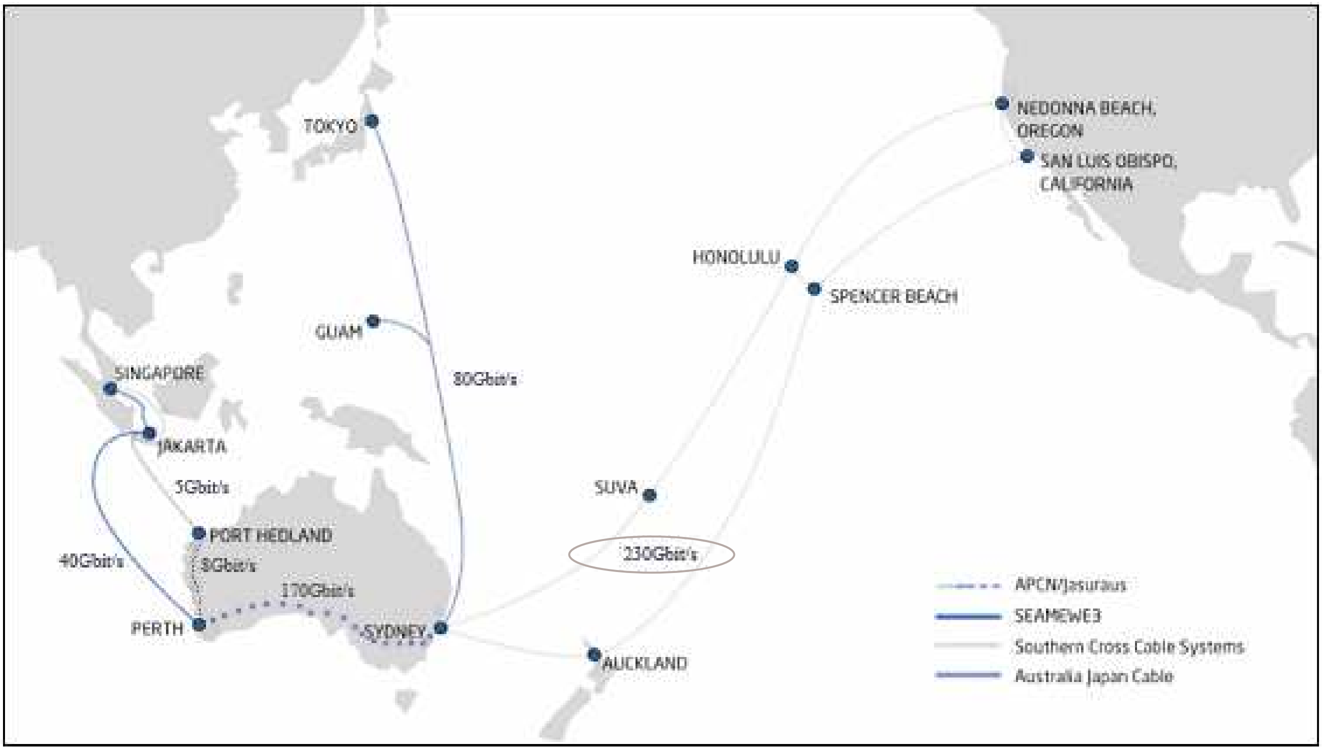
- International communications infrastructure is no longer supplied exclusively by publicly owned carriers in Australia. So, other ways have to be found to overcome the "externalities" that lead to sub-optimal investment in the global communications infrastructure. Four possible options are identified: leveraging the State's own purchasing power; finding "anchor tenants"; providing capital grants (subject to cost-benefit analysis and competitive tender); and developing new financial instruments to reduce risk and uncertainty.

The State Government needs to stimulate the utilisation of databases with the intention of maximising both commercial and social returns to the community.

- The government, by the nature of its business, collects and stores data that has high commercial value and high social value coupled with community ownership. Promoting open access to databases would be a desirable policy objective in a knowledge economy. It provides a way to encourage greater use of data collections. Exploitation of such data by both public and private sectors can not only maximise the return on public investment in R&D, but also creates new industries and high value employment
- Issues such as privacy and intellectual property will clearly require evaluation (e.g. in the aggregation of particular data sets). The State Government needs to identify, audit and review across government its intellectual property policies, existing data collections and access provisions with the intention of maximising both commercial and social returns to the community.

New value-based pricing for IP networks needs to be developed.

- The carriers and service providers must develop more innovative pricing structures that deliver more affordable bandwidth at the same time as increasing industry revenues. Layer-based pricing is suggested as a workable solution to pricing along the demand curve. It may provide a more sustainable basis for value-based pricing in an all-IP network.



Australia's Connectivity (see Chapter 2, Figure 2.5)

Conclusion

The poor global connectivity off Western Australia affects not just Western Australians but all Australians. Unable to compete with some countries on labour costs, and remote from major markets, Australia faces the challenge to find new ways to participate in global production systems and global markets from a geographically remote location. Its international communications infrastructure will be an essential ingredient, without which the challenge may prove insurmountable.

The rising importance of the China and India export markets and the proximity of the Singapore Hub emphasises the importance of Western Australia as a "Big Pipe" exit point for Australia.

Barriers to Western Australia's connectivity are essentially a lack of affordable international connections due to a lack of competition in the existing Western Australian exiting "Big Pipes".

Recommendations

This report has established that "Big Pipes" for international connectivity are a critical building block in the Cyberinfrastructure for all Australians; not just those in Western Australia.

It has also demonstrated that the Western Australian Government, due to lack of a competitive environment, needs to actively facilitate the development of this infrastructure not only because it is committed to the establishment of a knowledge economy in Western Australia, but also because there are "externalities" which will lead to sub-optimal investment in cable capacity in the absence of government leadership.

The recommended "action steps" for the State Government are to leverage both Commonwealth Government programs and private sector investment by developing a plan for improving:

Recommendation 1: Western Australia's International Connectivity

The Western Australian Government should test the viability of available options by issuing a "Request for Proposal" (RFP) to the marketplace. This RFP should canvas a broad range of possible solutions including private sector investment in return for guaranteed capacity (new cable or upgrade of existing infrastructure).

Recommendation 2: Western Australia's National Capacity

The Western Australian Government should consider capitalising on Commonwealth Government programs or making a capital grant (as has been the case in South Australia) to extend the AARNET3 optical network to Western Australia in order to fully support the APAC grid, the xNTD and other known and future "Big Science" projects.

Adopting this plan of action will help secure Western Australia's position in the global knowledge economy.

1 The Knowledge Economy and Western Australia

Cabinet endorsed the co-ordinated development of a Western Australian knowledge economy in December 2004 and the concept of the knowledge economy (KE) is familiar through the reports TIAC commissioned to support the State's economic development starting with "Mines to Minds" in 1999. The six reports between 1999 and 2002 developed the policy for Western Australia's move towards a knowledge economy.[1] Since then, the focus of the reports has shifted to enabling the creation of a knowledge infrastructure.[2] In this report, we position Western Australia's transition towards a knowledge economy in the context of globalisation. And, we explain the roles of international connectivity and the other parts of the "Cyberinfrastructure" (see Box 1.1) that support the knowledge economy.

Cyberinfrastructure

The term "Cyberinfrastructure" was coined by a National Science Foundation (NSF) blue-ribbon (Atkins) committee to describe the new research environments in which advanced computational, collaborative, data acquisition and management services are available to researchers through high-performance networks. The term is now widely used to embrace a range of e-research environments that are emerging from the changing and innovative practices – often called "e-science" or "e-research" – of scientists and scholars in all disciplines. Cyberinfrastructure is more than just hardware and software, more than bigger computer boxes and wider network wires. It is also a set of supporting services made available to researchers by their home institutions as well as through federations of institutions and national and international disciplinary programs.

Box 1.1: Cyberinfrastructure

Source: Association of Research Libraries (http://www.arl.org/forum04/)

1.1 The Global Knowledge Economy

The Global Knowledge Economy is emerging from two defining forces: the rise in *knowledge intensity* of economic activities, and the increasing *globalisation* of economic affairs.[3] The rise in knowledge intensity is being driven by the combined forces of the information technology revolution and the increasing pace of technological change, while globalisation is being driven by national and international deregulation and by the IT-related communications revolution.

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[1] *From Mines to Minds: Western Australia in the Global Information Economy* (February 1999), *Western Australia's Minerals and Energy Expertise: How can it be optimised? – Growing the R&D Sector* (June 1999), *Drivers and Shapers of Economic Development in Western Australia in the 2st[t] Century* (September 2000), *Export of WA Education and Training: Constraints and Opportunities* (October 2000), *Biotechnology West: Strengths and Weaknesses and Opportunities* (December 2000) and *Directions for Industry Policy in Western Australia within the Global Knowledge Economy: Sustainable Prosperity through Global Integration* (March 2002).

[2] *The Organisation of Knowledge: Optimising the Role of Universities in a Western Australian Knowledge Hub* (June 2002), *Creating Western Australia's Knowledge Infrastructure: Towards Global Competitiveness and High-Value Employment* (June 2003), *Enabling a Connected Community: Developing Broadband Infrastructure and Services in Metropolitan Western Australia* (September 2003), *Initiating and Supporting Major Economic Infrastructure for State Development: Defining the Issues* (May 2004), *Initiating and Supporting Major Economic Infrastructure for State Development: Opportunities for Government* (September 2004), *Trade in Western Australian Health Industry Services Directions for Development* (November 2004) and *Enabling Growth: The Contribution of ICT to the Western Australian Economy* (February 2006).

[3] This section draws on and updates Houghton, J.W. (2002), *The Global Knowledge Economy*, a supporting paper for TIAC (2002), *Directions for Industry Policy in Western Australia Within the Global Knowledge Economy*. Available http://www.wa.gov.au/tiac/ See also Houghton, J.W. and Sheehan, P.J. (2000) *A Primer on the Knowledge Economy*, Centre for Strategic Economic studies, Melbourne; and Sheehan, P.J. and Tegart, G. Eds. (1998) *Working for the Future: Technology and Employment in the Global Knowledge Economy*, Victoria University Press.

The last twenty years have seen an explosion in the application of computing and communications technologies in all areas of business and community life. This has been driven by sharp falls in the cost of computing and communications per unit of performance, and by the rapid development of applications relevant to the needs of users. Digitalisation, open systems standards, and the development software and supporting technologies for the application of new computing and communications systems, are now helping users realise the potential of the ICT revolution.

In economic terms, a central feature of the ICT revolution is the ability to manipulate, store and transmit large quantities of information at very low cost. An equally important feature of these technologies is their pervasiveness. While earlier episodes of technical change have centred on particular products or industrial sectors, information technology is generic (a "general purpose technology"). It impacts on every element of the economy, on both goods and services; and on every element of business, from research and development to production, marketing and distribution.

Emphasising the importance of the information and communications infrastructure, the knowledge economy has been defined as:

> *"…one in which the generation and exploitation of knowledge has come to play the predominant part in the creation of wealth. It is not simply about pushing back the frontiers of knowledge; it is also about the more effective use and exploitation of all types of knowledge in all manner of economic activities."*[4]

In a knowledge economy, the capacity of the innovation system to create and disseminate the latest scientific and technical information is an important determinant of national prosperity.[5]

The other main driver of the emerging knowledge economy is the rapid globalisation of economic activities. The global communications revolution has been accompanied by a widespread movement to economic deregulation, including:

- the reduction of tariff and non-tariff barriers on trade in both goods and services. The globalisation of trade in goods and services has opened up new and increasingly large markets;
- the floating of currencies and deregulation of financial markets more generally. The globalisation of financial markets has triggered sharp growth in investment portfolios and large movements of short-term capital, with borrowers and investors interacting through an increasingly-unified market;
- the reduction of barriers to foreign direct investment and other international capital flows. The globalisation of corporations and industries (see Box 1.2) was led by sharp increases in foreign direct investment and relocation of enterprises, driven by joint ventures, cooperation agreements, strategic alliances, and mergers and acquisitions;
- the reduction of barriers to technology transfers. The globalisation of technology stems from the speed with which innovations are propagated, with international networks linking to public and private research centres, as well as from converging standards; and
- the deregulation of product markets in many countries, particularly in terms of the reduction in the power of national monopolies in areas such as telecommunications, air transport and the finance and insurance industries. The globalisation of competition heralds the emergence of new strategic considerations for enterprises.

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4 Department of Trade and Industry (1998) *Building the Knowledge Driven Economy: Competitiveness White Paper*, Department of Trade and Industry, London. :http:/www.dti.gov.uk/comp/

5 OECD (1996) *The Knowledge-Based Economy*, OECD, Paris, p16.

Together, these changes have led to the fragmentation of production processes, with different stages of production carried out in different countries.[6]

Measures of Globalisation

On any measure, the world economy is highly globalised. In 2004, there were an estimated 69,727 multinational enterprises (MNEs) with some 690,391 foreign affiliates employing around 57 million people worldwide. At almost USD19 trillion, affiliate sales were worth twice as much as world trade. Worldwide, foreign direct investment (FDI) inflows amounted to USD 648 billion and accounted for more than 7% of global gross fixed capital formation.

Box 1.2: Measures of Globalisation

Source: UNCTAD's World Investment Report 2005

The keys to participation in the emerging global knowledge economy are affordable access to the necessary information and communications infrastructure, and the ability to develop the workforce, managerial and organisational competencies required to support participation in highly fragmented global production systems.

1.2 The Cyberinfrastructure for the Knowledge Economy

The knowledge economy depends upon the high-bandwidth communications networks, data collection equipment, distributed and high performance computing, and large data repositories and warehouses that provide the capacity to collect, store, collate, process and communicate information. These all form part of the Cyberinfrastructure which is one of the elements that supports the knowledge economy. Application of the "Big Pipes" building block in this infrastructure to science and commerce is the topic of Chapter 3.

1.2.1 Communications as Key Infrastructure

Roads, ports, airports and railways provide the basic infrastructure for the movement of goods and people. Communications infrastructure (local loop, switches and the inter-exchange transmission networks) underpins the knowledge economy. If the transport infrastructure fails, factories stop and shelves empty. Similarly, if the communications infrastructure fails, banks will close their doors, services fail and airports, docks and distribution centres grind to a halt. Even if neither of these infrastructures "fails", any country with an inferior infrastructure will be put at a competitive disadvantage, with higher costs and lost opportunities to collaborate and compete.

Infrastructure is often provided as a public service when one or more of the following conditions apply:

- It is a "public good" (i.e. it is not possible either to charge or exclude some users);
- There are "externalities" (see Box 1.3);
- It is a "natural monopoly" (i.e. one provider is the most efficient industry structure); or
- It is too big or risky for private enterprise to undertake.

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6 OECD (2005) OECD *Handbook on Economic Globalisation Indicators*, OECD, Paris.

The communications infrastructure exhibits some elements of all of these conditions, and was, until relatively recently, typically provided by publicly owned national monopoly carriers.[7] Deregulation and privatisation have created new challenges and new patterns of infrastructure investment, which are still evolving.

Externalities

Communications carriers in Australia are expected to make a profit (with the exception of AARNet). They need only look at their "bottom line" in their profit statements. However, the actions of private enterprises may generate benefits (and costs) that do not appear in their "bottom line". The State (or Federal) Government has a duty of care beyond any one company's profit statement. It needs to be aware of the "externalities" not captured in private books. For example, "Big Pipes" will generate benefits not just to their users but also to their suppliers. To the extent that the carriers do not anticipate or cannot appropriate enough of these benefits to justify building "Big Pipes", such building will not occur.

One way to close the gap between private and public benefits is to provide a subsidy to the carrier. For some projects, which Telstra terms "enterprise projects", a capital grant will make an investment in infrastructure possible. An example of this is enhanced CDMA mobile coverage on the Perth-Esperance route, which is part-funded by Federal and State Governments.

Box 1.3: Externalities

1.2.2 Other Building Blocks of the Cyberinfrastructure

Just as the Cyberinfrastructure for a knowledge economy requires high-bandwidth communications networks ("Big Pipes"), it also requires data collection equipment ("Big Dishes") distributed and high performance computing ("Big Irons"), and large data repositories and warehouses ("Big Boxes"). Together, they provide the capacity to collect, store, collate, process and communicate the rapidly expanding information base that underpins the knowledge economy. They are held together by the communications infrastructure: the "Big Pipes".

The "Big Pipes", "Big Irons" and "Big Data" metaphors were used in the major review of Cyberinfrastructure for the US National Science Foundation in 2003, which also observed:

> *"From the perspective of applications and users, the performance of the backbone network is only one element of overall performance, which is also affected by local area networks, various processing and caching bottlenecks, processing delays in middleware and operating system layers, and computer I/O bandwidths, among others".*[8]

Our view of the various "building blocks" of the knowledge economy's Cyberinfrastructure is presented in Figure 1.1. More details about the size and application of some of the building blocks in Western Australia can be found in the ICT Sector report released earlier this year.[9]

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[7] Australia considered its international communications so strategically important that it nationalised Cable and Wireless assets after WWII into the Overseas Telecommunications Corporation, which later became part of Telstra. More recently, Telstra has out-sourced its international connectivity requirements to Reach, in which it vested its overseas cable assets as a part-owner of Reach.

[8] Atkins D. "*Revolutionizing Science and Engineering Through Cyberinfrastructure*", report to the National Science Foundation from the Blue Ribbon Advisory Council on Cyberinfrastructure, January 2003.

[9] *Enabling growth: The Contribution of ICT to the Western Australia Economy* (February 2006) from the Western Australian ICT Development Forum in partnership with the Department of Education and Training. www.wa.gov.au/tiac

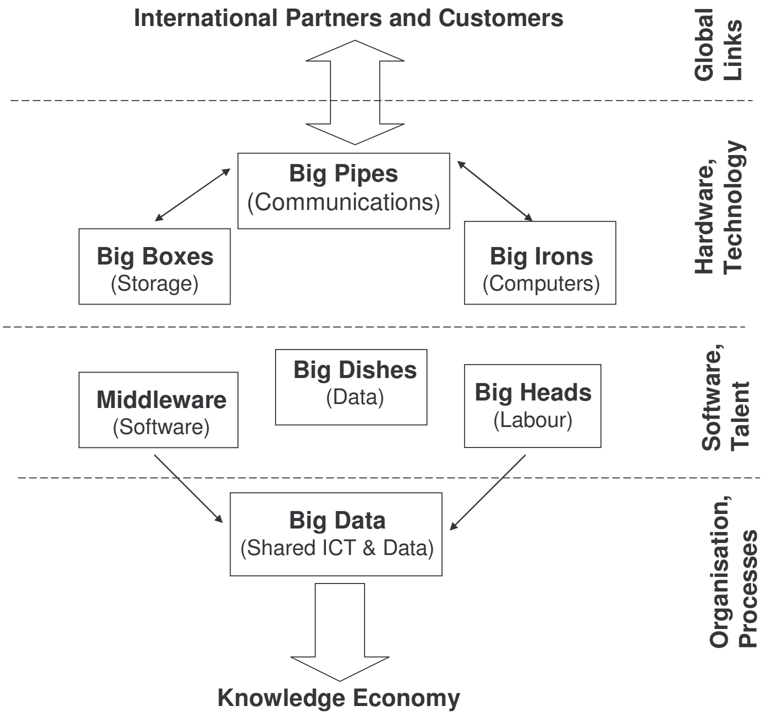

Figure 1.1: Building Blocks of the Cyberinfrastructure

Source: Gibson Quai – AAS

Big Dishes – Data Collection

Scientific, medical and commercial observation and data collection, as well as the tracking and tracing of the many millions of physical and related financial transactions that are the daily product of the knowledge economy, depend upon a wide range of data collection equipment. These include medical scanning and imaging, remote sensing and mapping, identity scanning and reading in distribution and logistics, and a wide range of financial transaction recording equipment.

The radio telescopes planned for Western Australia may be currently top of mind, but there are other important data collections held in Western Australia that are of interest overseas and advance Western Australia's credentials as a knowledge economy – such as the BioBank human genetics database, which has some unique characteristics (discussed in Chapter 3).

But, the large instruments do not have to be in Western Australia to be important to Western Australia's international connectivity. Other world-class facilities being completed in Australia include:

- The $300 million "Open Pool Australian Lightwater" (OPAL) reactor at Lucas Heights south of Sydney. This is expected to service over 1,000 scientists (including overseas scientists). It also has significant commercial uses, such as examining the microstructure of large-scale industrial products under stress (e.g. engines and gear-boxes) and the irradiation of silicon to produce high quality silicon chips.
- The $200 million synchrotron in Victoria, which will be shared with Asian countries and is set to advance the frontier of biotechnology research. It will also be useful to the minerals industry, where the instrument can be used to study ores and refining processes.

"Big Dishes" do not have to serve only "Big Science" or even be "Big" to generate enormous volumes of data that need to be distributed and analysed. Box 1.4 gives an example of how sensors on Rolls Royce aircraft engines generate "Big Data". Similar (or larger) data volumes will be generated by other high-throughput sensor experiments in fields such as environmental and earth observation, and of course, human health-care monitoring.

Rolls Royce

It is estimated that there are around 100,000 Rolls Royce aircraft engines currently in service. Each trans-Atlantic flight made by each engine generates about a Gigabyte of data per engine – from pressure, temperature and vibration sensors. The goal is to transmit a small subset of this primary data for analysis and comparison with engine data stored in three data centres around the world. By identifying the early onset of problems, Rolls Royce hope to be able to lengthen the period between scheduled maintenance episodes, thus increasing profitability. The engine sensors will generate many Petabytes of data per year worldwide, and decisions need to be taken in real-time as to how much data to analyse, how much to transmit for further analysis and how much to archive.

Box 1.4: Rolls Royce[10]

Big Irons – Computing

Processing the information requires distributed and/or high performance computers (HPC). The former depend upon networked access to the Internet, while the latter (i.e. HPC computing grids) depend upon high bandwidth access to local, national and international networks ("Big Pipes").

The Top 500 HPCs

To get into the world's top 500 HPCs (www.top500.org), a HPC must perform 1.166 trillion calculations per second (1 TFlop/s). The entry level for the top 100 is now 3.4 TFlop/s. However, 304 of the Top 500 systems are clusters of HPCs which means that while the new HPC at iVEC does not quite reach the entry-level threshold, it is meaningless to compare it with over 300 closely-linked HPCs (i.e. it is bigger than it might seem from its exclusion from the Top 500 list).

Only 5 Australian HPCs qualified for the Top500 list at June 2005 (bearing in mind the caveat above). Two of these are run by Animal Logic in Sydney (http://www.animallogic.com/home.html). The biggest of the five is the HPC at ANU (8.9 TFlop/s and No. 26 on the Top 500).

Box 1.5: The Top 500 HPCs

Western Australia now has a number of HPCs at different sites. The advanced computing centre at iVEC has just acquired a new supercomputer in a joint venture between CSIRO and three Western Australian Universities.[11] And, at the same site, ISA Technologies provides access to the best IBM, HPC and visualisation facilities in the Asia-Pacific region for both commercial and scientific purposes.

Big Boxes – Data Repositories

An obvious corollary of "Big Irons" and "Big Data" is the need for (petabyte) "Big Storage". Around 1 per cent of the cost of the SKA telescope facility (Chapter 3) is likely to be spent on storage. (This 1 per cent will equate to "tens of millions" in Australian dollars). Apart from being required on a long-term basis for archive and retrieval, storage can also play a significant short-term role in substituting for higher bandwidth. That is, the same amount of data can be transported over a longer period from storage using slower connection speeds. This "store and forward" at slow speed option is suitable for "transient" astronomical events.

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[10] Hey, Tony and Trefethen A., *The Data Deluge: An e-Science Perspective*. http://www.ecs.soton.ac.uk/~ajgh/DataDeluge(final).pdf

[11] The Age, 26 July 2005.

