Submission 198
Date received: 10/03/2011

National ICT Australia

Submission

to the

Inquiry into the role and potential of the National Broadband Network by the House Standing Committee on Infrastructure and Communications

March 2011

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Executive Summary

NICTA welcomes the Parliamentary Committee's inquiry into the role and potential of the national broadband network (NBN). A national broadband network has the potential to greatly improve Australia's economic, social and environmental performance and make us more competitive in the global economy. NICTA believes that growth in demand for bandwidth will continue to grow as new uses and applications are developed. There are already bandwidth intensive applications such as high-definition two-way video which have not yet penetrated the mass market, due to Australia's current limited broadband capacity, so investing in a fibre-based NBN is necessary.

The NBN provides a value proposition across many aspects of industry.

For example, high-speed broadband will enable

- Very high-quality video communications so that emergency or specialist medical diagnoses can be made quickly and accurately and without the patient having to travel
- 'rich media' like x-rays and complex medical imaging files, detailed graphics, video and photographic stills to be created and sent anywhere
- Elderly people to stay in their own homes for longer, as they will be able to be monitored and treated via the NBN, and keep in close and constant contact with their friends and families.
- small businesses to run at lower costs and expenses on software due to the ability to store and access data from the 'cloud' through cloud computing,
- government and businesses in general to more effectively communicate with their customers and provide a better, more convenient quality of service
- a higher value electronic market for goods, services and innovation. Online retail is one example of the many things to come in this space.

For regional Australia

The NBN provides an opportunity for regional Australians to have access to quality health care, social services and education alongside their city colleagues. In a country as large as Australia, high-speed, high-volume symmetrical broadband connectivity available from a national broadband network will effectively 'level the playing field' between regional and metropolitan Australia.

However, developing a fast network alone will not translate to these benefits without full community and business understanding of the value proposition that the NBN provides. As different experiences around the world demonstrate, uptake does not happen automatically. Innovation and uptake will need to be fostered through education, pilots and trials.

When the NBN removes the "last mile" bottleneck, commercial service providers may need to upgrade their systems to cope with the increased demand for their business. We may also find that our deployed international data capacity will not keep pace with the demand the NBN can potentially unleash. The NBN is likely to significantly increase the demand for cloud computing, so there may also be a need for large scale data centres to be built in Australia.

There are also some benefits from the NBN that may be less obvious. In coming years, smart infrastructure will improve the efficiency of our transport and energy systems. These systems will need a pervasive, reliable network to realise their full potential. Wireless data from smart phones, tablets and other mobile data devices is exploding. Ultimately most of this traffic will need to be carried on the backbone of the NBN.

The NBN is likely to serve us for more than 30 years. We are already seeing increasing amounts of data being transmitted from users' home premises for services like YouTube and photo-sharing, placing heavy demands on up-link capacity. With the proliferation of video conferencing and other user-generated content this will increase, so network architecture should be developed that allows symmetrical bandwidth to be provided cheaply. It is also likely access speeds on the NBN will grow to 1 Gigabit per second and beyond over the life of the network, so we should design the system to minimise the costs of any upgrade of this nature. The fibre itself is infinitely upgradable but the end equipment will also need to be chosen carefully.

Government has an important role to play - both as a lead-user and in supporting the development of pilots, major projects, national standards and new technology needed to ensure the nation benefits as quickly as possible from a national broadband network.

General Comments

For each of the areas in the terms of reference, pervasive high-speed broadband provides benefits and these are addressed in detail within this submission. The following comments also apply generally.

Projecting human skills through video

High-quality two (or more) way video conferencing is only possible at NBN levels of service. High quality multi-person video can be used to support a myriad of services that needed to be previously delivered in person. This applies across health, education, finance, business, community and will be discussed in each term of reference.