Until very recently, commercial databases have been the largest data collections stored electronically for archiving and analysis. Such commercial data are usually stored in relational database management systems such as Oracle, DB2 or SQLServer. Today, the largest commercial databases range from 10's of Tbytes up to 100 Tbytes. This situation will change dramatically as the volume of data in scientific data archives will vastly exceed that of commercial systems.

Middleware – Data Management

New "Middle Ware" and "metadata" (data about data) will have to be developed to manage the "Big Data" that emerges from "Big Irons" and "Big Pipes".

> *"Particle physicists are energetically assisting in building Grid middleware that will not only allow them to distribute this data amongst the 100 or so sites and 1000 or so physicists collaborating in each experiment, but also will allow them to perform sophisticated distributed analysis, computation and visualisation on all or subsets of the data. Particle physicists envisage a data/computing model with a hierarchy of data centres with associated computing resources distributed around the global collaboration."* [12]

The data access, integration and federation capabilities of the next generation of Grid middleware will play a key role for both e-science and e-business. And, there will be a need for "metadata" that annotates distributed collections of scientific data.

Big Heads – Talent and Skills

The Knowledge Economy has to attract and hold skilled workers.

> *"To be a successful knowledge-based region, regions need to have a high concentration of high skilled (scientists, engineers, etc.) designer global knowledge workers. These workers tend to migrate to regions with scale and diversity of social and community infrastructure and cultural and lifestyle choices."*[13]

The US economic development guru, Richard Florida, has influenced some state governments in Australia and talks of the three Ts – Technology, Talent and Tolerance.[14] All three are present in creative, knowledge economies. The idea that technology and talent capabilities cluster is not new, but the importance of tolerance is novel. Highly talented labour needs a liberal, easy-going lifestyle to thrive or it will leave. Skilled workers are attracted by life-style. Fortunately, Perth has been rated among the world's best five cities to live in.[15] Western Australia must remain a pleasant place to live! Governments should not underestimate the importance of urban and regional planning, environmental management and a wide range of life-style issues.

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12 Hey, Tony and Trefethen A., *The Data Deluge: An e-Science Perspective*.

13 Stylised Fact Five from the National Economics (NIEIR), *State of the Regions report 2005-06*, November 2005. http://www.alga.asn.au

14 *The Rise of the Creative Class* and *The Flight of the Creative Class*.

15 The Economist Intelligence Unit quoted at: www.doir.wa.gov.au/investment/index.asp

The State Government has also assisted in bringing leading world researchers to Western Australia.[16] In early 2006, the State Government announced the first of two new chairs in radio astronomy to develop computer simulation capabilities; Dr Lister Staveley-Smith, of the CSIRO Australia Telescope National Facility in New South Wales, and Dr Peter Quinn, of the European Southern Observatory based in Germany.

Western Australians rank among the leading researchers of the world. People such as Professor Fiona Stanley (Director, Telethon Institute for Child Health Research and Chief Executive Officer of the Australian Research Alliance for Children and Youth), Dr Fiona Wood (Head of Royal Perth Hospital's Burns Unit, Director of the Western Australia Burns Service and co-founder of Clinical Cell Culture), Dr Robin Warren and Professor Barry Marshall (the two recent Nobel prize winners in medicine) will continue to work and prosper in Western Australia if the facilities for a knowledge economy are provided along with the wonderful lifestyle.

1.3 The Role of the Internet

The Internet is an important enabler of the knowledge economy. Digital content, goods and services can more easily be traded and delivered. The Internet also facilitates the movement of people[17], goods[18] and services[19], money and financial transactions that underpin globalisation.

Evans and Wurster characterised the impact of the Internet as an expansion of the frontier of richness and reach (see Figure 1.2).[20] “Richness” refers to the depth and quality of information in an interaction, while “reach” refers to the number of entities that can be reached via Internet. In the past, it was possible to share rich interactions with a limited number of suppliers or customers. A major impact of Internet-based communication and commerce is that it has greatly increased reach *and* increased the potential for richer, more customised and targeted interactions. Organisations can now broaden their supplier or customer base (better reach) *and* make relationships deeper and more effective (greater richness).

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16 Examples include Ian Short (a molecular geneticist from Paris), Klaus Regenaur-Lieb (from Mainz), Julian Gale (a nano-chemist now at Curtin University) and Rudi Appels (an HPC user and expert on the rice and wheat genomes at Murdoch University).

17 Houghton, J.W. (2005) *Digital Delivery in Travel and Tourism Series*, Working Party on the Information Economy, OECD, Paris.

18 Houghton, J.W. (2005) *Digital Delivery in Distribution and Logistics*, Working Party on the Information Economy, OECD, Paris. http://www.oecd.org/document/20/0,2340,en_2649_34223_34884628_1_1_1_1,00.html

19 Houghton, J.W. (2004) *Digital Delivery of Business Services*, Working Party on the Information Economy, OECD, Paris. http://www.oecd.org/dataoecd/40/5/31818723.pdf

20 Evans, P. and Wurster, T.S. (2000) *Blown to Bits: How the new economics of information transforms strategy*, Harvard Business School Press, Boston.

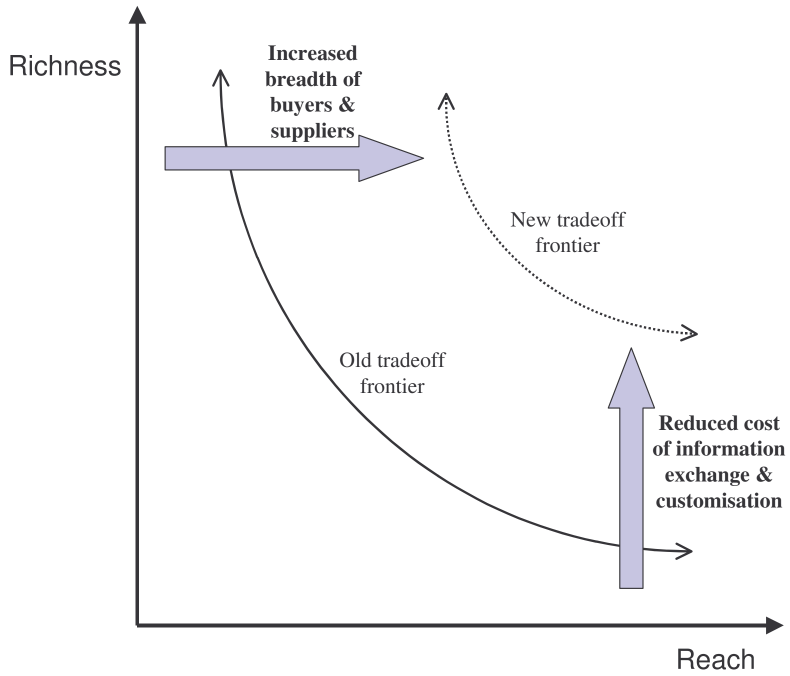

Figure 1.2: The Impact of the Internet: Richness and Reach

With the increasing deregulation of trade, most especially in knowledge intensive services, the impact of the Internet on local economies is likely to increase.

Amenability of Services to Digital Delivery

Important factors influencing the amenability of services to digital delivery include: the significance of the role of information exchange in the service concerned; the level of standardisation; the complexity of the tasks involved; the nature of the knowledge involved; the nature of the "problem" addressed by the service; and the context of delivery.

The level of *standardisation* of processes is an important determinant. Services that can be standardised and delivered in digital form (e.g. research reports, statistical updates, images, etc.) and services that can be standardised and ordered via the Internet (e.g. courier delivery services, advertising space, airline tickets, etc.) are most amenable to digital delivery. Those that resist standardisation tend to be less amenable.

The *complexity of the tasks* involved is one of the factors retarding standardisation and digital delivery. Morris (2000)[21] pointed out that many have underestimated the complexity of the work environment, and noted two related concepts that shed light on these complexities: articulation and emergence. Articulation is the way in which people arrange and co-ordinate activities to mesh with colleagues. Emergence refers to actions that are often difficult to articulate too far in advance. Complexity makes remote delivery more difficult, although bandwidth increases enable greater richness of interaction and can support remote delivery of more complex services.

The *nature of the knowledge* involved also affects the amenability of services to digital delivery. It is common to make the distinction between codified and tacit knowledge. Codified knowledge is knowledge that can be written down and readily transmitted from one person to another (e.g. standard operating procedures, policy manuals, legislation, taxation formulae, etc.). Tacit knowledge tends to resist codification and remain a part of the knowledge and skills of individuals – it is more fluid and interpretive. Knowledge that can be codified is more amenable to digital delivery than tacit knowledge. The transmission of tacit knowledge often requires face-to-face interaction in the negotiation of meaning and in learning. This makes digital delivery more difficult. Again, however, high bandwidth networks can enhance the richness of mediated communications and enable the digital delivery of more knowledge intensive services.

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[21] Morris P. *World Wide Work: Globally Distributed Expert Business Services,* Emerging Industries Occasional Paper No. 4, Department of Industry, Science and Resources, Canberra.

The *nature of the problem* involved also effects amenability to digital delivery. Rittel and Webber (1973)[22] noted that there are major differences between different kinds of problems and hence strategies to solve them. A "tame" problem can be expressed independently of its solution. In engineering, for example, one can specify what needs to be designed independent of any particular design solution. In contrast, a "wicked" problem cannot be explained without its solution. In working out a solution one understands the problem more clearly and can redefine it if necessary, which in turn leads to a better solution, and so on. Tame problems are easier to distribute in space and time, because they can be more accurately specified, and worked on independently, drawing on codified knowledge bases.

The *context of delivery* also affects amenability. In high context work, significant (informal) interaction is needed between co-workers to get the job done, whereas in a low context activity workers can proceed relatively independently. High context work tends to require a high degree of awareness of co-workers and of clients. Clearly, low context work is more amenable to digital delivery than high context work.

Source: Derived from Houghton, J.W. (2003) *Digital Delivery of Business Services*, OECD, Paris.

Box 1.6: Amenability of Services to Digital Delivery

1.3.1 Location of Production

It is not yet clear whether the Internet and global connectivity will provide equal opportunities to all regions to participate in wealth creation leading to "convergence" (i.e. the closing of gaps so that areas become more alike) or lead to concentration of supply, with other regions simply being consumers of services through global networks:

> *"In the popular mind are two different notions about the effect of information technology on industrial convergence. On the one hand is the image of the 'technopolis', of which Silicon Valley is the most obvious and best documented example……The other image is the firm on the farm (or the yacht, or the mountaintop), using information technology to communicate with clients, suppliers and competitors located elsewhere."* [23]

The Internet lowers the transport cost of many intangible services (a force for concentration) and makes many formerly locally produced and consumed services tradable (e.g. banks moving out of regional towns, Indian call centres, business process services and software development centres).

Communications costs do not change some of the benefits of geographical proximity in production. Firms have been inclined to locate as specialised capability clusters because they may benefit from:

- knowledge spillovers; information concerning new applications or other innovative practices may spread faster among the firms that are geographically closer to each other;
- the availability of skilled labour - which is fostered by spatial agglomeration of firms. Such concentration also makes skilled labour more available to be poached. With the current boom in the Western Australian oil and gas sector, a prime concern of Austal Ships is loss of staff whose skills were gained through TAFE and apprenticeships and do not allow a short replacement lead-time;
- good infrastructure; and
- supporting institutions such as specialised suppliers, universities and research centres.

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22 pp 155-169 Rittel H. and Webber M. (10973) *Dilemmas in a general Theory of Planning,* Policy Studies 4(1).

23 p214 Kolko J. *Silicon mountains, silicon molehills: geographic concentration and convergence of Internet industries in the US* in Information Economics and Policy, Vol.14, No.2, June 2002.

This is the paradigm that led to Western Australia's Technology Park at Bentley. It has patent attorneys, IT specialists and testing authorities as well as access to common user infrastructure, such as high performance computing and visualisation facilities, and linking education programs to industry requirements.[24]

At this point, the global knowledge economy exhibits a polarisation around concentration which will pose particular problems for peripheral economies. These include the tendency for knowledge-intensive activities to cluster in areas of critical mass and strong tacit skills, near large markets, and hence in or near major centres. As a result, peripheral regions are likely to be excluded from value-adding activities within product systems, and to be forced down the value chain to focus on commodity-producing activities. The location of these activities will tend to be determined mainly on price. As a result, firms in peripheral regions providing these products and services will tend to be price-takers.

> *"Under these circumstances there is a risk that peripheral economies will tend to be "hollowed out" and become branch office economies. This will progressively place them in an increasingly marginal position in the world economy, with the high value activities and jobs increasingly located in the major countries.*
>
> *On the other hand, trends in terms of globalisation and the ICT revolution offer, at least in theory, the potential to enable smaller firms and regions to participate more actively in global markets and in global product systems (characterised by terms such as "the collapse of distance"). Thus a central challenge of industry policy, both in Australia and in Western Australia, is to achieve high value growth, and the good jobs that go with it, through greater integration into the global economy, and in spite of the tendencies for exclusion noted above. Achieving this will largely depend on the state taking a learning mindset, in particular learning ways of enhancing the level of connectedness - of both individuals and organisations, technically and socially, with colleagues, partners, customers and clients around the world".*[25]

The globalisation of production and the emergence of international production systems reflect the responses of multinational firms to technological change, policy and trade liberalisation and increased competition. Increasingly, global markets involve competition between entire production systems, orchestrated by multinational firms – rather than between individual factories or firms.[26] In many cases, production is now characterised by a high degree of specialisation along the value chain, with standardisation supporting high levels of specialisation and outsourcing.[27] Increasingly, this fragmentation of the value chain is global, with the formation of specialised production clusters participating in global production systems.

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[24] http://www.doir.wa.gov.au/investment/5613DE72077C4A6D963B1D21B769DA70.asp

[25] Supporting Paper No 2 *Peripheral Economies in a Global Knowledge Economy* by Peter Morris Whitehorse Strategic Group February 2002.

[26] UNCTAD (2002) World Investment Report 2002: *Transnational Corporations and Export Competitiveness*, United Nations, New York and Geneva, pxxi.

[27] E-business Watch (2003) *ICT and e-business in the Electrical Machinery and Electronics Sector*, European Commission, Sector Report 11/II, p13. http://www.ebusiness-watch.org/marketwatch/

Labour-intensive manufacturing and services activities are shifting to contract suppliers in Asia, while Western Europe and the United States retain the high-end, knowledge intensive stages of the value chain, such as research and product development.[28] Nevertheless, high volume products and services evolve quickly from small-scale production near design centres of gravity, to large scale production near market centres of gravity, and finally to large scale production near low cost labour centres of gravity.[29]

The way these forces play-out is not yet clear. It looks like talent and technology are important requirements to avoid being "hollowed-out". But, there is no option to abstain from the global knowledge economy. Western Australia must "play on" and learn the rules of engagement. Part of the requirement to be at the high end of the global value chain is to have excellent international communications infrastructure. Our focus in the following sections is on the "Big Pipes" infrastructure that will deliver this outcome.

1.3.2 Costs

Until recently, US-based knowledge industries enjoyed a communications cost advantage over other regions because the Internet was, and still is, US-centric. This is a product of US leadership in the knowledge economy and its superior concentration of capabilities. It meant that when the Internet was commercialised in the early 1990s, non-US participants had to connect to the USA for access to content and to each other.

There are two major components to global Internet connectivity: carriage and exchange.[30] International carriage comprises the transmission links across the Pacific and to a much lesser extent the Indian Oceans. Under Internet charging agreements, the non-US entity pays 100% of the transmission link costs to the US, because the (peering or transit) agreements are applied at the exchange point in the US. Around 1993, the price of capacity from Australia was over USD100,000 per Mbit/s per month.

The emergence of much higher capacity fibre optic cables has greatly reduced unit transmission costs. Since 2000, with healthy competition between Southern Cross (SCCN) and the Australia-Japan Cable (AJC), coupled with discounts for greater volumes, prices for international transmission capacity have fallen. SCCN is now offering a price for unprotected capacity that is equivalent to USD270 per Mbit/s per month. It is notable, however, that although SMW3 is on Perth's doorstep, ISPs in Western Australia find it is cheaper to use East Coast cables (i.e. either AJC or SCCN).

At the same time as competition on transmission links to the US has increased, the economics of delivery (transit) have improved. The cost of accessing US content and delivering Australian traffic into the US decreased initially as a result of the movement of content providers and overseas entities to public peering points, where they can peer with each other (see Box 1.7). As a result of using such opportunities, transit now accounts for less than 50% of the delivery of an Australian ISP's traffic in the USA. This public peering induced competition for the supply of transit between the "Tier 1" carriers, such that the price of transit has fallen to around USD70 per Mbit/s per month.

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[28] E-business Watch (2003) *ICT and e-business in the Electrical Machinery and Electronics Sector*, European Commission, Sector Report 11/II, p14. http://www.ebusiness-watch.org/marketwatch/

[29] NEMI (2003) *Technology Roadmaps: December 2003*, NEMI, p11. http://www.nemi.org/

[30] Hibbard and de Ridder reviewed Internet Charging Arrangements in a study for DCITA (LECG 2004). http://www.dcita.gov.au/tel/international/trade_related_issues/international_communications_costs

As a consequence of these changes, the share of total costs accounted for by international connectivity for Australian ISPs has fallen from around 45% in 1997 to about 10%, as the cost of international connectivity has fallen from 12-14 cents to 0.5 cents per MB downloaded from overseas.

Public Peering and WAIX

Public peering exchanges are co-location facilities where carriers and service providers can exchange data and traffic without incurring transit fees.

WAIX has provided peering since 1997 (the first such peering point in Australia). Currently, there are 55 organisations peering at WAIX. These are, with one exception (Asia Netcom and also Singtel until it acquired Optus), domestic organisations outside the "gang of four" (Telstra, Optus, AAPT/Connect.com and iiNet/Ozemail). It has 400 Mbit/s links into the "gang of four" to get access to their customers and the customers of other ISPs not on the WAIX.

Unlike Equinix, it does not provide a data centre. But, like Equinix, it does not compete with its ISP customers by only providing services at its centre (i.e. not transport). The cost of peering at the WAIX is only $250 per port pa, compared with around $1,200 at Pipe Networks, because its overheads are low, it provides no service level agreements (SLAs) and employs few staff.

Box 1.7: WAIX

1.4 Western Australian Asset Analysis

Western Australia is not a large economy in terms of population. It has just over 2 million people with nearly three quarters of them in Perth.[31] But, it has strengths in some key sectors that provide a platform on which to build a knowledge economy.

Chief among these skills is innovative individuals. One example of the export of Western Australian skills is Lateral Sands, which excels in chip design (see Box 1.8).

Lateral Sands

Lateral Sands is a privately owned Western Australian company located in Perth that started in 1999 by proofing circuit lay-outs for computer chip designs (www.lateralsands.com). Reviewing and checking microprocessor chip designs is highly specialised work that involves deep engineering skills. As well as catching any shortcomings, team members can also enhance and "fine tune" the designs they are asked to test.

At the beginning of every job the two or three staff travel to the client's premises. They stay for at least three weeks, possibly as long as six weeks, to ensure they have a good feel for the way the client operates. Once they have returned to Australia, there is a disciplined weekly routine of reviewing and reporting. This process relies on the Internet. Lateral Sands does not have a single client within 10,000 kilometres. Most are in Silicon Valley and include industry leaders such as Sun.

Their reliance on the Internet has been extended from supplying their service to acquiring cheap labour at the point when they partner with India or Eastern Europe to improve the margins on the more routine elements of their work.

In February 2005, Lateral Sands acquired its only Perth-based competitor, SMR Electronics, which has been in operation since 1993 and has 24 clients in five countries. This consolidates and strengthens their skills sets as well as broadening their respective markets.

Box 1.8: Lateral Sands: Remote Technical Testing

Source: Gibson Quai-AAS based on Morris[32]

In terms of geographical location, Australia is located in close proximity to Asia and Perth is closer to Asia than either Sydney or Melbourne. Direct flights to Hong Kong and Singapore take 1 and 2-3 hours longer, respectively, from Sydney than they do from Perth.

31 ABS *Population Projections* Cat No. 3222.0, ABS *Australian Demographic Statistics,* Cat 3101.0, June 2005.

32 Morris, P. (2003) *The Impact of Broadband on the Shape of Work*, Telesis Communications, Fremantle.

Perth is the "front door" to the fast growing economies of Asia. China and India are moving closer together economically. Already, their trade has jumped from USD3 billion in 2000 to USD13 billion in 2003, and it will increase further. In the words of Chinese Prime Minister, Wen Jiabao;

> *"Cooperation is just like two pagodas. One hardware and one software. Combined we can take a leadership position in the world."*[33]

Australia and, particularly, Western Australia already have close links with China, not only in terms of commodity supply, but also in terms of research collaboration. So, Perth is well placed to provide a door to a combined market representing 40% of the world's population (see Table 1.1).

	Share (%) of			Average Annual Output Growth (%)	
	World's Population	Australian Exports	Australian Imports	1987-1996	1997-2006
China	20.7	9.3	12.7	10.0	8.4
India	17.0	4.6	0.8	5.9	6.0
"Tigers"[34]	1.3	16.4	11.3	7.9	4.2
Japan	2.0	18.9	11.8	3.2	1.1
USA	4.7	8.1	14.5	2.9	3.3
European Union	N.A.	11.2	23.7	2.2	2.4

Table 1.1: Australia's Markets

Source: DFAT, July 2005 and IMF World Economic Outlook 2005

1.5 Key Sectors in Western Australia

A key feature of the current phase of globalisation is the relatively recent and rapid internationalisation of services, especially knowledge intensive services, accelerated by the Internet, deregulation of international trade in services and related national investment and regulatory regimes. Tracking foreign direct investment (FDI), UNCTAD (2004) noted that:

> *The structure of FDI has shifted towards services. In the early 1970s, this sector accounted for only one-quarter of the world FDI stock; in 1990 this share was less than one-half; and by 2002, it had risen to about 60% or an estimated USD4 trillion. Over the same period, the share of the primary sector in world FDI stock declined, from 9% to 6%, and that of manufacturing fell even more, from 42% to 34%. On average, services accounted for two-thirds of total FDI inflows during 2001-2002, valued at some USD500 billion. Moreover, as the transnationalisation of the services sector in home and host countries lags behind that of manufacturing, there is scope for a further shift towards services.*[35]

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33 Remarks made by prime Minister Wen Jiabao on his visit to India on 11 April, 2005.
34 The four economies grouped by the IMF are Korea, Taiwan, Singapore and Hong Kong.
35 UNCTAD (2004) *World Investment Report 2004: The Shift Towards Services,* pxx.

In the past decade or so, advances in information and communication technologies have made it possible for more and more of these services to be produced in one location and consumed elsewhere – they have become tradable. The implication of this "tradability revolution" is that the production of entire service products (or parts thereof) can be distributed in line with the comparative advantages of individual locations and the competitiveness enhancing strategies of firms and governments. In non-tradable services, market growth remains the principal location advantage for attracting FDI. But, with directly tradable service, the main location advantages are access to good information and communication technologies, an appropriate institutional infrastructure and the availability of productive and well-trained personnel at competitive rates.[36]

In the context of this new wave of globalisation of services, Western Australia's major knowledge economy strengths and opportunities include a range of activities around the energy and resources sector (including mining and construction engineering, mapping and sensing), as well as defence and marine related engineering. There are also major strengths and opportunities in biotechnology, education and health services, and a range of related design, research and technical services. All of these sectors are being transformed by the joint forces of the Internet revolution and globalisation, and they provide opportunities to build on traditional strengths and local capabilities in areas undergoing rapid globalisation.

1.5.1 Engineering and Related Services

The largest sector of the Western Australian economy is mining and energy. In 2004-05, mining accounted for 21% of Western Australia's Gross State Product, compared with a national average of 5%, and in recent years mining and energy have played a major role in the State's high rates of growth.

Almost all of Western Australia's major mineral and energy commodities recorded production increases in the year to June 2005. The main driver of growth in exploration is strong demand from China and Japan, as well as higher world prices. Nickel, iron ore and cobalt have done well, although stainless steel producers in China and India are turning to new alloys with less nickel content. Petroleum exploration in Western Australia remains below the high levels experienced in mid-2004 but is still only just below the five-year average of $143 million.[37]

There is an enormous amount of engineering construction and upgrading currently underway in the mining sector. Table 1.2 indicates the major known projects, which have an estimated collective value of approximately $25 billion. The implementation of these projects will require substantial design teams, engineers, draftsmen, estimators and project managers.

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[36] UNCTAD (2004) *World Investment Report 2004: The Shift Towards Services,* United Nations, Geneva and New York, ppxxi-xxiv.

[37] ABS (2005) *Western Australian Statistical Indicators,* Cat No 1367.5, Canberra.

Company	Project/Location	Type of Project	Resource	Investment (AUD m)	Project Life/Expenditure Life
Portman Ltd	Koolyanobbing		Iron and steel	$ 65	
Ravensthorpe Nickel/BHP Billiton	Ravensthorpe		Nickel/Cobalt	$ 1,400	Completion in 2007
Hamersley Iron	Pilbara-Dampier		Iron and Steel	$ 700	Completion in 2005
Robe River Mining	Pilbara-Dampier	Rail Upgrade	Iron and Steel	$ 200	Completion mid 2006
BHP Billiton	Pillbara Rapid Growth Project 2	Upgrade	Iron and Steel	$ 745	Completion end of 2006
Alcoa	Pinjarra/Huntly	Upgrade	Bauxite/Alumina	$ 460	Completion early 2006
Worsley Alumina	Worsley/Boddington	Upgrade	Bauxite/Alumina	$ 257	Completion early 2006
Woodside Energy	Enfield (Carnarvon)		Gas	$ 1,480	Start Q3 2006, 20yr life
Alcoa	Wagerup/Willowdale	Upgrade	Bauxite/Alumina	$ 1,500	Start 2006
Worsley Alumina	Worsley/Boddington	Upgrade	Bauxite/Alumina	$ 900	Start end of 2005
Griffin Coal	Collie		Coal	$ 20	Under consideration
Argyle Diamonds	Argyle	Upgrade	Diamonds	$ 850	Start end of 2005, 13yr life
Heron Resources	Gongarrie		Nickel	$ 1,400	Under consideration
BHP Billiton	Yakabindie	Feasibility	Nickel	$ 20	Under consideration
Chevron	Gorgon		Gas	$ 11,000	Start late 2006
BHP Billiton	Onslow	Feasibility	Gas	$ 4,000	Q3 2007 - late 2011
Total Expenditure				**$ 24,997**	

Table 1.2: Significant Resource Projects Underway or Planned in Western Australia

Source: Gibson Quai-AAS[38]

Whether it be in exploration, production, or in related construction and engineering, the mining and energy related services can expect continued growth in demand. Moreover, this cycle of mining and energy activity may well be sufficient to generate the critical mass required to establish Perth more firmly as a global centre for the supply of a broad range of engineering and related mining and energy services. As this occurs, the role of the supporting IT and communications infrastructure will become increasingly critical.

1.5.2 Biotechnology

TIAC (2000) identified significant strengths and opportunities for Western Australia in biotechnology. The study found that Western Australia had world-class research in agricultural biotechnology at the State Agricultural Biotechnology Centre. It also had world-class research in biomedical biotechnology at the Lions Eye Institute, the Institute for Child Health Research, the Western Australian Institute for Medical Research and the Western Australian Biomedical Research Institute. Western Australia's biotechnology industry was found to be small but entrepreneurial, with excellent researchers and teaching.[39]

Since that report, the industry has grown. In 2003, the Australian biotech industry employed about 6,000 people. Most Australian biotech firms are spin-offs from the research sector, making the health of the research sector a key to future industry development. Seventy per cent of new firms in 2003 emerged from public research organisations. Estimated public sector spending on biotech R&D was AUD968 million in 2000-01, and business spending on R&D in biology and medical/health sciences was AUD517 million in 2001-02.[40]

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38 Figures extracted from the September 2005 issue of *Prospect*¸ published quarterly by the Western Australian Government's Department of Industry and Resources.

39 TIAC (2000) *Biotechnology West: Strengths, Weaknesses and Opportunities,* TIAC, Perth.

40 Ausbiotech. www.ausbiotech.org

The biotechnology sector is said to be the fastest growing sector in the global economy, expanding at 16 per cent per annum, with a current value of more than USD18bn.[41] There are more than 140 companies in Western Australia's biotechnology sector.

Perth has biotechnology clusters centred on biomedicine, agriculture and the environment. Biomedical R&D collaboration occurs between the various institutes listed above and several of Perth's universities, in addition to collaboration with a growing number of biotechnology companies in Western Australia. The major research focus includes the molecular basis of disease control, targeting Alzheimer's, cancer, diabetes, malaria and other parasitic diseases. The Centre for Bioinformatics and Biological Computing at Murdoch University along with the Western Australian Bioinformatics Consortium is playing an active role in drawing together the major biotechnology centres in Perth.

The AJ Parker Cooperative Research Centre (CRC) for Hydrometallurgy has developed world-class expertise in mining biotechnology. The Research Centre partners, including CSIRO, Murdoch University and eleven national and international mining companies, conduct leading R&D on bioleaching and the hydrometallurgical process in sulphide ores. Perth also hosts CSIRO's headquarters in environment and resources research and has a strong focus on agricultural biotechnology through the work of the State Agriculture Biotechnology Centre, the Department of Agriculture and the universities of Western Australia, Curtin and Murdoch.[42]

One key to the development of biotech industry opportunities will be ongoing support for access to the IT and communications infrastructure, which make possible ready access to the relevant research databases (see Section 3.3.2).

1.5.3 Education Services

Australia has a well-developed education system with participation rates and secondary school completion rates among the highest in the world. Total expenditure on education in Australia in 2000-01 was AUD40 billion, with government expenditure of AUD29.6 billion and private expenditure of AUD10.3 billion. Total education expenditure accounted for 5.9% of Gross Domestic Product (GDP).[43]

TIAC (2000) noted that international education is Western Australia's seventh largest export industry. Not only is the education and training sector a significant contributor to Western Australia's export income, it also has great potential for future expansion. The education and training sector is a service industry, which makes it less susceptible to frequent dramatic changes in commodity prices. It is one of the few high value added export industries in Western Australia. TIAC (2000) anticipated that by the year 2005 the industry would have expanded to 27,000 international students, with export income generation per year of $600 million.[44] It is likely this estimate has been reached, if not exceeded.

Education services have been one of Australia's export success stories of recent years. In 2003, there were 303,324 international students in Australia, of which some 30,000 were in Western Australia. A large proportion was in higher education, with a significant proportion of those at the post-graduate level. A large number of all international students focus on business administration, management, computer and information systems subjects.

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41 Western Australia's Minister for State Development, Alan Carpenter MLA, 16 June 2005.

42 DITR (2004) *Global Partners: Australian Biotechnology 2004*, Biotechnology Australia, pp33-34.

43 ABS (2002) Education and Training Indicators: Australia 2002, Cat No 4230.0, ABS, Canberra.

44 TIAC (2000) *Exports of Western Australian Education and Training: Constraints and Opportunities*, TIAC, Perth, October.

Asian countries are the source of some 75% of all overseas students in Australia; India and China account for 22% between them. The total value of Australia's education exports is over $6 billion a year, and growing at more than 10% a year.[45]

The development and delivery of education services, both domestically and internationally, will be facilitated by the development of local, national and international communications networks.

1.5.4 Health Services

Increasing wealth among the "middle classes" in rapidly developing economies in the Asia-Pacific region and beyond, combined with limitations of funding for healthcare systems in those countries, provides a significant opportunity to expand the export of health services, both through health-related "tourism" and remote delivery (i.e. tele-medicine).

TIAC's "Drivers and Shapers" report identified health services as one of two knowledge based sectors with considerable potential for expansion, especially into overseas markets.[46] More recently, TIAC commissioned a detailed report on directions for development of trade in Western Australian health industry services.[47] It noted that:

> *"Globally, health expenditure as a proportion of Gross Domestic Product (GDP) ballooned in the second half of the 20th century, experiencing an almost threefold increase from 3% in the 1950s to 8.5% by 2001. The good news for health service providers everywhere is that this trend shows no sign of abating. In fact, over the last decade, annual growth in per capita health spending has outpaced GDP in most OECD countries by a significant margin…*
>
> *Asia Pacific Economic Cooperation (APEC) member economies are also keen to promote trade in health services. Several member countries (in particular Malaysia, Singapore and Thailand) have already implemented domestic policy programs to attract foreign patients and expand health services trade with the objective of creating an 'Asian health and medical hub'."*

The World Health Organization estimates total health services trade at around USD 30 billion.

According to TIAC (2004), emerging opportunities for trade in Western Australian health services include: Health and Wellness, Plastic Surgery, Health-related Educational Services, Aged Care and Home-based Health Care Services, Rehabilitation, Sports Medicine, Child Health, Telehealth, Health Management and Information Systems, and Emergency, Disaster and Risk Management Services.

The number of international tourist arrivals worldwide reached 703 million in 2002, from 456 million in 1990. In 2001, the majority of international tourist arrivals were for the purpose of leisure, recreation and holidays (54%). Business travel accounted for 19%, and 24% of arrivals were related to travel for other purposes (e.g. visiting friends and relatives, for religious purposes/pilgrimages, for medical treatment, etc.).[48] TIAC (2004) noted that: health tourism offers a way to expand tourist activity in Western Australia.

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[45] IDP (2005) *International Students in Australian, 2004*. www.idp.com

[46] TIAC (2000) *Drivers and Shapers of Economic Development in Western Australia in the 21st Century*, TIAC, Perth.

[47] TIAC (2004) *Trade in Western Australian Health Industry Services: Directions for Development*, TIAC, Perth.

[48] WTO (2004) *Tourism Highlights 2003*, World Tourism Organisation, Madrid.

Health tourism helps in developing a diversified and sustainable tourism industry, and demand for health tourism is likely to be more stable than the usual highly seasonal tourist trade.[49]

The IT and communications infrastructure provides an essential foundation for the delivery of health services, both domestically and internationally. It is also a foundational element in the medical research that underpins the local capabilities upon which successful health services exports depend.

1.5.5 Research, Design and Technical Services

As the pressure to innovate increases and the means of doing so become more complex, there is a growing tendency to outsource research, development and technical testing activities. This trend provides an opportunity for Western Australia to build upon its strong R&D base.

Focusing on the internationalisation of R&D, UNCTAD[50] noted that:

> *"…R&D is a form of service activity and like other services it is "fragmenting", with certain segments being located where they can be performed most efficiently… (if countries) develop the capabilities that are needed to connect with the global R&D systems of TNCs. From a host-country perspective, R&D internationalization opens the door not only for the transfer of technology created elsewhere, but also for the technology creation process itself. This may enable some host countries to strengthen their technological and innovation capabilities. But it may also widen the gap with those that fail to connect with the global innovation network."*

It went on to note that:

> *"Technical change and advanced science-based technologies in many industries call for more high-level skills and intense technical effort. These require better infrastructure, not least in information and communication technologies (ICTs). They also require strong supporting institutions, as well as stable and efficient legal and governance systems. Finally, they require access to the international knowledge base, combined with a strategy to leverage this access for the benefit of local innovation systems."*

Reflecting the increased internationalisation of R&D, foreign affiliates are assuming more important roles in many host countries' R&D activities. UNCTAD (2005) noted that between 1993 and 2002 the R&D expenditure of foreign affiliates worldwide climbed from an estimated USD 30 billion to USD 67 billion (or from 10% to 16% of global business R&D). The share of R&D by foreign affiliates in different countries varies considerably. In 2003, foreign affiliates accounted for more than half of all business R&D in Ireland, Hungary and Singapore, and about 40% in Australia, Brazil, the Czech Republic, Sweden and the United Kingdom. Conversely, it remained under 10% in Chile, Greece, India, Japan and the Republic of Korea.

Technical and design services are also globalising. For example, UNCTAD (2005) also reported that, *"from practically nothing in the mid-1990s, the contribution of South-East Asia and East Asia to global semiconductor design reached almost 30% in 2002."*

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49 TIAC (2004) *Trade in Western Australian Health Industry Services: Directions for Development*, TIAC, Perth.

50 UNCTAD (2005) *World Investment Report 2005: Transnational corporations and the internationalization of R&D*, United Nations, Geneva and New York.

Recently, IBM (which has substantial global operations based in Perth) announced that India's HCL Technologies will become the first external design centre for its Power Architecture chips, highlighting India' growing role in the design of high-end chips.[51] Such services depend upon the "Big Pipes", "Big Irons" and "Big Dishes" of the knowledge economy's Cyberinfrastructure.

1.6 Summary of Key Findings

There are powerful forces for globalisation which are being enabled by the Internet and improved global communications. "Big Pipes" go both ways. There is a risk of weaker peripheral regions in the global economy being "hollowed out"*;* a risk earlier TIAC reports have discussed. But, no economy can or should insulate itself from the rest of the world.

Despite the risks, Western Australia must "play on or be preyed on".

The risks of marginalisation and being pushed down the global value chain are reduced by developing and enhancing a region's competitive strengths. Through the various TIAC reports, these have been identified as engineering, biotechnology, education, health and technical services. These sectors can provide a platform for successful participation in this new form of global services production. Importantly, they are areas with particular dependence upon information and communications infrastructure.

Another advantage that Western Australia has is its geo-political position at a time when the balance of economic strength is shifting to Asia. China and India are leading the pack in terms of growth and opportunity and the communications gateway to these markets is Singapore; which also means Western Australia will become more important to all Australians.

Western Australia must leverage its position as the "front door to Asia".

The "main artery" of Western Australia's globalising knowledge economy is international communications links. Communications infrastructure is to the knowledge economy what roads and rail were to the industrial economy. It is prone to some of the same "externalities" that can lead to sub-optimal investment in road and rail without public intervention.

Given Western Australia's isolation and its desire to develop its knowledge economy, the State Government needs to support investment in international links.

Given the State Government's Cabinet Decision of December 2004 to develop Western Australia's knowledge economy, "Big Pipes" and other parts of the knowledge economy infrastructure should be supported.

While the communications infrastructure is probably the most important, there are other "building blocks" which make up the "Cyberinfrastructure" supporting a knowledge economy. Many of these can be enhanced with government policy and support. Western Australia already has a good track record in attracting key talent to the State. Current thinking is that regions with "technology, talent and tolerance" will prosper in the global knowledge economy.

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51 Rai S. *Indian Concern to Design IBM Chips,* New York Times, 18 November 2005.

2 Supply: Western Australia's National and International Connectivity

Western Australia's international communications infrastructure is essential to its place in a global knowledge economy. Surprisingly, most of its international connectivity is obtained out of Sydney. In this chapter, we review the existing and planned capacity of the international communications infrastructure available to Western Australia.

2.1 Evolution of International Connectivity

As background to the current state of international connectivity to Western Australia, it is useful to have an appreciation of the history of connections to the State.

1889 to 1966 – Telegraph Cables

The first international connection to Western Australia was the Java to Broome (WesternAustralia) submarine telegraph cable, which was first laid in 1889. Subsequently, cables were laid from Cocos, with connections to South Africa and elsewhere. The era of telegraph cables ended in 1966 when the Cocos to Cottesloe (Western Australia) cable was turned off. These cables supported the telegram service.

1930 onwards -- Radio Telecommunications

Radio communications supplemented telegraph cables, providing limited voice communications through stations at Applecross (Western Australia) and Bassendean (Western Australia). In due course, Applecross was replaced by Gnangara station (both in Western Australia)

1966 – Satellite Communications

Australia's first earth station was built in Carnarvon (Western Australia) in 1966 to receive television, telephone and data communications. This continued until 1982 when it was relocated to Gnangara (Western Australia). Western Australia continues to have an earth station complex at Gnangara providing international communications.

1987 – Australia-Indonesia-Singapore Cable (AIS)

The AIS was Western Australia's first coaxial submarine cable affording international telephony. It had a bearer capacity of 1,380 voice channels. It came ashore just north of Perth and had its cable station at Gnangara (Western Australia). It was retired in 2001.

1993 – Lockridge Earth Station (Western Australia)

Optus established its earth station primarily for domestic communication but with the capability for international communications.

1997 – Jasuraus Cable

Originally planned to route Jakarta-Surabaya-Australia, the cable was established solely between Australia and Jakarta (yet the name was retained). Completed in 1997, Western Australia's first international fibre optic cable had a single fibre pair capable of carrying 5Gbit/s (see Box 2.1). It landed at Port Hedland (Western Australia) with a terrestrial link to Perth. It remains in service.

2000 – SEA-ME-WE3 (SMW3) Cable

The SMW3 cable to Perth was a spur of the greater SMW3 system, which went from South East Asia (actually Japan) to the Middle East and Western Europe (hence its initials). It had two fibre pairs equipped each for 20Gbit/s making a total of 40Gbit/s. It remains in service.

Translating Traffic into Capacity

Data traffic (the "payload") is conveyed in bytes within packets. There are 8 bits (8b) to a byte (1B). Typically each byte of data will have a 20% overhead associated with framing, synchronisation, packing, etc.

Capacity is measured in bit/s, more usually Mbit/s (Mbps) or Gbit/s (Gbps).

Traffic can vary across a week. As a metric for designing networks, a figure of average 85% of the daily peak traffic is sometimes chosen when actual data is not available. So a peak daily traffic figure of 1.68 GB per is dimensioned on the basis of 10 GB per week (1.68 x 0.85 x 7).

Traffic does not flow along capacity like water along a hose. While bits flow back and forth at all times, many of the packets contain no customer payload. Hence the payload transfer does not equal the capacity multiplied by time. The packets containing the payload come in bursts. The peak level of the burst that can be carried is determined by the size of the capacity. A common planning assumption is that 10% of a day's traffic is carried in the busy hour; a pipe to carry 1.68 GB/day has to be dimensioned to carry 168 MB/hour. If each byte of data traffic is equivalent to 10bits then this is 168×10^{7} bits or a pipe 460 kbit/ s capacity.

Equivalently, on these assumptions, a 1 Mbit/s pipe capacity can carry 21.4 GB per week.

Box 2.1: Translating Traffic into Capacity

2002 – NAVA Cable

NAVA cable was proposed as Western Australia's first privately sponsored cable connecting Singapore and Indonesia to Perth, with a potential capacity of 2,560 Gbit/s. However it failed to materialise due to lack of funding and demand.

2002 – A2A cable

A2A cable was actively promoted by Singapore Telecom concurrently with NAVA and was inspired in part as a response to NAVA, which had support at the Singapore end from STARHUB. The proposed capacity was an enormous 7,680 Gbit/s. When NAVA failed to materialise, the plans for A2A were quietly shelved.

2.2 Current West Coast Cable Systems

Two cable systems operate off the West Coast, with others proposed from time to time because of the lack of price competition between the two existing cables.

2.2.1 Jasuraus

Current Configuration

The Jasuraus cable is a 1-fibre pair cable equipped for 5 Gbit/s. It is routed from Jakarta through the Sunda Strait and then to Port Hedland (Western Australia); but accessed in Perth (see Figure 2.1).

In following the 2,795 km route, it has to traverse the shallow north-western shelf with its rock hard limestone floor. In order to minimise abrasion from the seabed, and to provide added protection in this shallower water, it has been buried for more than 100 km off the coast, which is longer than normal for the Australian shoreline. The use of Port Hedland involved a shorter sea route than going to Perth, however, the significant cost of burial on the shelf made the overall costs of the two routes comparable. The cable is extended from Port Hedland to Perth using a dedicated terrestrial fibre link provided by Telstra.

Figure 2.1: Jasuraus

At Jakarta, the cable is connected to the APCN (Asia Pacific Cable Network) comprising 2-fibre pairs each of 5 Gbit/s. The APCN provides connectivity to Singapore and most countries in the corridor between Singapore and Japan. It has landings (often via branches) to Malaysia, Thailand, Philippines, Hong Kong, Taiwan, Korea and Japan. There is discussion about the retirement of this cable because there are several others available to provide the extension to Singapore from Indonesia.

Commissioned in 1997, Jasuraus has a technical life of 25 years, although its relatively small size will mean that it is unlikely to be economic for that length of time. The original cost of the cable system was around USD120 million.

Upgrade Potential

Jasuraus was one of the first cables to use optical amplifiers. This means that the capacity of the cable is not dictated by the design of the submarine amplifiers that lie on the seabed. The optical amplifiers do provide the flexibility for the replacement or augmentation of the terminal equipment at the end of the cable. This equipment could provide additional capacity by taking advantage of technology that has emerged since the cable was laid. Of course, the older design of the submarine amplifiers does constrain the upgrade potential.

Studies indicate that the Jasuraus cable could be increased in capacity from 5 Gbit/s to 20 Gbit/s (and possibly 40 Gbit/s) by the use of new technology involving 10 Gbit/s wavelengths. The cost of such an upgrade would be less than USD6 million for the submarine section but around AUD10 million for the link from Port Hedland (Western Australia) to Perth (Western Australia). Although a capital outlay of less than AUD20million could provide an additional 15 Gbit/s (possibly 35 Gbit/s) of capacity from Western Australia to Jakarta, capacity on other cable systems would be required for transit on from Indonesia to Singapore. It is not likely that the agreement of the owners at both ends of the cable systems to Singapore and Telstra would be forthcoming.

Commercial Arrangements

The Jasuraus cable was organised by a consortium of Telstra, Optus and PT Indosat, the Indonesian international carrier. In 2001, the Telstra shareholding was transferred to Reach Global Networks as part of the Telstra-PCCW joint venture. In 2003, the Optus shareholding became effectively owned by Singapore Telecom (Singtel).

The cable is commercially constructed in two half-sections, where the carrier at one end owns the portion of the section to the mid-point, and the carrier at the other end, owns the section from their end to the mid-point. The southern half of this cable is owned by Reach (70%) and Singtel (30%). The northern half owned by the APCN owners, comprising 10 different Asian carriers.

Parties wishing to purchase capacity need to do so at the Australian end from Reach or Singtel, and at the northern end from one of the APCN owners. Reach and Singtel have supplied prices for bandwidth in the southern half. The price for a circuit from Perth to Jakarta is currently around USD30,000 per Mbit/s capex, or about USD800 per Mbit/s per month.

Of the 5 Gbit/s of capacity from Australia, approximately 3 Gbit/s are in use. However, the cable is effectively “full” for the section from Indonesia to Singapore. The cable contains capacity for STM1 through-connection to northern Asian locations and many of these capacity units are only partially used, but are unavailable for use with other destinations.

As indicated, the cable can be upgraded but the commercial arrangements require that Telstra/Reach, Singtel and the APCN owners, particularly Indosat, all agree. Getting agreement has proven difficult. The link from Port Hedland to Perth is controlled by Telstra which has set a high price (AUD10 million) for upgrade. It would be extremely difficult to change the current commercial supplier.

While the APCN system north from Jakarta is close to full (and may possibly be retired), there are other cables between Jakarta and Singapore that could satisfy any demand. Interestingly, the retirement of APCN could free up some capacity in Jasuraus, and may even make it easier to gain approval for an upgrade. However, the prospect of such approval is not high.

2.2.2 SEA-ME-WE3

Current Configuration

The SEA-ME-WE3 (SMW3) cable network is the longest system in the world, with a total length of 39,000 km. In December 1994, a Memorandum of Understanding was signed by 16 parties for the development of the SMW3 project between Western Europe and Singapore. In November 1996, additional MOU(s) were signed to extend the system from Singapore to the Far East and also to Australia. Finally in January 1997, the Construction and Maintenance Agreement for SMW3 was signed by 92 international carriers. By end-2000 the entire network was completed. The total cost was some USD1.2 billion.