Video is the biggest user of bandwidth

Videoconferencing and video download or streaming, and uploading, are likely to remain the most bandwidth intensive activities for the foreseeable future. This is detailed in the response to the "optimal capacity" section of this submission. The effect of the NBN will be most noticeable in sectors where high quality video makes a difference.

Economy of scale

Pervasive, high performance broadband also makes it possible to aggregate electronic services into larger data centres, and provide these services at extremely low cost and high functionality wherever there is a broadband connection. Cloud services are the most recent evolution of that trend. The network must have minimal delay, high reliability and good bandwidth for these services to work effectively. These attributes are also important across every sector.

Creation of larger markets

NBN will raise the level of bandwidth access across the bar, especially on the up-link. Making it available everywhere, is essential to creating a larger and more effective market for digital goods and services. It also provides a platform for innovation in those services. In a pervasive NBN environment, perhaps the next 'Google' or 'Facebook' style world-wide phenomenon will be developed in Australia.

Think 50 years ahead: new applications and services will keep coming

Every few years, a new service or company arises which surprises everyone and sends bandwidth demands soaring. Over the last decade or so, Netscape, Amazon, eBay, Google, iTunes, YouTube, Twitter, Facebook evolved. Each of these started small and seemed trivial at the time. There is no reason to think the process will stop. We do not know what is next, perhaps it will be a new application for personal health or video on demand, but something will be next.

The NBN is designed to last at least 30 years. We should not constrain ourselves to thinking about the applications currently available, but also look at services and applications that can might (and will) be developed in the future. For this reason, the strongest, most robust broadband framework that has the capacity to scale up should be provided.

Bandwidth demand is relentless and increasingly symmetrical

At no time has demand for bandwidth decreased. In fact, it has increased year on year by 50% per annum as will be discussed in section i). And, equally important, demand for up-link capacity is increasing, driven by two-way video, working from home, cloud services and user-generated content like photos and videos. The capacity of fibre is effectively infinite, but the

equipment that drives it needs to be designed to minimise the cost of upgrades as demand inevitably grows.

Areas with the poorest broadband will benefit most noticeably

Many parts of regional and rural Australia, and even the urban fringes of our major cities, have significantly worse broadband than in dense urban areas. The NBN roll-out will address this and 'level the playing field' wherever it reaches.

The digital economy needs a scalable foundation network

The digital economy includes all the current well-known Internet applications, but also growing machine-to-machine communications for smart infrastructure, transport and energy systems, booming mobile data from smart phones and tablets and things we have not yet imagined. Some of these applications will be more reliably carried on fixed networks.

Digital inclusion

Some people, such as small business owners, the aged or disadvantaged, may need training on how to fully engage in the sorts of services the NBN will offer, and on how to take advantage of the transition to a more digital economy. Providing the technology alone won't be enough.

Fostering uptake

Demonstrations to people and businesses on the benefits of NBN and the digital economy will be valuable in raising awareness about the value the NBN can add. This might take the form of trials or testbeds which will demonstrate the kinds of new services and activities that can be delivered or achieved through the NBN. The Australian Centre for Broadband Innovation (ACBI) a partnership between CSIRO and NICTA and the Institute for a Broadband Enabled Society (IBES) are two centres which are looking to communicate these concepts, but this type of activity needs to be expanded.

Review of legislation and development of new standards

The debates about copyright, privacy, security, online shopping and the GST are the first of many as business and consumers discover more effective ways of running businesses, and their lives more generally. Legislation should foster innovation while protecting citizens and business.

The delivery of government services and programs

By raising the level of broadband access to homes and every business premise, the NBN will help take the delivery of government services to higher levels of performance, reach and depth. Pervasive broadband will enable the provision of more data-intensive services, that can be upgraded with real-time interactivity video and greater personalisation. Government services will also be able to take advantage of the benefits of so-called 'cloud' architectures, and that there are fewer barriers to locating government employment in regions. The key points are outlines following.

E-Government

The NBN's greater capacity for both high-speed download and upload means that the public can engage with government service delivery centres in their own homes. This could include face to face interviews and meetings. This could be particularly beneficial for Australians living in regional and remote areas or those who are less mobile such as the elderly and disabled.

The capacity of the NBN may support applications that allow a wide range of government services to be delivered online, and allow transactions that are currently initiated online to be entirely completed online, regardless of a person's location - for example Centrelink services (see below) which currently require face-to-face meetings.

Given a choice, most Australians have already expressed that they would prefer to use an e-Government channel to access a government service. For example, in 2009 four in five (78 per cent) people preferred to use the Internet or phone) to contact government[1].

Greater use of e-Government approaches can save time and money so that resources may be directed to other priorities. A report by Price Waterhouse Coopers (PWC) for the UK Government found that face to face transactions cost on average £10.53, the cost of a telephone engagement was £3.39 and by mail was £12.10 compared with the cost of an online transaction cost at just £0.08[2].

Around the world, these changes are being made. The European Commission recently reported a significant increase in the availability of government services online to citizens in Europe. According to the Commission's 9th e-Government benchmarking report, the average availability of online public services in the European Union (EU) went up from 69 percent in 2009 to 82 percent in 2010. The report notes that making more government services available online helps cut public administration costs and reduces red tape for citizens and business[3].

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[1] Interacting with Government: Australians' use and satisfaction with e-government services*, December 2009, Australian Government Information Management Office,* *http://www.finance.gov.au/publications/interacting-with-government-2009/docs/interacting-with-government-2009.pdf*

[2] *PriceWaterhouseCoopers,* The Economic Case for Digital Inclusion *(October 2009)* *http://www.parliamentandinternet.org.uk/uploads/Final_report.pdf*

[3] Digitizing Public Services in Europe: Putting ambition into action*, European Commission, December 2010.* *http://ec.europa.eu/information_society/newsroom/cf/item-detail-dae.cfm?item_id=6537*

Centrelink in Australia

There has already been significant progress in Australia to expand delivery of government services and programs online. However, it continues to be the case that fully completing many transactions with government, even where they are commenced online, still may require the client to visit a government office. For example, currently around 62 percent (69.5 million) of Centrelink transactions are made on-site, which involves people presenting at a Centrelink office. This is inconvenient and costly for clients as well as Centrelink staff. It also means Centrelink must maintain larger client waiting areas and transaction counters[4].

An additional benefit from pervasive broadband is that gives the government greater scope to locate government employees outside Australia's major cities. This benefits the regions bringing high-value jobs to the region, the government by lowering the cost base, and alleviates the congestion and over-crowding that plague our cities.

Government 2.0, Public Participation and Open Data

Government 2.0 or e-Government services will enable governments to offer a wide range of services to citizens at reduced cost, and with faster turnarounds. These services can also encourage civic participation. Various levels of government are beginning to use the power of social media and networking.

A powerful example of the way in which social media was recently used was the Queensland Police Service's use of Twitter and Facebook during the 2011 floods and Cyclone Yasi. The Queensland Police Service was able to distribute important information to a wide audience quickly and curb the propagation of rumours and false information[5]. Developments like these have led the United Nations to rank Australia favourably in terms of its e-Government services and usage of those services by citizens[6]. While the social nature of Twitter and Facebook do not in themselves use large amounts data, people embed links to videos and photographs which drives up demand.

Recently there has been a major push in Australia and other parts of the world to make public data available via government websites. In Australia, the data.australia.gov.au and data.nsw.gov.au websites host a range of public datasets, which innovators can use to create useful tools for the general public, government agencies, non-government organisations and the private sector. To catalyse the use of this service, the Government 2.0 Taskforce[7] launched the Mashup Australia Contest in 2009[8], calling for software developers to submit novel web applications making use of the public datasets. By way of example, a team of two from Queensland created one of the two winning entries. Their application, Suburban Trends[9], enables users to visually compare over 8,000 Australian cities and suburbs along a number of dimensions, including economic index, education levels and perceived safety.