SMW3 includes 39 landing points in 33 countries and four continents from Western Europe (including Germany, England and France) to the Far East (including China, Japan and Singapore) and to Australia.

The System capacity has since been upgraded twice already and today it consists of two fibre pairs each carrying 8 wavelengths. Some wavelengths operate at 10 Gbit/s whilst others operate at 2.5 Gbit/s.

For Western Australia, the relevant section is between Perth and Singapore (Figure 2.2). This is a 2 fibre-pair cable, with one pair having a landing in Jakarta before continuing on to Singapore. Each pair has been equipped for 8 wavelengths operating at 2.5 Gbit/s, giving a total capacity of 40 Gbit/s. The distance from Perth to Singapore is 4,722 km. The cost of this section was approximately USD100 million.

The cable station at Perth is at Pier Exchange. The system was designed for a 25-year technical life, ending at 2025.

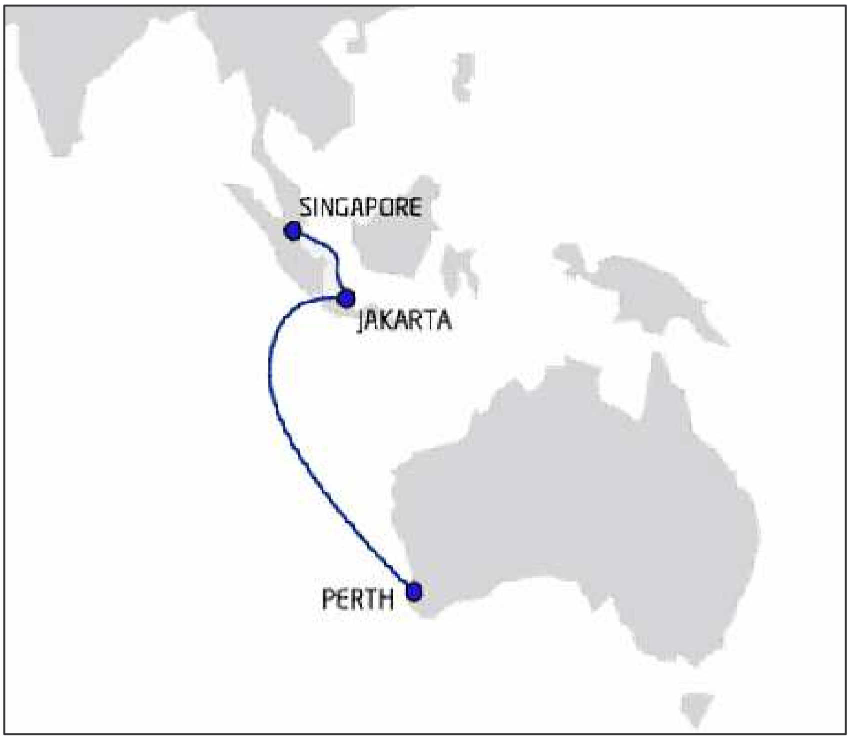

Figure 2.2: SEA-ME-WE3

Upgrade Potential

The segment from Perth to Singapore can be readily upgraded with recent technology. Other segments of SMW3 have been upgraded. Based on expert advice, four of the eight 2.5 Gbit/s wavelengths in each fibre pair of SMW3 out of Perth could be upgraded to 10 Gbit/s giving a total cable capacity 100 Gbit/s. With physical testing to confirm the cable characteristics, this could potentially be upgraded further.

Since no modifications are needed to the submarine plant, such an upgrade would only take a matter of months with no interruption (beyond a few milliseconds) to service.

Commercial Arrangements

As mentioned, SMW3 is owned by 92 different entities spread across the length and breadth of the system and even beyond. The most significant owners are Singapore Telecom (Singtel) and France Telecom. These have been the largest investors in the project and they manage most of the ongoing activities. Reach (for Telstra) and Telecom New Zealand (for AAPT and its NZ business) are also investors. As with Jasuraus, capacity has to be negotiated with half-circuit owners at both ends of the cable.[52]

The commercial arrangements for such a large system need to take into account the diversity of needs of the different owners. As a consequence, a scheme has been devised, based on the MIU*km concept. An MIU (Minimum Investment Unit) is equivalent to 2 Mbit/s capacity. So, for each kilometre at 2 Mbit/s, there is one MIU*km or colloquially one point. Based on the level of investment in the system, each owner was allocated so many points which they could use as they wished in the system.

Singtel chose to establish most of its circuits between Singapore and Europe and so used the majority of its points on those connections. It also used some of its points to Asian countries, leaving a limited number of points for the link to Australia. On the other hand, Reach decided to focus the use of its smaller number of points on the Perth-Singapore segment. As a consequence, Reach has entitlement to far greater capacity on the Perth-Singapore sector than does Singtel.

While the acquisition of Optus allowed Singtel to add in the Optus points to give them more capacity, the need to link the two companies more closely utilised that extra entitlement. As such, it is understood that Singtel has utilized all its points and has none to acquire more capacity, which they will need for themselves and their customers.

On the other hand, it is understood that Reach has capacity beyond its current needs. However, with its change of policy in February 2005 to sell capacity only to its parents and not third parties, none of its spare capacity is for sale directly to Singtel. Of course it could possibly be bought via Telstra.

Of the 40 Gbit/s currently in SMW3, only around 8 Gbit/s are in use, leaving a significant amount of unsold, spare capacity. This capacity can be bought from the SMW3 Consortium at a price equivalent to about USD9.5 million for a full STM1 (a standard module with a bandwidth of 155 Mbit/s). This price compares very unfavourably to the price of an unprotected STM1 between Sydney and Tokyo on the Australia-Japan Cable (AJC) of USD2 million (noting that the SMW3 is intrinsically "unprotected"[53], because it has no inbuilt back-up path). It is not surprising that Singtel will not buy capacity from the SMW3 Consortium. In a way, this is ironic, because Singtel is the most influential party in SMW3 and yet has been unable to garner the support of enough owners to obtain a price change.

2.3 The Singapore Hub

Singapore is one of the great telecommunications hubs of the world. From Singapore, submarine cables and/or terrestrial systems radiate to almost everywhere in Asia, as well as to Europe and to the USA. In many cases, there are multiple links to these places affording a high level of diversity, and hence security. This is evident from Table 2.1.

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[52] Our focus is on cables, but ISPs will normally buy end-to-end services. For example, 23 suppliers responded to AARNet's RFP for capacity to Europe. The suppliers have to put together the links to do this.

[53] A "protected" service includes a back-up, physically different route in the price.

The only issue which exists in relation to international connectivity from Singapore is the dominance of Singtel. With a regulatory environment which is generally supportive of the incumbent carrier, the flexibility of interconnection can be constrained and the price could be above the market rates found in a more competitive environment. The ease of interconnection in Singapore is a counterbalance to this because most systems have common terminating points or an interconnecting network to afford the requisite security and diversity.

Submarine Cable	Design Capacity (Gbit/s)	Destination(s)	Singapore Carrier	Onward Connections
APCN	10	Indonesia, Malaysia, Thailand, Philippines, Hong Kong, Taiwan, Korea, Japan	Singtel	Australia via Jasuraus
APCN2	2,560	Malaysia, Philippines, Hong Kong, Taiwan, Korea, Japan, China	Singtel	USA, Canada via J-US or TGN[54], Europe via USA
EAC	2,560	Malaysia, Philippines, Hong Kong, Taiwan, Korea, Japan, China	Asia Netcom	USA, Canada via J-US or TGN, Europe via USA
C2C	7,680	China, Hong Kong, Japan, Korea, Philippines, Singapore and Taiwan	Singtel	USA, Canada via J-US or TGN, Europe via USA
SEA-ME-WE3	40	Indonesia, Malaysia, Brunei, Vietnam, Philippines, Hong Kong, China, Taiwan, Korea, Japan, Australia, Myanmar, India, Sri Lanka, Middle East, Europe	Singtel	USA via Pacific USA via Atlantic
SEA-ME-WE4	1,280	Malaysia, Thailand, Bangladesh, India, Sri Lanka, Pakistan, Middle East, North Africa, Europe	Singtel	North and South America via Atlantic
I2I	8,400	India	Singtel	
TATA Cable	5,120	India	VSNL	
TIS	320	Thailand, Indonesia	Singtel	
Terrestrial Systems		**Destinations**	**Singapore Carrier**	**Onward Connections**
Optical Fibre Land Systems		Malaysia	Singtel and Starhub	South Africa via SAFE cable
Microwave Systems		Indonesia	Singtel and Starhub	

Table 2.1: Singapore's Global Connectivity

Source: Gibson Quai-AAS

Refer also to Box 3.6 in Section 3.3.4 Health Services which includes some discussion of AARNET's Singapore Point-of Presence.

54 TGN, Tyco Global Network, acquired by India's carrier, VSNL in November 2004.

2.3.1 Satellite Systems

Although largely superseded by submarine cable systems, satellite systems still play a significant part in some international telecommunications. Cables are expensive and extra landing points add substantial cost, so smaller country destinations are often bypassed (e.g. a Pacific island). Such destinations are readily serviced by satellite. Satellites also play a major part in television distribution where a common signal can be radiated to a suite of countries.

The Gnangara earth station complex in Western Australia is one of the most comprehensive in the world. Not only does it operate to both Indian and Pacific Ocean regions to provide international telecommunications, it also supports communications to ships, and tracks and monitors satellites.

2.3.2 Western Australia's Unique Position

Western Australia is well serviced by satellites because it is almost perfectly placed. Being positioned due south of South East Asia, it can take advantage of north and south beam configurations on satellite antennas. Also, earth stations in Perth can see satellites over both the Indian and Pacific oceans affording direct links to all countries in Africa, countries in Central Asia and Europe, as well as all the Pacific islands, including North America's west coast. It is only South America that cannot be seen from Perth.

2.3.3 Major Systems and Future Developments

In terms of providing global connectivity, satellites no longer account for much of the total traffic and capacity in and out of Australia. The National Bandwidth Inquiry (NBI), reporting in 1999, found that satellites accounted for 11 Gbit/s out of 18.5 Gbit/s total equipped overseas capacity; but this was before SMW3, SCCN and the AJC cables were brought into service.

The NBI reported proposed satellite systems that would deliver overseas connectivity were Skybridge and Teledesic; noting that it was "unlikely" that all announced systems would be implemented. Neither of these took-off (literally).

Satellites will be very important to Western Australia's Internet connectivity, but generally with respect to local connectivity in regional areas and for content distribution (e.g. movies), not international connectivity. The HiBIS scheme has improved the economics of satellite-based service providers like Austar and IPStar.[55] Improved connectivity from satellites and other improvements in broadband access will feed the demand for "Big Pipes" (see Section 4.2).

New technologies that may play an important role in the future improvements in local connectivity, such as High Altitude Platforms (HAPS), will continue to emerge. However, the focus of this report is infrastructure directly providing international connectivity.

2.4 Current East Coast Cable Systems

There are two major cable systems off the East Coast which together account for over 90 percent of Australia's global connectivity.

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55 See www.austar.com.au/ and www.ipstar.com.au/en/.

2.4.1 Southern Cross Cable

Current Configuration

The Southern Cross Cable Network (SCCN) was commissioned in 2000. It provides two diverse paths from Sydney to the USA with landings in Auckland, Suva and Hawaii. The cable was commissioned using 2.5 Gbit/s wavelength technology. Some of the wavelengths have been upgraded to 10 Gbit/s such that SCCN is now equipped with 230 Gbit/s of capacity from Australia to the USA. By lighting more wavelengths, SCCN has the potential to offer around 800 Gbit/s of capacity out of Australia. Currently approximately 60 Gbit/s have been activated including two (unprotected, physically diverse) 10 Gbit/s link for AARNet.

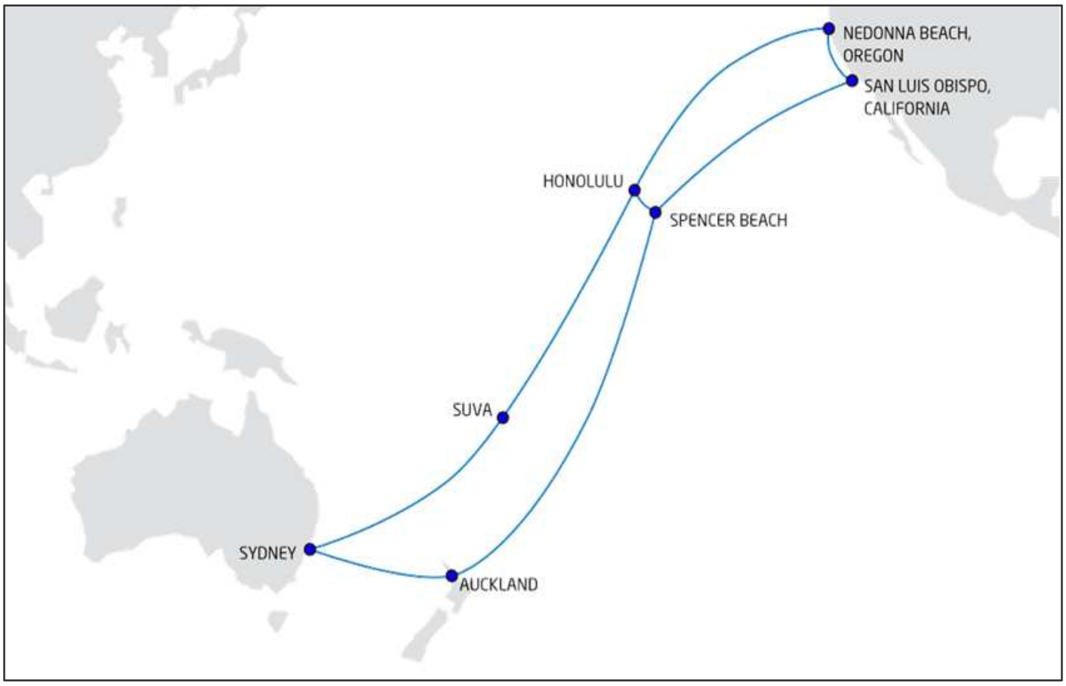

Figure 2.3: The Southern Cross Cables

Commercial Arrangements

The SCCN is a private cable system owned by Telecom New Zealand (50%), Singtel/Optus (40%) and MCI of the USA (10%). Ownership and capacity entitlement are not linked. Any intending user can acquire capacity. There are no restrictions or commercial complications, and there is capacity available.

Capacity can be acquired as "protected" or "unprotected". In the former case, the capacity comes with an entitlement to an automatic switch over to the parallel path in the event of a failure.

The standard price for an STM1 (i.e. 155 Mbit/s) to the USA is a single charge of USD2.77 million for protected, or USD1.95 million for unprotected capacity, provided for 15 years. Additionally, there is a charge of around USD10,000 per month for operations and maintenance. The lease price for a protected STM1 is USD60,000 per month.

2.4.2 Australia Japan Cable

Current Configuration

The Australia Japan Cable (AJC) connects Sydney with Guam and Tokyo. Commissioned in late 2001, it comprises dual landings in the three countries for protection with a common deepwater cable. The two fibre pairs are designed to support 640 Gbit/s. It is currently equipped for 80 Gbit/s and there are plans to double this.

Figure 2.4: AJC

Commercial Arrangements

The principal owners of the private cable are Telstra[56] (40%), MCI (15%), AT&T (10%), NTT (10%) and Japan Telecom (10%). Ownership and capacity entitlement are not linked. Any intending user can acquire capacity. There are no restrictions or commercial complications, and there is capacity available.

The standard price for an STM1 (i.e. 155 Mbit/s) to the USA is a single charge of around USD2.6m for protected, or USD1.9m for unprotected capacity, provided for 15 years. Additionally, there is a charge of around USD20,000 per month for operations and maintenance. The AJC prices are designed to provide connectivity to the USA at about same price as SCCN after allowance for the capacity from Japan to the USA. The typical lease charge for an unprotected STM1 is around USD60,000 per month which includes O&M.

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56 Telstra owns the equity; Reach owns the capacity.

2.5 Current Connectivity to East Coast

There is abundant and competitively priced capacity from Perth to Sydney to pick-up East Coast international cables or vice versa.

Public information about the capacities and pricing of the trans-Australia capacity provided by Telstra, Optus and Nextgen is scant. A study for Commonwealth Government managed to piece together the following overall statistics (see Table 2.2). The Perth to Darwin route in Western Australia will pick up the traffic from Jasuraus at Port Hedland (Western Australia). In view of the fact that the design capacity of this route is 4800 Gbit/s and the maximum possible capacity of Jasuraus is 20 (and possibly 40) Gbit/s we do not consider the cable route from Port Hedland to Perth to be a limiting factor in relation to access capacity to Jasuraus.

Route	Estimated Number of Fibres	Estimated Fibres in Use	Estimated Wavelengths Currently In Use	Estimated Equipped Capacity (Gbit/s)	Estimated Active Capacity (Gbit/s)	Estimated Design Capacity (Gbit/s)
Adelaide-Perth	124	56	28	170	67	24,800
Perth-Darwin	24	18	3	8	6	4,800

Table 2.2: August 2003: Capacity on Inter-Capital Optical Fibre Routes

Source: Telsyte Trunk Transmission Capacity Study for DCITA

Telsyte[57] gathers and publishes pricing information for many retail and wholesale telecommunications services. It reports that the Industry Median Wholesale price for a Sydney-Perth STM-16 (2.4Gbit/s) link is currently approximately AUD5 million per annum.

2.5.1 Telstra

Current Configuration

Telstra has three optical fibre cable routes from Perth to the eastern states of Australia (this includes IP1's assets acquired by Telstra).

Firstly, there is the original route along the Eyre Highway between Perth and Adelaide. Initially the 14-fibre cable was equipped for 2.5 Gbit/s wavelengths, which was subsequently upgraded to DWDM and 10 Gbit/s wavelengths.

Telstra has a second system (28-fibre) along the railway route across the Nullabor. This route, like the previous route, is solar and/or wind powered. Following upgrades, this system now has also fibre pairs with wavelengths at 10 Gbit/s.

Telstra's third system resulted from its acquisition of AMCOM's IP1 system. This system follows the highway route and was built in 2001 with 24 fibres. Each fibre pair has a design capacity upgrade path to 800 Gbit/s, and if 40 Gbit/s wavelength is used, a fibre pair could support 1.6 Tbit/s (1,600 Gbit/s). The system was acquired by Telstra when IP1 encountered financial problems. At present it is minimally equipped, but could easily be expanded as demand dictates. It operates using 10 Gbit/s wavelengths. It is quite lightly utilised to date. Currently, most of Telstra's spare capacity is IP1 based.

57 Telsyte is a division of Gibson Quai-AAS.

Commercial Arrangements

Telstra does not publish prices for high capacity inter-capital links. Its current commercial arrangements probably make it reluctant to sell a customer a 10 Gbit/s wavelength as an IRU with a lump sum payment. Rather Telstra will try to lease managed capacity on a monthly basis. But in a competitive supply context, Telstra probably would sell a 10 Gbit/s wavelength rather than a managed STM64 with the same capacity. But, this would only be on a customer-specific, price on application (PoA) basis.

2.5.2 Singtel Optus

Current Configuration

Optus has a single route 28-fibre cable system across the Nullarbor, which follows the Eyre Highway. It was installed in November 1999 and has been upgraded with the ability to operate at 10 Gbit/s per wavelength. Optus makes extensive use of 10 Gbit/s transmission systems between capital cities and may use 2.5 Gbit/s systems on smaller routes.

As of August 2003, the optical fibre cable used in the Optus trunk network was single mode optical fibre (SMOF). Optus has a single fibre route from Adelaide to Perth, with IP1 providing protection capacity. The Optus Transmission Network is equipped with DWDM equipment across the major backbone segments, from Brisbane to Perth.

Optus makes extensive use of DWDM equipment with a design capacity of 80 wavelengths. Each wavelength is capable of supporting 10Gbit/s SDH equipment. However, these systems are only equipped, at present, with a fraction of that capability.

Commercial Arrangements

As with Telstra, pricing of backbone capacity is PoA and would probably include selling 10 Gbit/s wavelengths.

2.5.3 Nextgen

Current Configuration

Nextgen networks, now a subsidiary of Leighton Holdings, built a system across the Nullarbor in 2002. Due to limited take-up initially, Nextgen had financial difficulties and the system was sent into receivership. At that point, AARNet and Leighton acquired it with AARNet taking two of the 12 Nextgen fibre pairs. Currently, AARNet's circuits are dimensioned for 10 Gbit/s per wavelength, but will be upgraded to 40 Gbit/s when the cost of the interfaces is justified. The system is currently owned and operated by Leightons.

The Nextgen system follows the railway route to Adelaide and extends onward to Melbourne, where it connects to Nextgen's east coast network. It is powered by diesel generators.

The trunk cable contains 12 fibre-pairs each capable of carrying up to 32 wavelengths at 10Gbit/s. As at build completion the Sydney-Melbourne was 800 Gbit/s capable and was upgradeable to 1.6 Tbit/s. Other parts of the networks were 320 Gbit/s capable and upgradeable to 1.44 Tbit/s. Currently, the system is equipped with 40 Gbit/s between Sydney and Melbourne and 20 Gbit/s on all other routes.

Within Perth, Nextgen has developed a CBD fibre network to enable ready connection at the highest possible capacity to buildings within the city. This is available free of charge to its customers connecting on-net buildings in Perth to on-net buildings on the East Coast.

Commercial Arrangements

There are no restrictions on the purchase of capacity from Nextgen. All purchases, whether as a lump sum payment for IRUs, wavelengths or tailored leases, are negotiable.

The current list price for a 10 Gbit/s wavelength from Perth to Sydney is $140,000 per month. The additional cost of O&M is estimated to be an additional 2.5% per annum.

The separate ownership of the Nextgen system affords an added level of geographical diversity, and hence security, should issues arise with Telstra or Optus.

2.5.4 Future International Capability

This area is explored in Chapter 4 of the report with some discussion of both SIAC (Singapore-Indonesia-Australia Cable) and Ochre Networks.

2.6 Summary of Key Findings

Western Australia appears physically well equipped with Indian Ocean submarine cables to service the demand for most conceivable applications in the near term (see Figure 2.5). However, this assumes no new data-intensive applications or "wild cards" come into play (see Section 4.1). With current capacity of 45 Gbit/s and potential capacity of 120 Gbit/s (or even more), the existing systems of Jasuraus and SMW3 only have around 11 Gbit/s activated, indicating a high level of spare capacity for future needs.

It also does not take into consideration, the complexity and difficulties associated with the multiple owners and half-circuit capacity regime make it difficult to access this "spare" capacity.

Cable	Age	Equipped/Lit Capacity	Active	Design/Potential Capacity
		West Coast Cables:		
Jasuraus	8	1Fx5G=5G	3G	1Fx2Wx10G=20G
SMW3	5	2Fx8Wx2.5G=40G	8G	2Fx4Wx2.5G + 2Fx4Wx10G=100G
		East Coast Cables:		
SCCN	5	2Rx((2Fx3Wx2.5G)+ (2Fx5Wx10G))=240G	75G	2Rx2Fx20Wx10G=800G
AJC	4	2Fx4Wx10G=80G	30G	2FxWx32G=640G
Total		**365G**	**115G**	**1,560G**

Table 2.3: Australian Cable Assets

Source: Gibson Quai-AAS

Notes:
F refers to the number of fibres in the cable.
W refers to the number of waves or colours used in each fibre.
R refers to the number of physically separate cable routes (SCCN).
G is Gbit/s on each fibre or wave or total.

There are a number of inhibitors despite Western Australia having access to East Coast cables where there are no commercial restrictions and abundant capacity to USA, NZ and North Asia, and that access to the East Coast is not hindered by lack of transcontinental capacity due to the three competing providers collectively having a combined design capacity bandwidth of more than 24 Tbit/s (24,000 Gbit/s, see Table 2.3 above).

Unfortunately, the commercial arrangements associated with each of these international systems will hinder greatly the utilisation of the spare capacity. In the case of Jasuraus, the cost is significant but the arrangements dictated by the APCN parties, which hold the northern half of the cable, will make access difficult. Expansion of the cable is also hindered by the requirements of Telstra in the terrestrial section from Port Hedland to Perth.

For the larger SMW3 cable, the existing consortium has set very high prices, which will discourage further use. Table 2.4 shows that there is effective competition between the two East Coast cables with prices per Mbit/s within USD50 of each other. However, on the West Coast, the "official" difference in price between SMW3 and Jasuraus is USD800 per Mbit/s. The price quoted for SMW3 is based on new capacity (using a price derived by the SMW3 consortium using an unchanged historical formula) and it may be possible to acquire resold capacity for less. Nevertheless, the unit price would still be significantly higher than on the East Coast. The West Coast pricing is artificially high due to historical arrangements and ineffective competition to SMW3 provided by Jasuraus because it is relatively small (currently 5 Gbit/s but with a maximum 20 Gbit/s). Hence, its owners are unlikely to agree to an upgrade and it may be retired early. Reach has spare capacity on SMW3, but announced in January 2005 that it would only supply capacity (apart from voice) to its owners (i.e. Telstra and PCCW).

	West Coast		**East Coast**	
	SMW3 (Segment A)	**JAS**	**AJC**	**SCCN**
Per STM1 (USD per month)	$250,000 ($9.5m for an IRU)		$60,000	$60,000
Per Mb/s (USD per month)	$1,600	$800	$370	$400
Ownership	Singtel Reach Telecom NZ	Singtel (15%) Reach (35%) APCN Owners (50%)	Reach (40%) AT&T (10%) MCI (10%) NTT (10%) Japan Tel (10%)	Singtel (40%) Telecom NZ (50%) MCI (10%)
Route	PER – Singapore	PER – Jakarta	SYD – Japan	SYD – USA

Table 2.4: Cable Pricing and Ownership

Unless SMW3 prices dramatically reduce, the motivation to provide an alternative cable will manifest itself again (see Section 2.1 above on NAVA and A2A).[58]

58 The prices in the Table are based on STM1 prices. Large users may obtain significantly better prices.

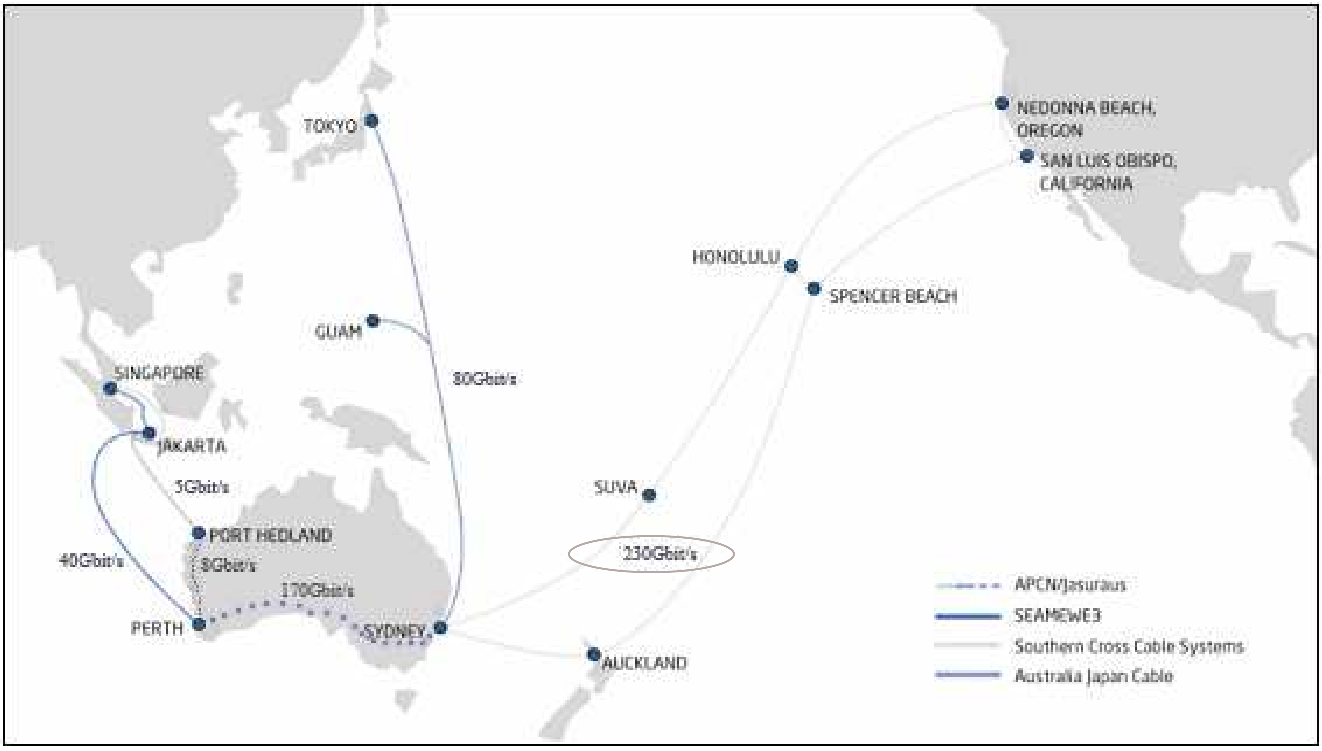

Figure 2.5: Australia's Connectivity

The lack of affordable connectivity is due to the lack of effective competition.

The problem is not so much physical scarcity; the principal cable off the West Coast, SEA-ME-WE3 has so much spare capacity and could be easily expanded further. The alternative cable, Jasuraus, although much smaller, could also be expanded. However, the complexity and difficulties associated with the multiple owners and the half-circuit capacity regime make it difficult to access this "spare" capacity. Consequently, the two cables do not exert the same competitive pressure on price that can be observed between the rival cables on the East Coast.

Regulated prices are a poor substitute for real price competition.

Another possible response to a lack of competition which has been exercised with respect to domestic transmission facilities is "declaration"[59], which provides the ACCC with the power to arbitrate prices. But, regulated prices would be counter-productive as they will "chill" investment in international capacity. Investment will be needed.

Once adequate connectivity is established to Singapore, then onward connection to China, India, Europe, Africa, other Asian destinations and North America is readily possible.
The rising importance of the China and India export markets and the proximity of the Singapore Hub emphasises the importance of Western Australia as a "Big Pipes" exit point for Australia.

Barriers to Western Australia's connectivity are essentially a lack of affordable international connections due to a lack of competition in the existing Western Australian exiting "Big Pipes".

59 See Part XIC of the *Trade Practices Act*.

3 Demand: Western Australia's Use of International Connectivity

In Western Australia, as in the rest of Australia, the domestic and international connectivity needs of "Big Science" are served by AARNet, using the physical capacity described in the previous chapter. Science and research often have special requirements in terms of communications, so it is appropriate to review the methods that are used by AARNet to meet these requirements.

The chapter then reviews the growing international bandwidth requirements of some leading edge research (astronomy and geoscience) and commercial applications for the sectors identified in Section 1.5.

3.1 AARNet

AARNet is owned by 38 Australian universities and the CSIRO, and is a licensed Australian telecommunications carrier. This entitles it to buy capacity at wholesale rates and also allows it to build capacity for third-party commercial use, although its charter precludes it from carrying commercial traffic except in special cases.

Under its charter, AARNet provides services principally to organisations that benefit research and education. An example of a commercial exception is AARNet's engagement with Southern Cross Cable Networks and SOHO Net to explore collaboration between film studios and post-production houses in Australasia the USA and the UK (www.sohonet.co.uk).

AARNet Terminology

- "on-net" means communications between AARNet members and between them and members of other National Research Education Networks overseas. Each country has one and sometimes more such networks. The rate of growth in national and international on-net (between NREN parties) in 2003 and 2004 was 44% and 19% respectively.
- "commodity" means communication between AARNet member(s) and off-net parties. Off-net Internet traffic in 2003 and 2004 grew, 34% and 26% respectively. Overall, AARNet's traffic grew by 24% in 2004.
- "commercial" means communications between parties none of whom are members of National Research and Education Network organisations. This is rare; AARNet has only 25 staff with a charter that principally supports education, research and the interests of its members.

Box 3.1: AARNet Terminology

From February 2004, AARNet was given responsibility for managing the Australian Research and Education Network (AREN). This is a co-ordinating and management role aggregating the interests of the various state initiatives.

AARNet relies primarily on Southern Cross Cables for its international connectivity. These cables are on the East Coast, as described in Chapter 2. The northern (Sydney to Seattle via Honolulu) circuit of SXTransPORT was activated in October 2004 providing AARNet a 10 Gbit/s link to the Pacific Northwest GigaPoP for research initiatives requiring very high capacity. The southern 10 Gbit/s circuit will support the Global Astronomy (Translight-Pacific) Initiative based on the international telescopes on the Big Island of Hawaii.

In addition, AARNet has four 622 Mbit/s circuits, two of which terminate at the world's largest public Internet exchange at Palo Alto (PAIX) in California and the other two at the Telehouse America exchange in Los Angeles.

West Coast international connectivity is not as well developed. AARNet is acquiring four 155 Mbit/s circuits across SMW3 and Jasuraus/APCN into Singapore. However, AARNet plans to expand its connectivity to Europe for high-energy physics (i.e. CERN's Large Hadron Collider), South Asia and Africa for education and North Asia for both research and education. During 2004, AARNet became a partner in the Trans-Eurasian Information Network (TEIN2) that will provide better connectivity to North and South Asia and to Europe.[60] As a result, AARNet will have points of presence (PoPs) in Singapore and Frankfurt. It will have access to the Taiwan-funded 2.5 Gbit/s on SMW4 from Europe to Singapore in 2006, going to 10 Gbit/s a couple of years later.[61] In the same time frame, the link from Singapore to Taiwan will be available to AARNet at 2.5 Gbit/s then 10 Gbit/s.

International Capacity

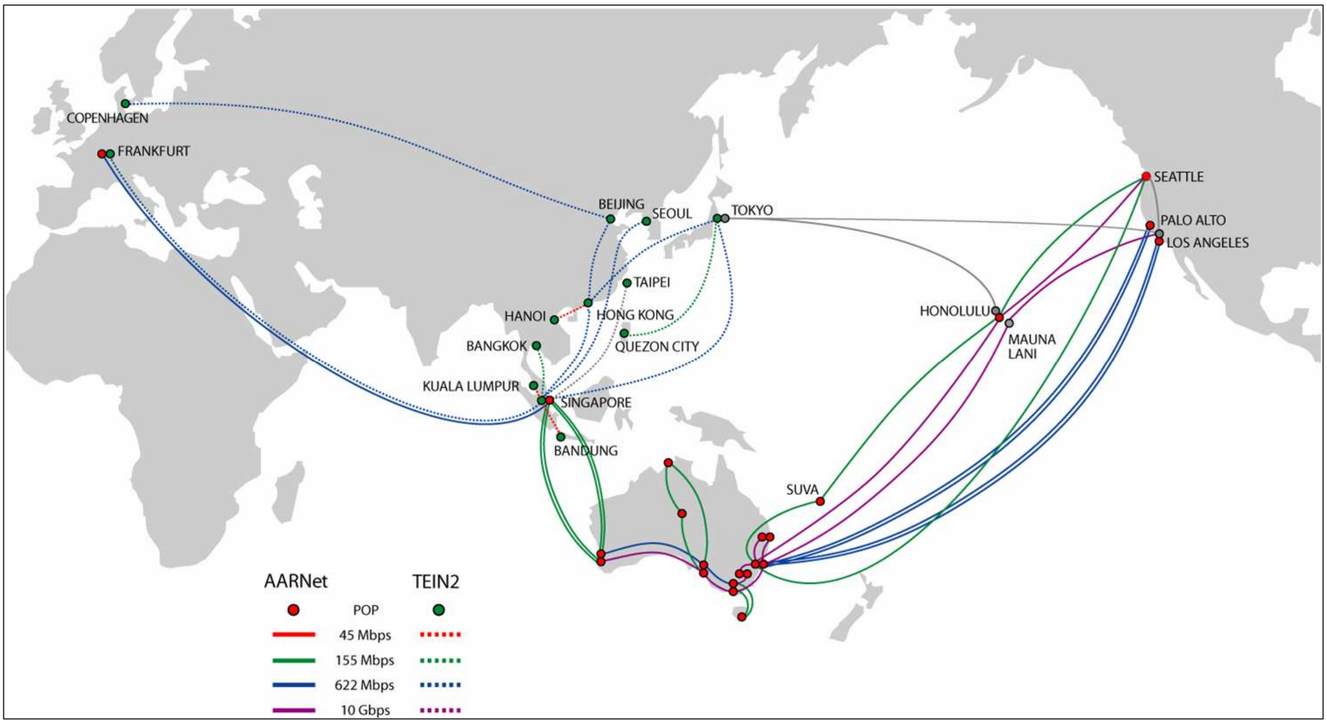

Figure 3.1: AARNet Global Connectivity

Source: AARNet

Deane Terrell, AARNet's Chairman notes in AARNet's 2004 Report that:

> *"In 2003 I said that networks of 10 gigabits and beyond would be a pre-requisite for collaboration on a world-wide scale. In the space of one year we are now looking to 40 gigabits and beyond in order to provide substantial opportunities for Australia to participate in global research and education initiatives."*

However, such plans for international connectivity at this scale will initially be based on multiple 10 Gbit/s paths. The prospect of 40 Gbit/s waves on submarine cables is dim (see Section 4.4).

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[60] The main beneficiary countries of the project are China, Indonesia, Malaysia, Philippines, Thailand and Vietnam with other regional participation from Japan, Korea, Singapore and Australia. The European partners in the project are France, the Netherlands and the United Kingdom.

[61] SMW4 is a yet to be deployed cable so capacity up to 2.5 Gbit/s would be available immediately. It will not extend to Australia initially. Commercial terms have yet to be determined.

AARNet will use hybrid optical/packet infrastructure, such as User Controlled Light Paths (UCLP), to support Australian participation in international projects such as the Large Hadron Collider (LHC) Project and the Square Kilometre Array (SKA) telescope. UCLP was developed by CANARIE (Canada's advanced Internet organisation and the developer and operator of Canada's National Research and Education Network, CA*net 4). It facilitates the provision of end-to-end private connections for scientific projects that demand huge amounts of dedicated bandwidth. By using this technology researchers can create their own dedicated capacity on demand.

Domestic Capacity

When Nextgen went into receivership (Section 2.6.3), it was acquired by Leighton Holdings under an arrangement with AARNet. The arrangement involved AARNet gaining Indefeasible Rights of Use (IRUs) to two of the 12 Nextgen fibre pairs. These fibres provide inter-capital city optical fibre connectivity across Australia. The two fibre pairs between Sydney and Brisbane pass within 30 km of each of three main Australian telescope sites (5 km in the case of Parkes). When the tails to Parkes, Coonabarabran (Mopra) and Narrabri are built, they will be among the 16 telescopes around the world that will be linked during early 2006 (the EXPReS project) with 1 Gbit/s circuits to the Netherlands.

Currently, AARNet acquires its 10 Gbit/s trans-Australia services on the original Lucent equipment that formed the original Nextgen service. These are dimensioned for 10 Gbit/s waves. It is possible to increase this by lighting more waves as demand dictates, or to upgrade to higher capacity waves as these options become more cost effective. In fact, AARNet is now re-equipping two fibre pairs with its own equipment to carry more waves and achieve a design capacity of 32 x 10 Gbit/s. This re-equipping will not initially extend beyond Adelaide to Perth (which will continue with the Lucent-enabled 10Gbit/s circuits) as the cost of the equipment that must be installed every 80 km across the Nullabor to support DWDM is not justified by current demand.[62] This may change as new high-demand projects, such as OPAL and the synchrotron (see Chapter 1), which will both aid industry and science in Western Australia, come online. It would also change if there were significant international capacity leaving Perth as this would be a more attractive route for the eastern states to get to South East Asia and Europe.

3.2 The Global Grid and "Big Science" in Western Australia

The concept of the "Global Grid" has emerged from the availability of increased bandwidth and the grid infrastructure that is being built on high capacity networks, computers, mass data storage systems, virtual reality and videoconferencing facilities and large-scale instruments. It is usually associated with e-research, but with the globalisation of production the concept is applicable to e-business too.

> *"Advanced networking enables people, tools, and information to be linked in ways that reduce barriers of location, time, institution, and discipline. In numerous fields new distributed-knowledge environments are becoming essential, not optional, for moving to the next frontier of research. Science and engineering researchers are again at the forefront in both creating and exploiting what many are now seeing as a nascent revolution and a forerunner of new capabilities for broad adoption in our knowledge-driven society."*[63]

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[62] Or, Western Australia could follow South Australia's lead and provide a capital grant to expedite the provision of these links.

[63] Atkins D. *Revolutionizing Science and Engineering Through Cyberinfrastructure*, report to the National Science Foundation from the Blue Ribbon Advisory Council on Cyberinfrastructure, January 2003.

The Higher Education Bandwidth Advisory Committee observed that the international dimension of the Grid is especially important for research, and reported that according to one estimate about 70 per cent of research now relies on networks involving global collaborations.[64]

The following sub-sections look at how astronomy and geoscience, which are both "Big Science" in Western Australia, collaborate across the Grid and the consequent demands they make on international connectivity.

3.2.1 Astronomy

The Cassini-Huygens Mission (see Box 3.2) shows that there has been progress since the conclusion of the 2002 Sargent Report that:

> *"Unfortunately, Australia does not, at present, have the network bandwidth or sufficient online storage to be a player in this ("virtual observatories") emerging branch of astronomy."*

With the low background radiation present in much of the State, Western Australia is an ideal location for radio telescopes. Despite the current, understandable hyperbole about the SKA (see below), it should be noted that Western Australia has an important place in advanced, bandwidth-hungry radio astronomy, with or without this facility.

The Cassini-Huygens Mission

In January 2005, AARNet played a leading role in the near real time transfer of data from two Australian telescopes, at Parkes and Mopra, to the Joint Institute for VLBI in Europe (JIVE) in the Netherlands as part of the Cassini–Huygens mission to Saturn and Titan.[65]

Using a technique known as Very Long Baseline Interferometry (VLBI), a network of 17 radio telescopes collected data to pinpoint the European Space Agency's Huygens probe during its descent through Titan's atmosphere. The data sent to JIVE from the Australian telescopes utilized SXTransPORT and a UCLP path from Seattle to the JIVE facility in Dwingeloo (the Netherlands). The data rate only occasionally touched 10 Gbit/s on the trans-Pacific leg.

This collaboration allowed for a quick end-to-end diagnostics of the Huygens VLBI tracking performance prior to the data from a worldwide collection of telescopes being processed to determine the position of the probe to within a kilometre.

Box 3.2: The Cassini-Huygens Mission

Source: AARNet

The xNTD

The "Extended New Technology Demonstrator" (xNTD) will be a $20 million radio telescope facility bigger than Parkes, built with American (MIT and Harvard) as well as Australian (ANU and Curtin) support. About 20 antennae and a processing ("correlator") facility will be located in a radio-quiet zone at Mileura, Western Australia. This is the same radio astronomy park nominated for the SKA.

xNTD will proceed regardless of the SKA outcome.

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[64] The Committee established by the Minister for Education, Science and Training, the Hon. Dr Brendan Nelson MP, in August 2002, to advise him of the short to medium term bandwidth requirements of the higher education sector with a particular focus on research needs.

[65] http://www.ieeaf.org/news/news_01b2005.html

In the Eastern States, AARNet is connecting each of three telescopes (see Section 3.1) to its Nextgen backbone network with 1 Gbit/s tails. At the xNTD site, at least this much will be required between each antenna and the "correlator" to collect 10 TB of raw data per day.

The "correlator" will compare the data across 20 antennae (190 correlations) and the resulting product will need global connectivity of 1 Gbit/s allowing for bursts up to 10 Gbit/s. This represents a significant level of demand for global connectivity out of Western Australia.

The SKA

The Square Kilometre Array (SKA) is the international radio telescope project for the 21st century. Australian scientists are hoping that Western Australia will be selected in 2006 for the €1 billion Square Kilometre Array (SKA) telescope project involving 20 countries and due for completion in 2020.[66] Three other countries are bidding for the right to host the SKA, which will be very large (60 to 120 antennae sites daisy-chained as an eVLBI facility). If the Australian site is chosen, the SKA will be centred in Mileura, with some antennae in other Australian States and New Zealand. But more than 90% of the antennae will be in Western Australia and the major processing capacity for the SKA is likely to be at Geraldton.

Note that all the sites will be "daisy-chained" with optical fibre. This (and the xNTD, which is definitely proceeding) may provide opportunities for communities passed by these links to tap into this broadband transmission infrastructure.

The SKA will have both unprecedented sensitivity (approximately 100 times better than any existing radio telescope) and unprecedented survey capabilities (due to a very large instantaneous field of view). As a consequence of these capabilities, the output datasets from the SKA will be vast. Many telescopes record over a Terabyte of data per night and the SKA telescope will have an effective collecting area more than 30 times greater than the largest existing telescope.

The amount of data generated by each SKA antenna depends on how much of the sky is observed and the resolution. Apart from the cost of communications transport, there are real issues in how much data can be correlated. There will be 18 to 75 times more processing than the XNTD, depending on the number of SKA antennae and their respective fields of view. If the raw data are sent abroad, the international connectivity required would be around 100 Gbit/s with bursts up to 1T. Processing the images locally and sending images could reduce this to 10 Gbit/s with bursts up to 100 Gbit/s. This single use is equivalent to Australia's current entire use of international connectivity (see Table 2.3).