This provides a glimpse of the utility that can flow when government agencies liberate their data allowing small, innovative teams of application developers to create useful tools. NSW Government has now run several workshops to develop apps for state government services Pervasive broadband will encourage the development of even more of these

An important point is that governments at all levels, and publicly funded organisations, are very often the custodians of data that may be most useful to the public. Opening up public

[4] Intel NBN Briefing paper
[5] http://igo2group.com.au/blog/for-qpsmedia-all-roads-lead-to-facebook/
[6] *United Nations, United Nations E-Government Survey 2010. Available at:* http://www2.unpan.org/egovkb/global_reports/10report.htm
[7] http://gov2.net.au/
[8] http://mashupaustralia.org/
[9] http://www.suburbantrends.com.au/

repositories of data as far as it is responsible to do so can spur innovation and wealth creation. The NBN will make it easier to store this data, and innovators to use it, and for citizens to gain value from the new services created.

Government and Cloud Computing

Cloud computing refers to a new way to provide on-demand computer services over the Internet. Webmail is a simple example of a cloud service. For cloud computing to work well there must be a reliable high-speed broadband connection, such as the NBN, between the user and the cloud facility.

Cloud computing provides two avenues of benefit for government. The first is in enabling government agencies to operate their IT architectures more efficiently internally and, because cloud approaches may it easier to share data and standardised services, support inter-agency integration. The second avenue lies in the ability to scale services to the public more efficiently and effectively, again using standardised services on scalable cloud architectures.

The key advantages of cloud computing are:

- **Cost reduction.** A study conducted by the United States-based Brookings Institution found that government agencies at the federal, state and local level, which had moved to the cloud for email and some other services, saw between 25 and 50% savings[10]. In this respect, governments can potentially reduce their IT costs in the same way that the private sector can, though due consideration must be given to the storage and transmission of sensitive data, privacy, risk, performance, security and legislative and regulatory constraints
  .
- **Scaling with demand***.* Cloud services are provided over the Internet or a private network on-demand. Such systems can cope much better with sudden increases in load. This sudden load could be because there has been an emergency (like in a natural or human disaster), or cyclic, like the capturing of regular information by the US Census bureau which uses cloud computing to deal with its annual peaks[11].

- **Public data.** Initiatives such as Gov 2.0, or more broadly, "open government" are facilitated by data and services hosted on the cloud. The cloud supported by NBN levels of broadband performance can provide highly valuable services to consumers.

Australian governments and their agencies are already exploring the potential of cloud services. AGIMO's Cloud Computing Strategic Direction Paper[12] notes:
"Cloud computing is a new way of delivering computing resources, not a new technology." The Australian Government Cloud Computing Strategic Direction Paper describes the whole of government policy position on cloud computing. The strategy states that: agencies can choose cloud-based services if demonstrating value for money, fitness for purpose and are adequately secure; provides guidance for agencies on what cloud computing is; and some of the issues and benefits of cloud computing that agencies need to be aware of.[13]

Additionally, NICTA is developing advanced technologies[14] for monitoring and predicting the level of service delivery from government sites. This will be particularly important as government IT architectures move towards cloud approaches to manage the much higher

[10] *West, Darrell M., Saving Money Through Cloud Computing (April 2010), The Brookings Institution. p. 1. Available at: http://www.brookings.edu/papers/2010/0407_cloud_computing_west.aspx*
[11] http://www.qas.com/company/data-quality-news/us census bureau praises cloud services 5752.htm
[12] Cloud Computing Strategic Direction Paper, AGIMO. http://www.finance.gov.au/e-government/strategy-and-governance/docs/draft cloud computing strategy.pdf
[13] Cloud Computing Strategic Direction Paper, AGIMO. http://www.finance.gov.au/e-government/strategy-and-governance/docs/draft cloud computing strategy.pdf
[14] http://www.nicta.com.au/research/projects/business adaptation and interoperation/epasa

loads which will be generated when the general public and SMEs have high speed access via the NBN.