The Australian Siting Proposal[67] recommends, *"a configuration of remote SKA array-station sites that spans the continent of Australia. The low population density, benign climate, high quality existing infrastructure and political and economic stability enable an optimum configuration for the SKA within Australia."* The proposal demonstrates that, *"an Australian location for the SKA will enable the highest quality scientific return on the significant international investment in the SKA over the coming decades."*

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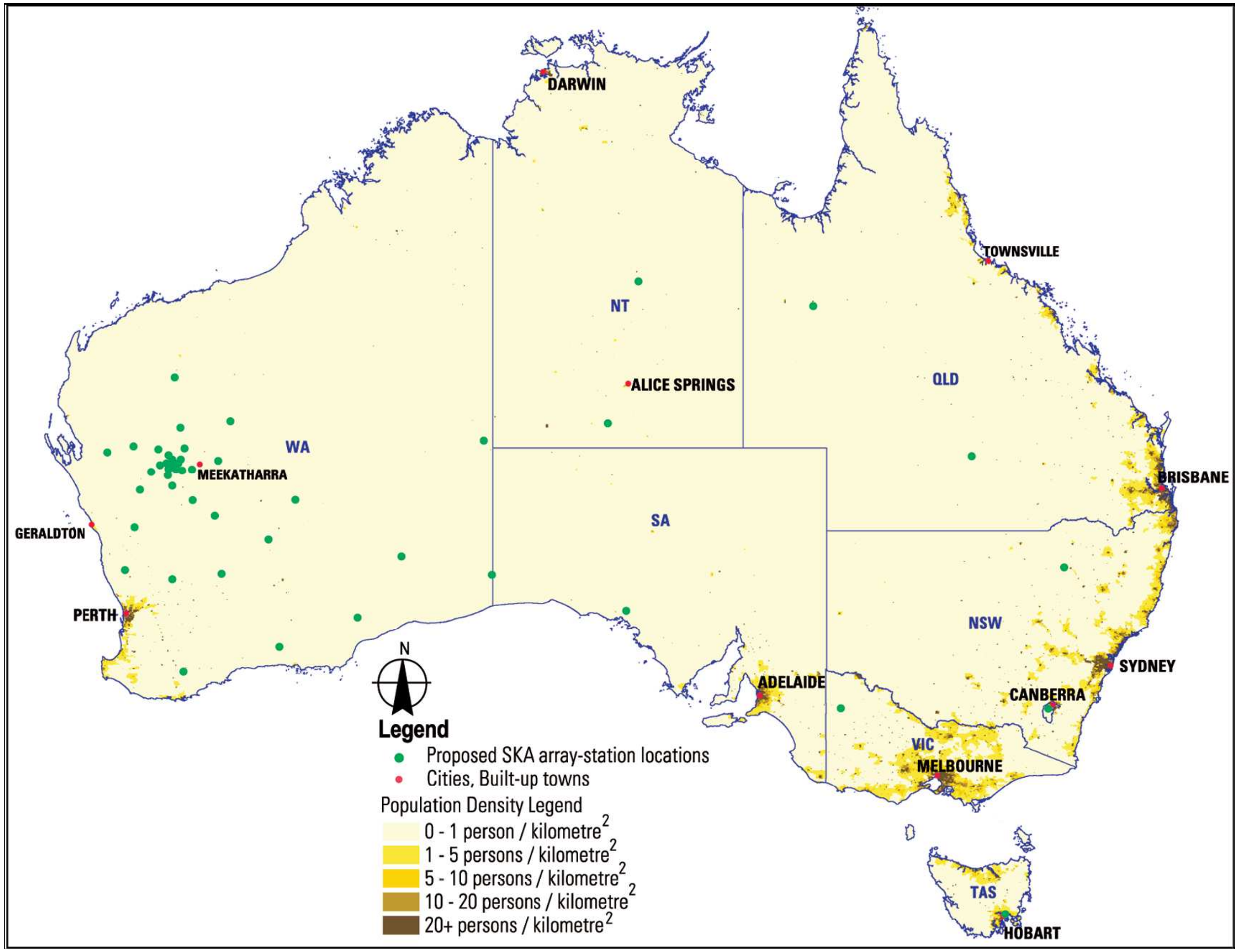
66 http://www.skatelescope.org/PDF/SKA_Booklet.pdf

67 *Proposal for Siting SKA in Australia*, submitted by Professor Brian Boyle, Australian SKA Director, on behalf of the Australasian SKA Consortium, dated 5 December 2005.



The proposed configuration for SKA in Australia, superimposed on a map indicating population density. The Australian SKA proposal places array-stations in very radio-quiet locations, with good access to infrastructure and excellent geophysical conditions.

Figure 3.2: Proposed SKA Configuration[68]

68 *Proposal for Siting SKA in Australia*, submitted by Professor Brian Boyle, Australian SKA Director, on behalf of the Australasian SKA Consortium, 5 December 2005.

The Australian Siting Proposal also points out:

> *"Astronomy is a high-impact, highly leveraged international science in Australia, and has strong Government support: Astronomy has the highest impact of any Australian Science [Source: Australian Department of Education, Science and Training (DEST) S&T, At a Glance 2004]. Australia has 420 professional astronomers and approximately 150 PhD students in any one year. About 30% of all activity in Australian astronomy is related to radio astronomy.*
>
> *Australia is already coordinating industrial assistance to the SKA within Australia. Because of the large number of components required for a distributed system such as SKA, engagement of industry in SKA design and construction at an early stage is critical. The activities on the Radio Astronomy Park provide a vehicle for early industry engagement in SKA R&D. Australia, and Western Australia in particular, has extensive experience in successful delivery of large and complex projects in remote areas."*

3.2.2 Environmental and Geoscience

The Sargent Report noted that increased satellite picture resolution, bandwidth coverage, and frequency of observations are creating a data avalanche that was largely unexploited. The biggest use of these images is in land management, and dealing with issues such as crop health and yields, salinity mapping, conditions of wetlands, and emergency management and forecasting (bushfire mapping, storm damage, etc).

Tremendous progress is being made in the modelling of wildfires, with the explicit inclusion of fuels and chemical reactions and full two-way coupling with the atmosphere. The use of HPC computational resources could allow for a more complete representation of land-surface characteristics, fuel composition and consumption, and feedbacks. This would lead to more effective strategies to combat fires including the development of chemical agents whose impacts can be tested empirically, at very large scales, in a virtual world. It is also possible to imagine the emergence of "rapid response collaboratories" that could enable an actual bush fire to be modelled in real time, based upon sensor data from the field. This could be used to monitor and direct the process of fire fighting.

The Australian Computational Earth Systems Simulator (ACcESS) provides a computational virtual laboratory facility enhancing minerals exploration through prediction of earth system evolution, improved natural and human-induced geohazard mitigation and prevention; potentially including breakthrough advances in earthquake prediction. The CSIRO and University of Western Australia (Centre for Industrial Solid Mechanics[69]) are among the core partners of ACcESS (http://www.access.edu.au).

In close association with the activities of ACcESS is the recent appointment of Dr Klaus Regenauer-Lieb as a Premier's Fellow jointly at the University of Western Australia (UWA) and CSIRO. His research activities include whole of Earth simulations of mantle convection and plate tectonics with applications to the other planets in the solar system as well. He will continue to be associated with the Minneapolis Supercomputing Centre once he moves to Perth in March 2006 and will be a large user of local HPC resources.

Two applications relevant to Western Australia are "geosequestration"; which refers to the burying of carbon dioxide and "geothermal power"; electricity generated by utilising naturally occurring geological heat sources. Both applications require detailed and complex computer simulation modelling of the sites proposed for such activities. This analysis is an exportable service that Western Australia could perform.

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69 http://www.ned.dem.csiro.au/research/solidMech/Solid-Mech-RC/

Clearly, it is necessary to have access to large-scale historical databases, over decades, to determine progress in salinity management, the effects of global warming on native vegetation, re-growth after bushfires and other natural disasters.

Satellite images now have a resolution of a few metres, and are available on dozens of bandwidths. These high-resolution, multi-bandwidth images are crucial – high-resolution enables detection of small crop and vegetation features, multi bandwidth enables automatic prediction of crop and vegetation condition and type, soil type, etc. A high-resolution image on multiple bandwidths, of just Victoria, would occupy about a terabyte of storage. Compression technology can reduce this, but it is clear that large-scale historical satellite records will occupy petabytes of storage.

Currently, Australia is air-freighting 1 TB of climate data to the USA daily!

3.3 International Connectivity and Commerce in Western Australia

Section 1.5 identified the key service sectors in Western Australia as: engineering and related services, biotechnology, education services, health services and research, design and technical services. Each of these is discussed briefly.

3.3.1 Engineering and Related Services

The Australian Resources Research Centre (ARRC), with 200 staff and post-graduate students, has been at Bentley Technology Park since 2001. Woodside Energy is a major commercial supporter of the ARRC, which has key research capabilities in geoscience and geo-engineering.

A good example of close international work in engineering design is shown in Box 3.3.

Austal Ships

Austal Ships[70] builds large aluminium ships for commercial and military use. In October 2005 it won a major US Navy Tender with Bath Iron Works, a subsidiary of General Dynamics. Each ship is worth $100 million and up to 80 may be built over the next 30 years.

The company is located in the Marine Centre of Excellence at Henderson. It has some current design-only contracts and consequently some of its 380 design staff are in Mobile, Alabama, so that synchronous exchange of files (i.e. low latency) is important.

It uses 3 Mbit/s of a 4 Mbit/s OF link it has to Perth provided by AMCOM where it crosses to its offices in Mobile through the "Internet cloud" using IPING as the ISP. At the other end, the office in Mobile has a 2 Mbit/s link to its ISP. Given the need to co-ordinate file-sharing closely in the offices both sides of the water, this is probably inadequate.

Box 3.3: Austal Ships

The opportunity for Western Australia is in the creation and retention of the teams of engineering excellence required to service the local mining sector, and the subsequent export of the information and knowledge through the use of "Big Pipes" and related technology to other parts of the world.

3.3.2 Biotechnology

As noted in Section 1.5.2, Western Australia has a very strong research base, and in November 2005, Perth hosted the AusBiotech conference.

[70] Austal Image builds small ships and is not engaged in imaging work despite its name.

Western Australia is reputed to be globally significant for genetics research. This is partly because Western Australia has an unusual integration of government hospitals and academia, giving it some unique medical databases. It is also easier than most places to "map".

> *"Western Australia has a geographically isolated population with low net migration, and because the state has only recently been settled it has an early history of very large families. Go back one or two generations and there were 10 or 12 kids in the families, which is good for genetic research. We are the genetics lab for the whole of Australia."* (Professor Lyle Palmer)

Western Australia has one of the most extensive collections of health information based upon population in the world. The acclaimed Busselton Health Study has been collecting data from the town's inhabitants since 1966. It is now planning to build a BioBank - a human genetics database containing the DNA of every consenting adult in the State. This and Data Linkage (see Box 3.4) will propel Western Australia into the global bioinformatics research marketplace.

Western Australia's Genetic Databases

At the Western Australian Institute for Medical Research's new laboratory for genetic epidemiology, director Professor Lyle Palmer is working on a database that will integrate all the state's human research information with the unique population data sets collected over the past 30 years. The Western Australian Genetic Epidemiology Resource (WAGER) database builds on the work of the state's Data Linkage Australia unit which links seven core population health datasets and strips patient identifying information from the data. In November 2005, the State Government provided a grant of AUD2m towards creating an international centre of excellence building on the Data Linkage Australia.

Recently, Data Linkage added Medicare and PBS claims information from the Health Insurance Commission, and aged care data from the federal Department of Health and Ageing.

Western Australia also has a large number of disease-specific banks of biological specimens. Ultimately, all of these will be integrated in WAGER and linked with the planned BioBank to produce: "*the best resource for human genetic research in the world*" (Professor Lyle Palmer)

Box 3.4: Western Australia's Genetic Database

Also in Western Australia, the Centre for Bioinformatics and Biological Computing (CBBC) at Murdoch University has unique experience in bringing together biologists and technologists to develop collaborative interfaces. In addition, Dr Fiona Wood (Head of Royal Perth Hospital's Burns Unit, Director of the Western Australia Burns Service and co-founder of Clinical Cell Culture) and Professor Matthew Bellgard (Director, Centre for Bioinformatics and Biological Computing) are working together on applying IT to the health sector.

The free access to genetic information allows scientists to study and compare the same data as their colleagues nearly anywhere in the world, and makes possible collaborative research that will lead ultimately to cures for diseases and improved health.

> *"Genetic research really is the future of clinical medicine, and holds the key to unlocking the causes of diseases such as asthma, cancer and diabetes."* (Professor Lyle Palmer)

None of the major international databases are hosted in Australia. The Australian National Genomic Information Service[71] did attempt to mirror such databases. However, the Sargent

[71] ANGIS provides access for over 5000 scientists from over 160 biological, medical and biotechnological organisations to a comprehensive system of bioinformatics software, databases, documentation, training and support, on a subscription basis (http://www.angis.org.au/).

Report noted that it was struggling to keep up in 2002 and now it seems to have given up. So, access to these critical databases is now by international links.

More medical and clinical databases are coming online, with increasing volumes of data. Large data sets include radiological images and MRI scans, which are produced with ever-greater resolution. MRI scans in raw form are at approximately 1 mm resolution, leading to about 1 MB of 3D data; radiological images are at far higher 2D resolution. Increasing use of these and other technologies will lead to huge databases of medical information. These databases will inevitably become more grid connected – to support portable medical records, large-scale data mining and epidemiological research. Although not as large as imaging (e.g. MRI scans), genome data is expanding fast. It is doubling every 18 months with 10 TB in sight.

APAC at least allows Australian researchers to stay in touch, but to be part of the global research effort they must also be connected with the PRAGMA (Pacific Rim Application and Grid Middleware Assembly) Grid**.**

The Centre for Bioinformatics and Biological Computing (CBBC) routinely has to exchange data with the national repository at the ANU via the network backbone that underpins the APAC National Grid. In Western Australia, the node for this Grid is at iVEC. Currently, it takes the CBBC five hours to get a complete copy of the ANU data. Therefore, updates are performed only once a week.

3.3.3 Education Services

Because of its geography, Australia was a pioneer in distance education and continues to be a leader in the use of technology in education for both distance education and e-learning. Charles Sturt University is now Australia's largest provider of distance education.[72] E-learning, the provision of training electronically, is also a significant market. It includes online learning, web-based training, virtual universities and classrooms, digital collaboration and technology-assisted distance learning (see Box 3.5 for a recent example of innovation).

Omnium

The Omnium Project is an Australian initiative to foster international online creative collaboration between students, teachers and professionals (http://www.omnium.edu.au).

One recent project was Creative Waves, which involved 120 art and design people on five continents over seven weeks in early 2005. Teams (five students plus mentor) were formed with no two members in the same country, and participants used Omnium's online design studio software supporting the exchange of text, image, sound and movies. They experienced a new form of collaborative design, which has traditionally been seen as an activity based on individual creativity.

Box 3.5: Omnium

OECD estimates suggest rapidly increasing ICT expenditures in primary, secondary and tertiary education, with total annual expenditures of around USD16 billion across OECD countries in the late 1990s – mostly on hardware and networks.[73] In the United Kingdom, education sector spending on ICT was estimated at GBP 1.6 billion during 2002 and increased by more than 30% during the year. An estimated GBP 719 million was spent by schools; GBP 595 million by higher education and GBP 265 million by further education.[74]

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72 AFR, 17 October 2005.

73 OECD (2001) E-Learning: The Partnership Challenge, OECD, Paris, p20.

74 Dudman, J. (2003) 'Vertical market focus: Stay in school,' *Computer Weekly*, 25 February 2003.

The Australian e-learning market was estimated to be worth some AUD150 million in 2001, with annual growth rates then projected to exceed 20 percent.[75] IDC suggested that the e-learning market in the Asia-Pacific region would have been worth USD453 million in 2004, with growth being driven by Australia.[76] Large populations in rapidly developing economies, and large and sophisticated education systems in the Asian region, provide opportunities for both the provision of education services and the services and tools that support them.

Expanding the provision of education services in international markets will depend upon the quality and capabilities of education service providers, and upon the availability of communications networks capable of supporting the delivery of those services.

3.3.4 Health Services

Many factors influence the successful export of health services, but the technological sophistication of local service suppliers and the ability to support remote health services in areas such as diagnostics, will play an important role. The public health sector is potentially a major user of ICT. However, the Health Sector in Western Australia is not yet a major bandwidth user.

As with education services, however, there is a crucial convergence, with the major service providers (i.e. hospitals and universities) also being the main centres for related research activities in such fields and biotechnology and bioinformatics.

Growth Opportunities for Asia-Australia Regional Telemedicine Collaboration

Surgical training relies heavily on trainee surgeons watching an experienced surgeon perform an operation (and listening to their commentary and asking questions). Strategically placed high-definition cameras and microphones, coupled with high capacity networks and quality video/audio equipment can take the teaching/training experience out of the operating theatre and to other parts of the country and region.

AARNet activated its Singapore Point-of Presence (PoP) on 20 January 2006. This was connected to one of its Perth PoPs by four 155 Mbps circuits resulting in substantially improved latency to Asia (round trip times of 50 ms from Perth to Singapore, and around 150 ms to North Asia, compared to over 300 ms when bouncing off the US west coast).

The benefits were illustrated to great effect during an interactive telemedicine (surgical) demonstration three days later, at the Asia Pacific Advanced Network meeting in Tokyo, where Flinders Medical School in South Australia participated with equivalent institutions in Japan, China, Korea and Singapore in a highly interactive live surgical operation (10 sites in total participated). The improvement in latency substantially enhanced the interactivity as well as catalysing a new spurt of Asia-Australia regional telemedicine collaboration.

Box 3.6: Growth Opportunities for Asia-Australia Regional Telemedicine Collaboration

3.3.5 Research, Design and Technical Services

A specific example in Western Australia is the national networked tele-test facility centred on a state-of-the-art semiconductor tester located at Edith Cowan University. This was funded by the only Federal Government grant won by Western Australia out of the Major National Research Facility Grants of 2001.[77]

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75 Monster Learning Asia Pacific survey, IDC, Frost and Sullivan.

76 DEST (2003) *Mapping Australian Science and Innovation*, Department of Education, Science and Training, Canberra, p303.

77 http://www.ausindustry.gov.au/content/content.cfm?ObjectID=E385CC7B-60FA-412B-ADC4F0F595575983&L3Keyword=major%20national%20research%20facilities%20(mnrf

The facility provides a capability for electronics and microelectronics researchers and industry communities around Australia to test and prototype very large scale integrated (VLSI) circuits and other systems on chip (SOC) devices, prior to moving to the manufacturing stage. Such testing is absolutely essential to ensure that the devices perform to specification. Large-scale computational engineering generates huge datasets and the Edith Cowan facility is linked to testing nodes at five other universities across Australia.

Dynamic Digital Depth is another example of knowledge-intensive skills developed in Western Australia. This was formed by an academic from Curtin University with support from Samsung and Motorola (see Box 3.7).

Dynamic Digital Depth

Dynamic Digital Depth (DDD) (www.ddd.com) creates 3D images as a post-production service for the film and advertising industries. It converts any 2D film into a 3D version. This can not only breathe new life into existing movies in a more spectacular way than colourisation but also has tremendous potential for mobile phones with Sharp and DoCoMo looking at 3D screens. Contrary to what might be expected, adding the extra dimension does not double the content that is sent to the mobile phone; good results can be obtained with only 10-20 percent of extra bandwidth.

While the ultimate users of the product may not need much extra bandwidth, the company does. DDD is on the Bentley Technology Park site where it has only a 2 Mbit/s pipe to its ISP. But, DDD has an office in Santa Monica and while it routinely moves 200 MB files between there and Japan electronically (FTP), it is currently more cost-effective to air-freight digital tapes to various parties around the world: primarily in the US, Japan, Israel, and Canada. Ideally, it would like a 100 Mbit/s link to the USA, but this would be too expensive. High-speed links would also allow it to communicate more effectively with its customers in Hollywood and Japan. If there was a service that offered this company a large pipe on-demand at a reasonable price it would use it. Another issue is reliability. It often has to re-initiate failed transfers, a painstaking process where transfers must be constantly watched to ensure they go through.

DDD uses the "Internet cloud" to reach its clients anywhere in the world (e.g. Israel). Again, for reasons of cost, it has to air-freight files back and forth.

Box 3.7: Dynamic Digital Depth

A related example, not in Western Australia but which could also make use of enhanced and more affordable international connectivity, is Animal Logic.

Animal Logic

A well-known post-production shop that has requirements for international connectivity is Animal Logic (http://www.animallogic.com/home.html).

Animal Logic provides visual effects for movies and advertisements; most of the former and half of the latter is for overseas clients. It is also currently doing a full feature cartoon graphics film.

It has two links. One is a 10 Mbit/s tail with UECOMM which supports both a 5 Mbit/s "all you can eat" (no byte charges) broadband Internet plan as well as a 2 Mbit/s private link to a peripheral activity in Sydney. The former is considered sufficient, as sending work-in-progress does not need more than 1 Mbit/s to 2 Mbit/s. The "all you can eat" service sends about 100-400GB per month overseas, and receives about 300GB per month.

The second link is a multi Gbit/s private link on sohonet (http://www.sohonet.co.uk/) to its co-location centre in Mascot, where their large computers are housed. Sohonet also provides up to 100 Mbit/s international connectivity to other Sohonet customers.

Their priorities have (like many others) shifted over time from tails (they now have fibre to the door), and broadband access costs (they now have "all you can eat") to international bandwidth. They need 20 Mbit/s to get quality video links, but would like more if it's cheap enough (like everyone else). Like DDD, they need a bandwidth service for "peaky (bursty) demand" which does not fit current pricing models.

Box 3.8: Animal Logic

All these examples show that Australia can have successful, knowledge-intensive, high value added export services that rely on affordable international connectivity to prosper.

3.4 Summary of Key Findings

The previous chapter showed that physical capacity is abundant in existing international cables. But, we have seen in this chapter that "Big Science" will stretch the limits of what can be provided with existing international capacity. Taking into consideration the future needs and demand of industry; "Big Business" will almost certainly ensure that requirements will exceed bandwidth.

Greater efforts must be made to include Perth in the upgrade of the network backbone that underpins the APAC National Grid

The science community in Western Australia is generally well served by AARNet. However, AARNet cannot afford to re-equip the long Adelaide-Perth circuits to carry multiple wavelengths at this time. South Australia provided a grant to make the enhanced APAC Grid available to its own researchers. Until the Western Australian Government provides a similar grant, researchers in Western Australia will not have the same bandwidth as those in South Australia and the eastern states for moving around very large amounts of data. This may constrain access to the new OPAL and synchrotron facilities on the other side of Australia (see Section 1.2.2) that Western Australians will need to use.

Such an upgrade works both ways. Researchers on the other side of Australia and the other side of the Pacific Ocean will need to access the new radio telescopes (xNTD which is proceeding and possibly the SKA) planned for Western Australia.

Telescope communications infrastructure should factor-in regional development.

If Australia is fortunate enough to be chosen in 2006 as the site for the SKA telescope, there may be the possibility of using the infrastructure linking SKA sites to provide improved access to business and people in remote areas. Most of the SKA sites are in Western Australia.

Even without the SKA, the xNTD telescope (which is proceeding) will provide significant opportunities. The "correlator" will compare the data across 20 antennae (190 correlations) and the resulting product will need global connectivity of 1Gbit/s allowing for bursts up to 10Gbit/s. This represents a significant level of demand for global connectivity out of Western Australia.

Business needs more affordable international connectivity.

Business can require large volumes of data to be shifted over communications links. But, the main requirement for business is for more affordable international connectivity. Demand is artificially constrained, despite the abundance of physical capacity, because of current retail pricing models that do not cater for the short, bursty requirements of some customers.

4 Identification of Gaps and Opportunities

Demand for international capacity is continuing to accelerate. At the same time, there is no sign of the log-jam in affordable global capacity off the West Coast being broken. Technological improvements always help extract more from what we have, but they are not a perfect substitute for increased capacity.

4.1 Future Demand

The principal driver of capacity ex-Australia is the Internet, fuelled greatly in recent times by the rollout of broadband to the home. Compared with dial-up connections, broadband is more convenient ("always-on") and faster. Definitions of broadband vary (see Box 4.1). But, the definition is a moving feast. For example, in the United Kingdom, the cable operator NTL raised its baseline speed from 128 kbps to 10 mbps between 2003 and 2005.

Broadband

In Australia, the ABS defines broadband as an "always on" Internet connection with an access speed equal to or greater than 256 kbps and the ACCC defines the threshold as 200 kbps

In the United States, the Federal Communications Commission (FCC) set the speed for broadband access at 200 kbps in one or both directions.

When the OECD first began to collect data on the take-up of DSL and cable modem access, no DSL or cable modem service advertised at less that 256 kbps for downstream connectivity. As this threshold was higher than basic ISDN (i.e. 128 kbps) it seemed a convenient benchmark.

For the purpose of statistical collection, the ITU also defines baseline broadband at 256 kbps but this includes both the upstream and downstream capacity. For the ITU, broadband is defined as being equal to, or greater than 256 kbps, as the sum of the capacity in both directions.

In December 2003, the European Commission's Communications Committee (COCOM), recognising that a small number of incumbent telecommunication carriers provided DSL service at 128 kbps, specified no threshold speed for the incumbent operators' DSL lines. The threshold speed for alternative platforms for both incumbent telecommunication carriers and new entrants was set by COCOM at 144 kbps.

Box 4.1: Broadband

Source: Gibson Quai-AAS and OECD[78]

The current Australian demand for Internet related capacity is 60 Gbit/s of protected basic capacity. Adding the corporate demand for IP connectivity, voice traffic, AARNet and miscellaneous traffic makes a total level of activated capacity at June 2005 of some 115 Gbit/s. This compares with the currently lit capacity of some 365 Gbit/s, and a potential design capacity of 1,560 Gbit/s (see Table 2.3).