Achieving health outcomes

NICTA's engagement with the health sector has confirmed keen interest and clear potential benefits from the national broadband network. There are direct clinical benefits which may include virtual home visits, remote professional accreditation, or the ability to deliver scarce skills into remote areas. Pervasive broadband also lowers barriers to the wider adoption of e-Health more generally.

Deloitte[15] noted: *"E-Health will enable a safer, higher quality, more equitable and sustainable health system for all Australians by transforming the way information is used to plan, manage and deliver health care service:*

- *E-Health will empower consumers to better manage their own health*
- *E-Health will provide care providers with access to decision support tools and up to date consumer information and knowledge sources at the point of care.*
- *E-Health will support care providers to automatically monitor individual care plans and health status"*

High bandwidth video

Through use of high bandwidth video consultations, and universal high-speed data transfer, e-Health allows

1. Existing services to be delivered more often, more conveniently and sometimes at lower cost (both for deliverer and consumer).
2. Services delivered at a time and place which is convenient to all parties, independent of physical geography: a clinician can work from anywhere they wish, an after-hours home consultation can be provided by remote clinicians who are still in office hours.
3. Clinical skills delivered from remote areas - so that as clinicians retire from face-to-face consultations, they can still provide support to the healthcare system

Data sharing by practitioners will be important in order to achieve significant changes in the current health system. Pervasive broadband (with the aim of universal access) means that data sharing and use are possible at all points in the health system in the same way that one may assume all households, businesses and hospitals have electricity connections.

Providing pervasive broadband was found to be one of the key enablers of e-Health in NICTA's *"Telemedicine in the context of the National Broadband Network"* report. It was found that the NBN would directly overcome this barrier[16].

There are also benefits to the business of health, derived from the improved efficiencies a digital technology can bring to process and administration. For example, the development of an e-Health culture is likely to stimulate new business models for delivery of healthcare services.

However, non technical barriers, such as billing for e-Health services for example, will also need to be addressed. It is important to understand that while pervasive broadband may

[15] Deloitte. (2008). National E-Health and Information Principal Committee: National E-Health Strategy
[16] Hanlen, L. and Robertson P. (2010) Telemedicine in the context of the National Broadband Network

remove some blockages, culture and process must be able to take advantage of what the technology allows. An initiative like the NBN may inspire cultural change as is happening around the new Medical Benefits Scheme (MBS) billing items for video consultation.

The NBN will help to achieve health outcomes in the following ways:

- Universal minimum standards for communication of health data will ensure that e-health technologies may be deployed independent of geographic location removing a significant barrier to adoption
- Interconnection of existing health networks will drive interoperability of devices and improved device design
- Provide a unique opportunity to change the way healthcare is delivered in Australia
    - High-definition video consultations, between patients and healthcare teams will allow direct diagnosis and response from home
    - Large scale data transfer and analysis: allowing clinical follow up outside local business hours
    - Clinical teaching via high-definition virtual environments, including haptic sensors
- Provide a catalyst which inspires new business models for healthcare delivery
    - Shifting from "just-in-case" to "just-in-time" clinician training and access to data and expertise through emerging informatics tools
    - Pay-as-you-use services for health information support so called `cloud services'
- Provide a platform for coordinated e-health trials, across multiple geographic jurisdictions, thereby improving the chance that such trials become sustainable
    - Develop and sustain test-bed, and "living laboratory" systems not only for dedicated trials, but also for simulating experiences in delivery of services across real networks as they are rolled out
    - Health informatics systems to support increasingly "personalised" health care and the access to, analysing and visualisation of data to support clinicians' requirements
    - Identifying and maintaining a "champion chains" for supporting innovation from clinician to administrative and legislative levels, and promulgation of successful innovations more widely
- Making outcomes of "trials" and evaluations live. Nationally accessible broadband will allow collaborative tools such as wikis to support CIO decision making, and vendor development.
- The Productivity Commission[17] recommends a "clearing house" of aged care health data
    - The WHO report *Innovative care for chronic conditions: building blocks for action* recommended information exchange on successful trials.

Discussion at the Broadband Future Summit held in 2009[18] in Sydney yielded additional ideas for how advantage could be taken of pervasive broadband;

- Establish e-health and tele-health fellowships. Perhaps this could sit under the National Institute for Clinical Studies.

[17] Caring for Older Australians, Productivity Commission Report, Jan 21, 2011
[18] http://broadbandfuture.gov.au/

- Ensure broadband to a clinician's home or practice has appropriate service and performance levels. For example, the uplink may need to be much faster than for residence due to the need to transmit large medical images.

- Develop an "NBN ready" kit of technologies for GPs and clinics which might cover video-conferencing techniques, patient records or e-prescriptions.

- Pilot programs which show consumers the benefits of e-Health at NBN levels of performance, akin to the Digital Regions projects.

Examples of broadband-enabled e-Health in practice

The following examples use high-speed broadband. Wider deployment of such broadband through the NBN will enable wider uptake of such beneficial services.

Telemedicine as a means for overcoming isolation (Western Australia)

[In Western Australia,] seven of the responding hospitals (all public) were classified as mainly providers of telehealth services and 95 (both public and private) were mainly receivers. Of these 95 receivers of services, 58 facilities (61%) reported that they had access to videoconferencing for telehealth purposes. The most common purpose for which videoconferencing was used for was reported to be education (76% of those using videoconferencing), wound care (55%) and psychiatry (53%). The most common store-and-forward application was tele-ECG, which was reported by more than half (54%) of respondents. Eighty-five percent of public health-care facilities reported the use of telehealth (either videoconferencing or store-and-forward) in comparison with 24% of those in the private sector. (Bahaadinbeigy, 2010)

Teleconsultation via dedicated broadband services (Grampians Rural Health Alliance, Victoria, Australia)

The Grampians Rural Health Alliance (GRHA) situated in western Victoria comprises of 12 hospital-based health services, four bush nursing centres and several stand-alone community health centres. It supports improved regional health outcomes by providing technology, applications and communications solutions to connect the regions health services.

The vendor (iVision) used a consultative approach. Ease of use and mobility, were primary factors for GRHA, iVision oversaw the design and development of the highly customized, integrated and mobile MediLink video conferencing units.

The mobility and simplicity of the 17 MediLink units deployed to date have made them particularly suitable for clinical support, supervision and mentoring. In addition to their installation in emergency departments, acute care nurses are using the units and district nurses to consult with wound care specialists on the needs of individual patients. Ultimately, the MediLink systems will enable health services to provide patients with immediate care using specialists typically not available in remote areas.

Remote laparoscopic surgery: providing urban quality of care (surgery) to remote & regional hospitals (Northbay, Canada)

The service was established between St. Joseph's Hospital in Hamilton and North Bay General Hospital 400 km north of Hamilton on February 28, 2003. The service uses an IP-VPN (15 Megabits per second of bandwidth) commercially available [fibre optic] network to connect the robotic console in Hamilton with 3 arms of the Zeus-TS surgical system in North Bay[19]*. [LH-3]*

This service includes an active line and a fully redundant (active backup) line enabling the telerobotic surgeon to use the second line immediately if there is failure of the first line. The telerobotic surgeries are performed at the highest priority QoS, which is a function of the network, thus ensuring signal transmission at the most rapid rate possible between the 2 sites. The surgical signals take priority over any other traffic on the network at the time.