In terms of forecasting the future requirements for global connectivity, the following points need to be made.

First, forecasts of global connectivity requirements should not be done at the Western Australian level. The demand generated within Western Australia is serviced by cables on either or both coasts. The converse is also true. Demand for connectivity to China, generated, say, in Sydney, could be serviced better by capacity off Western Australia, rather than going via Japan or the USA.

78 OECD *Guide to Measuring the Information Society*, November 2005.

Of all of the traffic currently generated into or out of Australia, some nine percent is attributable to Western Australia using voice telephony as a proxy for all traffic. Approximately one percent of that nine percent is non-Perth, with the balance due to Perth. Historically, Western Australia has split its international traffic evenly between direct international connections out of Western Australia, and international connections via the East Coast.

Second, as indicated in Table 4.1, there are a number of drivers increasing demand for Internet connectivity by both business and residential customers. The demand for broadband was only unleashed in early 2004 when Telstra, quickly followed by other ISPs, lowered entry-level prices for broadband plans to around AUD30 per month. As shown below, the number of broadband customers has doubled in a year and with another 4 million customers currently on dial-up, the potential for more customers to migrate to broadband is significant.

A number of ISPs have begun to offer higher-speed services based on Telstra's unbundled local loop, and further investments by several ISPs to rollout such services have been announced. In the last year, the share of broadband customers with access speeds over 1.5 Mbit/s has grown from a quarter to a third. This sector will not only grow, but will also lead to 6 Mbit/s becoming the new standard (which will also support video-on-demand).

Faster speeds are known to entice customers to spend longer at their computers and also facilitate greater downloads; at least 10 times more than a dial-up user. The average amount downloaded is also increasing. The "Small Pipes" (local access) are getting bigger and this creates more demand for "Big Pipe" capacity!

A recent study by Telsyte indicated that the retail broadband revenue generated by all ISPs in Australia has grown from just under AUD400 million per annum in June 2003 to almost AUD1.6 billion in December 2005[79]. Some of this demand is for entertainment (e.g. games, music, videos, etc.), which will increase as customers gain confidence in security and authorisation arrangements, and will lead to spin-offs in more main-stream areas (e.g. the quality of graphics). Nevertheless, Australia lags behind much of the developed world in broadband adoption, falling below the OECD average in terms of broadband subscribers per 100 inhabitants in June 2005. The level of broadband adoption among some of our major Asian trading partners (e.g. Korea) is more than twice that of Australia's.[80]

	March Quarter		Comments
	2004	2005	
Broadband users	0.8m	1.8m	Telsyte predicts[81] 7.7m broadband and 0.4m dial-up users by 2010.
Over 1.5 Mbit/s	24.7%	33.5%	Much higher speeds becoming available with competitive DSLAM roll-out.
Average broadband user's annualised download	23.1 GB	27.4 GB	Higher speeds, new applications (e.g. VoIP, IPTV) and lower prices will increase average downloads per user.

Table 4.1: Drivers of Demand Growth[82]

79 Telsyte Market Demographics and Forecast Series, *The Australian Internet Market: Narrowband and Broadband Services,* Version 1.0 November 2005.

80 OECD. Communications Outlook, 2005.

81 Reported in the SMH, 14 November 2005.

82 ABS Cat. No. 8153.0 and Gibson Quai-AAS.

Not shown in Table 4.1 is the demand from mobiles and other hand-held devices. Mobiles are moving to new technologies that focus more on content delivered to phones. So, demand for music, games and even video (see Box 4.2) may become significant.

PIXe

PIXe is a software algorithm developed by Blaze in Western Australia to compress video files. (http://www.blazelimited.com). PIXe uses an optical principle called "short-range apparent motion" which eliminates data from an image while fooling the eye into believing that nothing is missing. When used with a compression codec such as MPEG-4, files can be reduced in size by as much as 90 per cent. Its major trial is currently on Russia's largest mobile service provider (45m customers). Blaze is now looking to expand its San Francisco office as "*80 cents in every dollar in video compression goes through the US*" (Blaze CEO, Peter Hartshorne).[83]

Box 4.2: PIXe

Third, there are some "wild cards" that will result in major increases in capacity requirements. Chief among these is the data generated by radio-telescopes located in Western Australia. The SKA facility alone would need the equivalent of Australia's total currently active international capacity (see Section 3.2.1). Specific applications like these are likely to attract specific funding resources from overseas that could benefit international connectivity.

We have not been able to ascertain the needs of Defence, which may also be significant.

4.2 Future International Capacity

There is a feeling of *deja vu* in reviewing current plans for infrastructure investment in global connectivity. Section 2.1 noted that neither the NAVA nor the A2A cables mooted for Western Australia in 2002 came to fruition. These plans were a response to the high cost of capacity off the West Coast; which remains very high (see Table 2.4).

4.2.1 SIAC (Singapore-Indonesia-Australia Cable)

So, it is no surprise to see the current proposal being floated for the SIAC cable. The principal promoter is Singtel, which is looking for a cost effective way to link its Singapore and Australian operations. As mentioned above, existing pricing and commercial arrangements make new capacity attractive; if only as a negotiating lever. As an owner in SMW3, one might think Singtel would have more influence on pricing out of Perth. But, it has used up its investment credits (MIUs, see Section 2.2).

As the cable would traverse Indonesian waters, an Indonesian landing (presumed to be Jakarta) is included in the proposal. It is anticipated that the design capacity would be approximately 2 Tbit/s (i.e. 2,000 Gbit/s). Given the ideal deepwater approach to Perth, it is expected that it would land near Perth and terminate at the Optus switching centre in Perth. Tenders were called in July 2005 and it is estimated that it will cost around USD100 million. The nature of the commercial arrangements, including the terms under which other parties can join, are unknown.

Although this cable has reached the tender phase, there is no certainty that it will actually materialise. For instance, SMW3 consortium members, seeing that potential future sales will vaporise with the building of this cable, may well remove their opposition to price reductions.

[83] Article by Brad Howarth in Next portion of the SMH, 31 Oct-4 Nov 2005.

Should the SMW3 price then become more realistic, the idea of spending USD100 million on SIAC, when there is adequate capacity for the foreseeable future, would be hard to justify. This would be particularly the case for Singtel, given that it lost heavily when it sponsored the C2C cable from Singapore to Japan in parallel with similar systems, generating over-supply and insufficient sales to achieve an economic fill. C2C has just gone into receivership and it is expected that it will emerge in due course with reduced debt. C2C is, however, unlikely to produce cheaper capacity between Singapore and Asian points up to Japan. This is because prices are already low due to the glut in capacity and the heavy competition.

4.2.2 Ochre Networks

Another new cable has also been proposed recently by a West Perth company called Ochre Networks, which claims to have secured some funding support. Details are scant, but the cable is proposed to be between Perth and Singapore and will be modelled along the lines of NAVA, which failed to materialise when the market turned down in 2002. Given the potential capacity of the existing systems, and the possibility of the SIAC sponsored by a major operator (Singtel), the prospects of the Ochre cable materialising seem low at this stage.

In both cases, investment plans for new cables are threatened by the potential for inexpensive upgrades of existing cables. The combination of Jasuraus and SMW3 currently affords capacity of 45 Gbit/s out of Perth. This capacity can be increased to 120 Gbit/s with upgrades costing less than USD20 million, compared with around USD100 million for a new cable to Singapore. Currently, only some 11 Gbit/s of capacity is in day-to-day use, so technically there is plenty of spare capacity readily available out of Perth.

4.3 The Gaps and Opportunities

As noted, investment plans for new cables have been threatened by the over-hang of capacity available in SMW3. We also saw in Chapter 3 that there is pent-up demand for global connectivity at more affordable prices and we have seen in Chapter 2, that prices on the West Coast are exorbitant. If the price of international connectivity could be brought down towards cost, demand would increase greatly.

Australia sends around 90 percent of its traffic via East Coast cables and some 10 percent via West Coast cables. This is principally due to the fact that more than 50% of voice traffic goes to NZ, USA, Canada, UK and Japan, and over 75 percent of Internet traffic goes to or via the USA. These destinations are all well accessed from the East Coast. That still leaves West Coast connections under-represented, and this is probably due to higher prices for connectivity compared with the East Coast.

However, the case for new cable capacity off the West Coast is stronger than the issue with current pricing of SMW3. Even if SMW3 operated at it full design capacity (100 Gbit/s), the West Coast is Australia’s weakest link in global connectivity (see Figure 4.1).

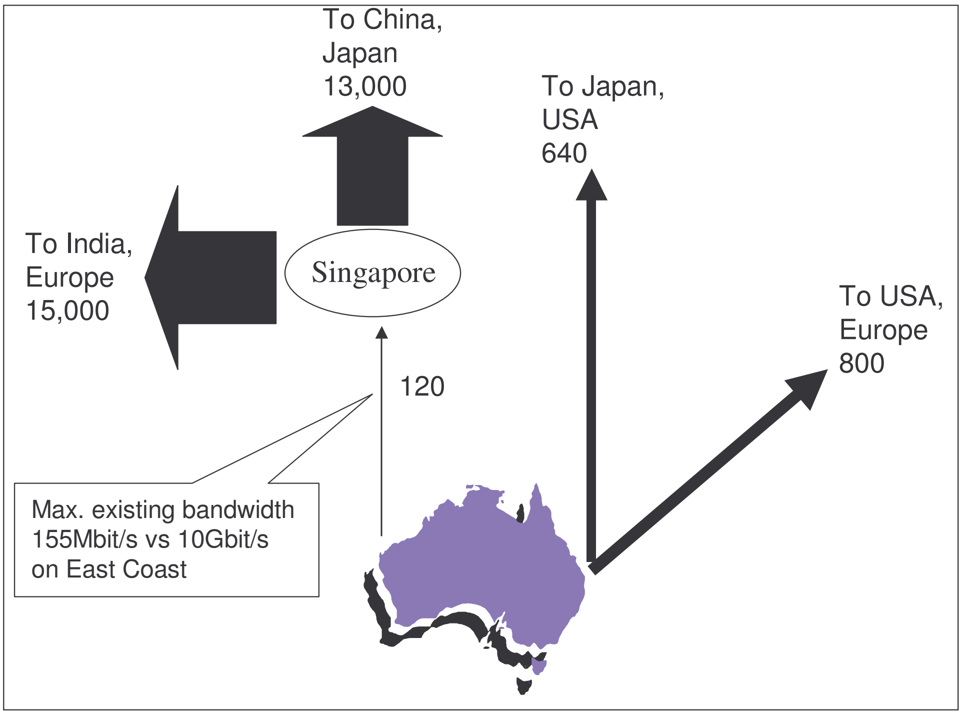

Figure 4.1: Global Links at Design Capacity (Gbit/s)

Source: Tables 2.1 and 2.3

New capacity is needed to tap into the new transmission systems going west (Frankfurt via India) and north (Taiwan) out of Singapore in 2006. Routing via Sydney then Japan or the US to reach Singapore is not as desirable as routing from Western Australia because of poorer quality of service (see Box 4.3).

AARNet has two international gateways in Australia: Sydney and Perth. Researchers can get 10 Gbit/s links from Sydney to the USA, but nothing like that going North from Perth. The largest international circuit provided out of Western Australia is currently only 155 Mbit/s.[84] With an increasing amount of research collaboration with China and other parts of Asia, West Coast cable capacity is a very weak link in Australia's global connectivity infrastructure.

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[84] On SMW3, this is because it has no suitable accessible optical interface – the largest SDH module available is 155 Mbit/s so if you buy 622 Mbit/s, you get 4 x 155 Mbit/s not 1 x 622. With re-equipping of SMW3 at the optical mix level, it would be possible to get the following interfaces: STM1, STM4, STM16 (2.5Gbit/s). And, upgrading the SLTE (Sub Line Terminal Equip) could give you 10 Gbit/s waves and STM64 interfaces.

QoS

Several interviewees commented that "latency" is the most important aspect of quality of service (QoS) for them. However, it is important to understand the relationship between the other parameters that have an impact on QoS - the type of traffic carried by the cables and the cable performance. The following parameters collectively define the QoS over a data network of which the big pipes are an important network element.

Latency

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Latency is defined as the time it takes a packet to travel from source to destination. For example, network latency is the delay introduced when a packet is momentarily stored, analysed and then forwarded. This is usually measured in milliseconds (ms) and deterministic applications like voice and video will generally require latency of less than 120 ms.

In relation to the submarine cables, the latency is substantially controlled by the speed of light. Within the optical fibres the latency between Sydney and Los Angeles is 70 ms on SCCN and 90 ms on the more roundabout (via Japan) route. But, latency is also increased by the electronic equipment connected to the end of the cables and the technology that is used to connect the submarine cables to the end users. In particular, equipment in the local loops far removed from the cable can be a major contributor to latency. Also, where bandwidth is shared through aggregation or a traffic management device (such as a router) then additional latency can be generated. By way of examples, here are the results of some "ping" tests, which give a measure of round trip delay including devices (all ex-Sydney)

Sydney – Tokyo via Perth	240 ms
Sydney – Tokyo via AJC	135 ms
Sydney – Perth	80 ms
Sydney – Perth – Singapore	180 ms
Sydney – Los Angeles via SCCN	175 ms

The design of a computer network is potentially complex if latency considerations are important and will have to take into consideration not only the latency contribution from submarine cables but also the physical location of the computers, the connections between the computers and the submarine cable gateway and all of the series electronic devices within that network.

Packet Loss Ratio

The packet loss ratio (PLR) represents the percentage of lost packets between the source and destination CE routers belonging to the same community. The major contributor to packet loss is usually the equipment connected to the submarine cables. This can vary considerably from one country to another, depending on the "last-mile" technology. There is no packet loss in submarine cables. There are bit errors, but with correction techniques the error rate on the cable itself can be expected to be better.

Jitter

Jitter is defined as the variation in the time between packets arriving. This is caused by network congestion, timing drift, or route changes. It is computed as the variation of the delay for two consecutive packets. Again this QoS parameter is substantially driven by the terminal and "last mile" equipment. The contribution to jitter by submarine cables is less than 0.15 nanoseconds for a 10 Gbit/s waveguide. This is negligible compared with that contribution which will be made by active network equipment connected to each end of the cable.

Clearly latency, packet loss and jitter are elements which need management, but with the right route selection, the impairments contributed by the international submarine cables are minor compared to what is contributed by other network elements.

Box 4.3: QoS

Globally, the shift of economic power towards China and India means that Western Australia should become increasingly important to the rest of Australia as the "gateway" to the fastest growing regions on the planet (see Table 1.1). With China building its five-year plan for 2006-2011 and the planned free trade agreement (FTA) between Australia and China, now is a good time to review Western Australia's connectivity to China. Western Australia already has strong trade ties with China, but it will not be able to leverage these into its aspirations to be part of the global knowledge economy unless it has the global infrastructure to support global partners.

Capacity from Singapore to India

AARNet has commenced working with some of its partners to put in place capacity between its Singapore Point of Presence (PoP) and India. It is likely that within a year, this capacity will exceed AARNet's capacity from Perth to Singapore. Optimal use of the Singapore-India link can only be realised through higher capacity paths from Perth to Singapore (either via upgrade or a new cable system).

Box 4.4: Capacity from Singapore to India

Western Australia is the natural gateway to Asia and Europe for the whole of Australia, not just because it reduces latency, but also because it provides route diversity. With national security issues becoming more important, Australia's reliance on Sydney for international connectivity makes it vulnerable.

Incidentally, there is no point seeking to build a link from Perth direct to China (although this may be what end users order); there is abundant capacity in all directions from Singapore to piggyback. We just have to expand the link to Singapore.

Investment in improved connectivity to Asia will not come from the USA or Europe, as they have their own gateways to Asia.

4.4 Technological Improvements

More capacity is being squeezed out of existing transmission systems by new technology, and more can be crammed into a given capacity with improved compression technologies.

4.4.1 Transmission Technologies

The capacity of the standard wavelength is now 10 Gbit/s compared to 2.5 Gbit/s at the end of the last century. There have been laboratory developments of 40 Gbit/s wavelengths, but these are not commercially viable for submarine systems, and the resources committed to development have tapered off. The principal impediment is that there is not sufficient demand to justify their development.

Another major development has been that of optical waves with narrower beam width. The pulse width has now been reduced to 0.3 nanometres (nm) from widths close to 3 nm in the mid 1990s. This has allowed increased gains in DWDM systems. In combination with improved fibre performance and better compensation at the edge of the band, it is now possible to get 128 waves with 10 Gbit/s per wavelength per fibre. In practice, an upper limit of 96 wavelengths is common. But, with long haul (sub-oceanic) cables, only 64 (or fewer) wavelengths are possible. The size of repeater housings, the power required and the heat generated limits the number of fibres, but with some designs 8-fibre pairs are possible.

The other major development has been in the upgrade of existing optically amplified cables. This can involve the substitution of 2.5 Gbit/s wavelengths with 10 Gbit/s or the addition of extra 10 Gbit/s wavelengths at the perimeters due the development of better edge compensation techniques. Most significantly with the use of couplers, one can mix and match the old and the new technologies ensuring continuity of service. The principal limiting factor is the optical power budget, which is dictated by the submarine repeaters, as all upgrades are premised on a zero requirement to modify the underwater plant.

The cost of upgrades has declined from approximately USD10 million per 40 Gbit/s capacity (i.e. 4 x 10 Gbit/s wavelengths) in 2000, to around USD2 million now. Hence the reference above that SMW3 could be upgraded from 40 Gbit/s to 100 Gbit/s or more and this, would cost far less than a new cable and provide the same functionality.

4.4.2 Dedicated Links

We have been told that "dedicated links" are vital. Some of the reasons given for exclusive bandwidth are:

- For a point-to-point transfer of vast amounts of data, users would prefer routers and switches to be by-passed (why make routers inspect every packet?) Also, by minimising the number of electronic devices in series, the probability of packet loss and data corruption is minimised.
- With increased Federal security requirements, many agencies (including CSIRO) have to have dedicated paths or, at least, encryption (which increases latency).
- Level 1 users with dedicated transmission paths are also less vulnerable to denial of service (DOS) attacks.
- A dedicated path allows more experimentation with the equipment that can be attached to each end of the link (e.g. for different "hybrid optical packet network" solutions like UCLP), which is important to academic users.

There might be a case to segregate data links (which might be dedicated simply on the basis of data volume and function) from the control plane, which should be in IP and networked. But, any dedicated link for any purpose reduces flexibility and becomes a limiting factor in future network development. The other counter points are:

- Flexibility with changing traffic routing – who is to say that in the future moving small High Performance Computers into the field will not change the data routing patterns and make their fixed dedicated design obsolete?
- There are very few users that must have dedicated links. Many choose to have them in order to enhance security from cyber attack. But, unless a great investment is made in redundant infrastructure (completely separate paths), the risk is transferred to the world of physical disablement/attack (e.g. a backhoe through a cable).
- Sensor overlay - the ability to run multiple sensors over the same link is very much easier with IP. If, in the future, there is a need to run half the sensors at double the bandwidth, then a dedicated design architecture will simply fail as the data will not fit in a single colour. IP allows one to simply balance the load across two fibres.
- Dedicated is never dedicated anyway; the power generators, battery management systems all need some bandwidth. If multiple colours of light are run over the fibres, how will a generator be interfaced with a DWDM colour let alone a SKA receiver?
- IP and ATM (except it is not fast enough) are the perfect grooming technologies to share access, or aggregate connections over fibre.
- Dedicated pipes are not efficient unless the instrument is designed "around" the fibre. Inevitably, there will be unused bandwidth somewhere. This may cover the IP overheads (remember very large packets yield very low overheads). Without IP the unused bandwidth is dead bandwidth (i.e. unusable). With IP, significant benefits can be gained by utilisation of bandwidth out of every colour if required.

4.5 Summary of Key Findings

"Small Pipes" feed the demand for "Big Pipes".

The demand for international connectivity is accelerating. The weakest link in the Internet delivery chain has been the local loop. Broadband local access loop connections have doubled in a year and will keep increasing as customers migrate from dial-up services. . The "Small Pipes" (local connectivity) are getting bigger not only because of the migration to broadband from dial-up but also because of the increasing bandwidth available on broadband connections.

"Wild cards" may bring their own funding to help augment international capacity.

While there is adequate near term international capacity out of Western Australia, either via the Indian Ocean or across Australia to the Pacific Ocean cables, there are significant drivers increasing the demand for international capacity even before "wild cards" such as the needs of radio telescopes and d are taken into account. Major users like Defence have a direct interest in improved international connectivity.

International communications links on the West Coast need to be strengthened.

Australia is too reliant on the East Coast which accounts for 90 percent of Australian international capacity. Historically, the development of international connectivity has reflected the status of the US as the centre of economic gravity and the Internet. But, this is changing with, particularly, China and India emerging as super powers in their own right. Australia has strong business and research links with countries to our north. For connection to Japan and the USA, the East Coast routing can be superior both on price and performance. However for South East Asia and Europe, direct access from Western Australia offers better performance.

Another important argument for improved West Coast connectivity is security. Perth as Australia's second international gateway can provide route diversity for all Australian traffic.

While upgrades to existing cables to service near-term needs are quite possible, the commercial arrangements surrounding Western Australian cables and the motives of the owners both create significant obstacles to achieving upgrades (and improved pricing).

Consequently, there are initiatives periodically announced to implement a new cable to overcome these commercial handicaps. Currently, two cables are mooted (SIAC and Ochre). It is hoped that they will fare better than earlier planned cables (i.e. NAVA and A2A), which did not proceed.

5 Policy and Development Options

The previous chapters have established the central importance of the international communications infrastructure to a global knowledge economy in Western Australia, as well as the inadequacy of the current infrastructure.

At first sight, there may not appear to be a capacity problem. The West Coast cables are under-utilised and can easily be expanded. However, while it would be cheaper to upgrade SMW3 than build a new cable (USD20 million versus USD100 million), it does not solve the problem of the lack of effective competition, which results in the current high prices (relative to the East Coast). A new cable would certainly have a capacity extension capability several orders of magnitude greater than the upgrade option, and consequently a much greater lifetime.

The Commonwealth should be keen to assist Western Australia with establishing a new cable. This is because it believes in promoting competition, it must increase the security of Australia's international connectivity (i.e. by enhancing the capacity of the Perth international gateway) and also because it wants to foster international trade and communications links to our north; particularly with China, where a bilateral free trade agreement (FTA) is being negotiated.

Internationally, the European Space Agency may have an interest in co-funding better international connectivity from Perth for their Western Australian based facilities. This might be done from the European Commission's 7th Framework Program, under which matching funding is generally a requirement.

There is a case for a new cable out of Western Australia regardless of current SMW3 pricing. This chapter suggests how the State Government can directly and indirectly help to ensure that, this time, such a cable is provided. We also discuss the use of information society policies such as open access to databases that the State Government could use to leverage enhanced global connectivity and to achieve its goal to transform Western Australia into a global knowledge economy.

And, we discuss the ability of carriers and service providers to make end-use requirements more affordable. Unfortunately, these are not in the domain of the State Government to change.

5.1 A New Cable

We saw in Section 4.2 how previous plans to build a new cable fell through. Current plans may be heading the same way without government support. Some of the grounds for government intervention were listed in Section 1.2.1. In this case, a new cable off the West Coast involves "externalities" and is "too big and risky" for any private operator to contemplate.

It has to be remembered that Australia is a very small market at the end of a long thin route.[85] The cost of a 10 Gbit/s lease between Amsterdam and New York is around USD18,000 per month. A lease of a trans-pacific link to Australia is 100 times greater. Australian cables do not have the economies of scale that can be enjoyed on major trans-oceanic routes. In Table 5.1, the South Pacific route refers to the SCCN cable. Any cable out of Western Australia will be even "thinner".

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85 National Bandwidth Inquiry, Section 13.8 (1999).

The cost of laying a new submarine cable from Australia has barely changed in twenty years. It is around USD100 million. This may not appear much, but it is risky because of the over-hanging capacity from SMW3. The collapse in prices that would follow could prevent the investment being recovered. Yet, this is precisely what Western Australia needs. So, how can such an investment be supported?

	IRU cost per 10 Gbit/s (STM64) USD m	Demand Gbit/s
Trans-Atlantic	1	2500
North Pacific	6	1000
South Pacific	100	50

Table 5.1: Thick and Thin Economics of Pricing

Source: Gibson Quai-AAS (“protected capacity” prices)

One support option that has been foreclosed by the privatisation of Telstra might have been to direct a public carrier to commission such a cable. This would be justified on “*social cost-benefit analysis*” showing that the benefits to the State and Australia exceed the costs of the investment; even if the public carrier makes a loss.

But, there are several other realistic development options still open to Western Australia:

- Leverage purchasing power: The West Australian government is currently evaluating bids for its telecommunications business. A carrier may argue, with some justification, that a greater commitment to buying its services would encourage it to invest more in Western Australia and/or a new West Coast cable.
- This approach has been used before in Australia to encourage industry development. A recent example is the Northern Territory Government five-year telecommunications contract with Telstra in June 2005.
- Guaranteed purchasing (“anchor tenant”): Another way to reduce uncertainty is to enter into forward commitments to purchase against future requirements. An “anchor tenant” (e.g. AARNet and/or Defence) with a committed requirement of 40 Gbit/s (4 x 10 Gbit/s) would probably be enough to trigger a new cable. The price of a protected (i.e. dual route) 10 Gbit/s (STM64) link on SCCN is currently USD115 million up-front (but it is highly unlikely that AARNet is paying that for its current 10 Gbit/s protected link on SCCN). Timing of requirements may hinder early commitment to a new cable, but this is not an insoluble issue.
- Capital grant (subsidy): A well-tried mechanism for bringing private and social benefits into line to bring about socially optimal investment is a capital grant. This allows the carrier concerned to achieve a commercially acceptable internal rate of return on the investment. Telstra calls these “Enterprise Projects” (see Box 5.1).

Enterprise Projects

An example of a Telstra "enterprise project" is the Tom Price project with BHP where Telstra was persuaded to lay a backbone transmission along the Hamersley railway with mining companies paying the full cost of tails to their sites and commercial rates for the services over this infrastructure. Taking a five-year view of expected revenues, the "enterprise contributions" made the investment possible.

Note that "enterprise contributions" do not imply any kind of "ownership".

Box 5.1: Enterprise Projects

- An advantage of this approach is that it can be subject to competitive tender. Apart from Singtel and Ochre (see Section 4.2), other carriers that might be interested are the Indian carrier, VSNL (which is a significant global wholesaler since its acquisition of Tyco Global Networks[86] in late 2004) and AsiaNetcom (China Netcom's international carrier).

  This may be an option that could be explored by Western Australia's DoIR, which facilitates and supports major capital investment in new projects, products or services of strategic importance to the State.

  While this option could be applied to an upgrade of the existing SMW3 cable at less cost, it would not address the lack of competitive supply that has resulted in the current level of prices on the West Coast.

- Financial instruments: Financial markets have developed ways of reducing uncertainty and risk. But, these are not currently applied to infrastructure investments. A carrier could offer forward contracts promising to supply capacity at, say, today's prices on SCCN (if these are profitable for a new cable). Users facing today's prices on SMW3 would be keen buyers of these forward contracts. If SMW3 prices do not fall to the level of forward prices by the time the new capacity becomes available, there is an opportunity to poach SMW3 customers at lower prices on a new cable. If SMW3 undercuts the forward prices, the carrier can either buy-back its forward contracts or buy capacity from SMW3 to on-supply to its forward contract customers at a profit without risk. Either way, this mechanism would force prices down towards the cost of supply.

The first and third policy options above may be the only levers directly available to the State Government. But, it does have indirect influence that it can use to take the other options to the parties who can implement them.

Once a cable is in place, it would probably fill quickly. For example, the SCCN cable lit up in November 2000 removed the bandwidth bottleneck between Australasia and the United States. Originally designed to deliver 120 Gbit/s of fully protected capacity, Southern Cross capacity was doubled two years later, in the first quarter of 2003, to 240 Gbit/s.

5.2 Facilitating Access to Databases

At the heart of the knowledge economy is the exchange of information and data. The question that follows is "Who writes the cheques?" There is some merit in Western Australia being the repository for data and, better yet, the place where value is added by analysis. This probably also involves supporting storage initiatives and the development of skills to handle large amounts of data.

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[86] TGN has been important to AARNet and the IEEAF (International Education and Equal Access Federation) whose members donate capacity for mutual use. www.ieeaf.org

An example of how open access to meteorological data has spawned a new industry is given in Box 5.2.

Weather Financials

With open access to meteorological data, a global USD5 billion derivatives industry has been created which did not exist five years ago. On the Chicago Mercantile Exchange, whose contracts cover only 29 cities worldwide, over 600,000 weather contracts have been exchanged in the first nine months of 2005 compared with less than 5,000 in 2002.

Box 5.2: Weather Financials[87]

Another recent example from the USA is "MyPublicInfo" (see Box 5.3).

MyPublicInfo

In July 2005 MyPublicInfo (http://www.mypublicinfo.com/) launched an identity theft protection tool, the Public Information Profile (PIP). For USD79.95 consumers can view public records that are connected to their name and what information is accessible to others when performing a broad background check. The records are collected from over 5,000 databases. The PIP also allows consumers to spot possible cases of identity theft, including impersonation of identity to buy or rent a house, receive a business license, or other illegal activity. According to the Federal Trade Commission, 27.3 million businesses and consumers suffered billions in losses as a result of this growing threat.

Box 5.3: MyPublicInfo

We have seen (Chapter 3) that Western Australia has already had some success in building unique databases of interest to others. In order to extract the greatest utility from these data sets, a policy of open-access[88] is something that could be promoted by governments. A lead has been provided by the OECD, among others.[89]

As an aside, the Internet guru, Bill Norton, has observed that the governments that have discouraged the hosting of adult or porn sites (such as Australia) have significantly retarded the development of content industries in their countries. This is not to say that banning the hosting of porn or gambling sites in Australia is a mistake, but that both negative and positive policies in relation to data will have implications in other areas.

5.3 Affordable Pricing

A new cable should certainly facilitate and maintain reduced prices. But, with fixed costs of supply, there is a danger that prices may be forced to marginal costs where new capacity is uneconomic to supply. If carriers and service providers want to avoid a race to the bottom on price, with or without new capacity, they could consider new pricing for this new environment of abundant supply.

Traditionally, bandwidth has been a scarce commodity. Pricing reflected distance (with costs proportional to distance), duration (minutes) and time-of-day (busy-hour peaks). However, bandwidth is no longer scarce. Yet, while transmission capacity is now abundant, it is massively under-utilised. Current pricing is holding back emerging e-business and the development of a knowledge economy. As we saw in Chapter 3, the post-production (film) industry really needs short-period, large capacity pricing. More affordable bandwidth could revolutionise this industry, and others.

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87 The Economist, 1 October 2005.

88 Pluijmers and Weiss (2005) make a strong case for open access to publicly collected information. They look at policy and practice in relation to weather and geographical information systems data in several countries.

89 http://www.oecd.org/document/0,2340,en_2649_34487_25998799_1_1_1_1,00.html

Most owners of transmission capacity are reluctant to make cheap capacity available, especially in large amounts, because it may be resold and so undermine their own retail revenues and profit margins. Only those owners/operators who have no retail business are more willing to sell raw capacity. However, greater capacity can be supplied profitably by all capacity owners by pricing down the demand curve (i.e. according to willingness-to-pay). This would enable users with large volume requirements to get more affordable access to bandwidth without compromising existing revenues. The trick is to avoid arbitrage across customer classes or applications (i.e. resale).

With the migration of traditional networks and services to IP, a byte is a byte is a byte. The bytes carrying voice and video are the same. Right? Wrong. At the "session layer"[90] where most retail services are provided, a service provider can identify not only what type of content is carried but also how it is to be handled.[91] There are five dimensions to content: audio; video; data; image; and text. With four dimensions in handling: interactive; retrieval; distribution; and messaging, we get a matrix of 20 flow types (see Table 6.1). For example, voice is audio/interactive.

	Audio	Video	Data	Imaging	Text
Interactive	Voice	Conferencing	VoIP	Games	Chat
Retrieval	Music	Movies	Files, Metering	Weather Maps	News
Distribution	Radio	TV	Share Prices	Advertisements	Notifications
Messaging	Voicemail	Web Talks	Diary	Photos	SMS, Email

Table 5.2: Session-Layer Traffic Flows

This still leaves considerable flexibility in the pricing of session types by service providers. The point is that pricing should be more sophisticated than the pricing per byte or pricing per bit/s that currently applies. Apart from extracting consumer surplus (and increasing output and asset utilisation), the marginal costs of each session type are very different. In pricing, more emphasis should be placed upon marginal costs of each session type.

Note that we have addressed only the session-layer. More sophisticated pricing approaches can and should be applied at other layers too. The difference between someone downloading movies (video/retrieval) and Animal Logic is in the security and reliability attributes which may be priced at the "transport layer". Value added should be captured at the appropriate layer.

5.4 Summary of Key Findings

At first sight, there may not appear to be a capacity problem. The West Coast cables are under-utilised and can be expanded.

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90 Gibson Quai-AAS are indebted to Dr Jude de Silva for these insights into layer-based pricing.

91 This could be provided in session initiation or by the TPDU within IP packets. Only two of the four TCP transport classes are currently used providing more scope for this taxonomy of traffic.

However, while it would be cheaper to upgrade SMW3 than build a new cable (USD20 million versus USD100 million), the upgraded capacity would only be 40 Gbit/s (with a consequent limited life). A new cable would certainly have a capacity extension capability of one (and possibly two) orders of magnitude than the upgraded option, and consequently much greater lifetime and revenue generation. An upgrade will also fail to solve the problem of the lack of effective competition, which results in the current high prices for West Coast.

There is clearly a case for a new cable out of Western Australia.

This case is based on continuing rapid growth in demand, the need for effective competition in West Coast international capacity, the shift in the balance of power in the global economy to Asia and national security. For these reasons, a new cable is important, not only to Western Australia, but also to the whole of Australia.

The State Government needs to support new cable investment.

International communications infrastructure is no longer supplied exclusively by publicly owned carriers in Australia. So, other ways have to be found to overcome the "externalities" that lead to sub-optimal investment in the global communications infrastructure. Four possible options are identified: leveraging the State's own purchasing power, finding "anchor tenants", providing capital grants (subject to cost-benefit analysis and competitive tender) and developing new financial instruments to reduce risk and uncertainty.

The State Government needs to stimulate the utilisation of databases with the intention to maximise both commercial and social returns to the community.

The government, by the nature of its business, collects and stores data that has high commercial value and high social value coupled with community ownership. Promoting open access to databases would be a desirable policy objective in a knowledge economy. It provides a way to encourage greater use of data collections. Exploitation of such data by both public and private sectors can not only maximise the return on public investment in R&D, but also creates new industries and high value employment

Issues such as privacy and intellectual property will clearly require evaluation (e.g. in the aggregation of particular data sets). The State Government needs to identify, audit and review across government its intellectual property policies, existing data collections and access provisions with the intention of maximising both commercial and social returns to the community.

New value-based pricing for IP networks needs to be developed

The carriers and service providers must develop more innovative pricing structures that deliver more affordable bandwidth at the same time as increasing industry revenues. Layer-based pricing is suggested as a workable solution to pricing along the demand curve. It may provide a more sustainable basis for value-based pricing in an all-IP network.

The poor global connectivity off Western Australia affects not just Western Australians but all Australians. Unable to compete with some countries on labour costs, and remote from major markets, Australia's challenge is to find new ways to participate in global production systems and global markets from a geographically remote location. Its international communications infrastructure will be an essential ingredient, without which the challenge may prove insurmountable.

6 Recommendations

This report has established that "Big Pipes" for international connectivity are a critical building block in the Cyberinfrastructure for all Australians; not just those in Western Australia.

It has also demonstrated that the Western Australian Government, due to lack of a competitive environment, needs to actively facilitate the development of this infrastructure not only because it is committed to the establishment of a knowledge economy in Western Australia but also because there are "externalities" which will lead to sub-optimal investment in cable capacity in the absence of government leadership.

The recommended "action steps" for the State Government are to leverage both Commonwealth Government programs and private sector investment by developing a plan for improving:

Recommendation 1: Western Australia's International Connectivity

The Western Australian Government should test the viability of available options by issuing a "Request for Proposal" (RFP) to the marketplace. This RFP should canvas a broad range of possible solutions including private sector investment in return for guaranteed capacity (new cable or upgrade of existing infrastructure).

Recommendation 2: Western Australia's National Capacity

The Western Australian Government should consider capitalising on Commonwealth Government programs or making a capital grant (as has been the case in South Australia) to extend the AARNET3 optical network to Western Australia in order to fully support the APAC grid, the xNTD and other known and future "Big Science" projects.

Adopting this plan of action will help secure Western Australia's position in the global knowledge economy.

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- Mr Vince Troth, Optus
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- Mr Peter Kent, Telstra
- Hon. Mal Bryce, Western Australian ICT Industry Development Forum
- Mr Earl White, Western Australian Technology & Industry Advisory Council (TIAC)
- Mr Gavin Tweedie, The West Australian Internet Exchange (WAIX)

B Report Terms of Reference

The terms of reference shall be to:

(i) Review the evolution of Western Australia's network connectivity over the last five years, both inter-state and international, including Singapore as a case study of prospective interoperation.

(ii) Classify the age, bandwidth and topology of existing and proposed infrastructure connecting Western Australia.

(iii) Characterise typology of use by sectors, by processing requirement and by volume, for use in evaluating capability in the State.

(iv) Review current plans for infrastructure investment and determine predicted implementation based on demand forecasts particularly in respect to our major trading partners and the global knowledge economy.

(v) Identify policy and development options in order to establish powerful and effective connectivity between Western Australia and the major world economies including our key trading partners.

C Steering Committee and Consultation Team

The membership of the ICT Industry Development Forum Steering Committee for this project is listed below:

Hon. Mal Bryce AO	ICT Forum Chairman (Chair)
Mr Geoff Harben	ICT Forum Member
Ms Lyn Thomas	ICT Forum Member
A/Prof. Andrew Rohl	iVEC - the hub of advanced computing in Western Australia
Mr Gary Hale	Cisco Systems Inc.
Dr Bruce Hobbs	Office of Science and Innovation
Prof. Ashley Lloyd	Curtin University of Technology
Mr George McLaughlin	Australian Academic Research Network (AARNet)
Mr Peter Kent	Telstra
Mr Mark Favas	CSIRO Petroleum
Dr Rhys Francis	Australian Partnership fro Advanced Computing (APAC)

The Steering Committee was assisted in its task by the following consultants:

Mr Cliff Gibson	Project Director, Gibson Quai - AAS
Mr John de Ridder	Economist, de Ridder Consulting
Mr John Hibbard	Hibbard Consulting
Prof. John Houghton	Victoria University, Centre for Strategic Economic Studies

TIAC Executive Staff:

Mr Earl White	Executive Officer
Ms Deanna Fleming	Senior Policy Adviser
Ms Shelley Rush	Executive Assistant

D Western Australian ICT Industry Development Forum (ICT Forum)

The Western Australian Information and Communications Technology Industry Development Forum (ICT Forum) was established as a committee of TIAC by the Minister for State Development in June 2004 under Section 23(14) and 25 of the Industry and Technology Development Act 1998 (ITD Act 1998).

The Chair of the ICT Forum reports directly to the Minister. The activities of the Forum are to be reported to Parliament in TIAC's Annual Activity Report under Section 26 of the ITD Act 1998.

D.1 Terms of reference

Scope

As a vital part of this State's future development, the Information and Communications Technology Industry Development Forum (ICT Forum) is concerned with:

(a) the advancement of the Information and Communications Technology (ICT) Industry in Western Australia;

(b) the industry's capacity to support the creation and maintenance of high quality jobs throughout the State's economy;

(c) access to ICT services throughout the State and ensuring the overall interests of Western Australia are served;

(d) the promotion of ICT as a driver of competitiveness and efficiency across industry; and

(e) the facilitation of ICT as a key enabler in a Western Australian "Knowledge Economy".

Strategic Role

To advise the Minister for State Development on policies and strategies necessary to ensure the continuing development of the Information and Communications Technology Industry and the application of information and communication technologies across industry and the community generally in Western Australia.

Outcomes

The Forum will assist the Government:

(a) in setting the environment for the development and attraction of expanded and new business opportunities for Western Australia in information and communications;

(b) by providing policy advice, which will facilitate the establishment of 'leading edge' telecommunication systems in the State;

(c) by providing policy advice on meeting the ICT needs of both regional and metropolitan Western Australia;

(d) by advising the Minister on broadband related issues namely:

(i) identifying the core value propositions and support mechanisms needed by various target groups (e.g. residents, SMEs, non-metropolitan areas) concerning broadband take-up and use; and

(ii) advising on a strategy designed to raise and maintain a public awareness program to encourage the take-up and use of broadband services by target groups; and

(e) by providing advice to the Minister, at the initiative of the Forum or at the request of the Minister, on any matter relating to the ICT industry and ICT applications generally.

Operations

The Forum will meet a maximum of 10 times per year with working parties established and meeting as required from time to time.

An Executive Officer from the Technology & Industry Advisory Council will co-ordinate meetings and prepare minutes. The Forum is to submit to the Minister a copy of the minutes of each meeting within 14 days after the meeting at which the minutes were confirmed.

This Forum will report through the Chairperson to the Minister for State Development.

Recommendations for action will be made to the Minister through the Chairperson. This will include business cases to support funding requests to conduct research or undertake specific projects.

Membership

An independent Chairperson will be appointed by the Minister.

The Forum will consist of up to 16 people with the option of initiating working parties with additional expert membership to progress specific projects.

The members will be appointed for their own strategic skills rather than as representatives of sectors or associations of the industry.

The Minister for State Development will appoint members.

Members will be appointed for three-year terms.

E Membership of the ICT Forum

Hon. Mal Bryce AO
Chairman

Mr Nic Beames
Director of Content
Dynamic Digital Depth

Ms Jo Bryson
Executive Director
Office of e-Government

Dr Bob Cross
Chair of ACS
Edith Cowan University

Mr Peter Fairclough
Group Manager – Corporate Affairs
Telstra Corporation Limited

Mr Neil Fernandes
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Dr Walter Green
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Mr Geoff Harben
General Manager Public Sector
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Ms Cheryl Robertson
Consultant

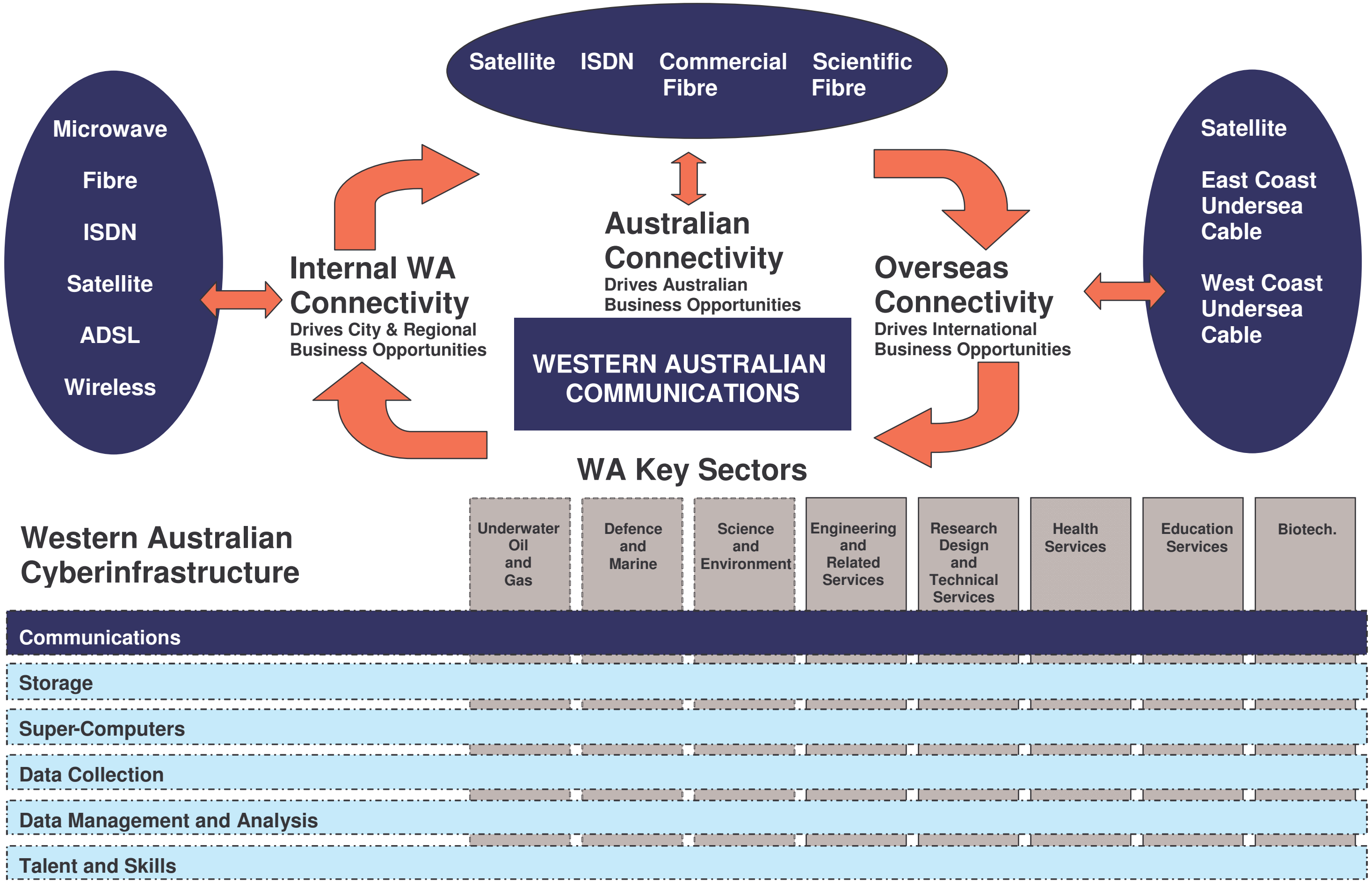
Mr Brett Sabien
Manager – Telecentre Support Branch
Dept of Local Government and Regional Development

Ms Lyne Thomas
Assistant Director General Development Strategies
Department of Industry and Resources

Mr Richard Thorning
General Manager WA Optus Business
SingTel Optus Pty Ltd

Mr John Tondut
Procurement Reform
Department of Treasury and Finance

F Western Australia's Connectivity – Impacts and Interrelationships



Source: "Big Pipes" Steering Committee

Notes:

The purpose of this diagram is to highlight the cyclical nature of assessing "Big Pipes". It is not necessarily perfect. However, it highlights "the chicken and the egg" nature of Cyberinfrastructure and in particular, the connectivity between Western Australia's key industry sectors and between Western Australia, the Eastern States and internationally.

Without "Big Pipes" it will be hard to grow business, and without business there is insufficient competitive pressure to make "Big Pipes" affordable.

PUBLIC COMMENT
REPLY SHEET

TO: THE EXECUTIVE OFFICER
WESTERN AUSTRALIAN INFORMATION & COMMUNICATIONS TECHNOLOGY (ICT) INDUSTRY DEVELOPMENT FORUM

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