The local laparoscopic surgeon as well as the nursing team in North Bay was trained with the use of the robotic arms and instrumentation prior to the start of the service. An experienced technician was also present during each case to ensure smooth setup of the robotic arms.

To date, 21 telerobotic laparoscopic surgeries have taken place between North Bay and Hamilton, including 13 fundoplications, 3 sigmoid resections, 2 right hemicolectomies, 1 anterior resection, and 2 inguinal hernia repairs. The 2 surgeons were able to operate together using the same surgical footprint and interchange roles seamlessly when desired. There have been no serious intra-operative complications and no cases have had to be converted to open surgeries. The mean hospital stays were equivalent to mean laparoscopic LOS in the tertiary institution.

Telerobotic remote surgery is now in routine use, providing high-quality laparoscopic surgical services to patients in a rural community and providing a superior degree of collaboration between surgeons in teaching hospitals and rural hospitals. Further refinement of the robotic and telecommunication technology should ensure its wider application in the near future.

Virtual Critical Care Unit (Katoomba and Nepean, NSW)

ViCCU developed as part of the CSIRO/DCITA funded Centre for Networking Technologies and Information Economy (CeNTIE)[20]*.*

ViCCU used high bandwidth, advanced networking technology to make information available in real time so a specialist could decide on patient treatment as if they were in the same room. The first installation of ViCCU was between Nepean Hospital, on the western outskirts of Sydney, and the Blue Mountains District ANZAC Memorial Hospital, 80 kilometres away in Katoomba. A clinical trial of the system ran for 18 months during which there were 443 documented 'activations'. This trial was independently evaluated by the Centre for Health Informatics at the University of NSW.

[19] Jimison, H. (2009). Barriers and Drivers of Health Information Technology Use for the Elderly, Chronically Ill and Underserved

[20] ViCCU http://www.csiro.au/science/ViCCU.html

ViCCU was modelled on the position and actions of the specialist in the hospital room. The objective was to embed technology within the workflow of the specialist without requiring a change to the work practice or the operation of the team. The unit had 3 video streams. The cameras and monitor placement simulated the placement of specialist at foot of the bed in the Intensive Care Unit. There was a side camera, because the specialist would sometimes look at the side, a hand-moveable camera, and a light bench with a video stream - to look at documents and x-rays or other images. The original system had no substantial video compression. In the original demonstration, a 70Mbps (full duplex) link was required.

ViCCU ceased operation when the low-cost high capacity broadband link was no longer provided and commercial capacity proved too expensive.

Improving the educational resources and training available for teachers and students

It is a long held belief in Australia that every child should be entitled to high-quality education regardless of socio-economic background or geographical location. The use of broadband technology should assist in achieving this goal.

The research and education sector has always been a leading edge user of high speed communications. The establishment of the first Australian Academic Research Network (AARNet) in the early 1980s led to the Internet being established in Australia, and the introduction of email. Eventually the network was spun out of academia to become Telstra's Bigpond, the pioneering commercial Internet service in Australia. The current implementation (called AARNet3) is a world leading research and education network linking most of our academic and scientific institutions at speeds of many 10s of Gigabits per second. (For more information see www.aarnet.edu.au). While AARNet also links some of our schools and TAFEs (mostly based on geographic convenience), it cannot cover all of them and, more importantly, does not connect the end users of our education system the students.

The role of the NBN is to provide universal connectivity to all parties in our education system. In other words to ensure that all schools and colleges have high speed connectivity and that all students, young and old, can access the education system from home or their place of work. The most important thing about using technology for education is that it has to be of high quality and fully interactive, this means high speed connections in both directions,

Education in the 21st Century.

There are two aspects to the use of technology in the education system. One is to enhance the traditional classroom experience and the other is to introduce new learning paradigms based on Broadband Access and Information and Communications Technology. Of particular importance are ICT technologies such as Cloud Computing and Storage, multimedia databases and associated search technologies, high quality video streaming, high quality two way interactive video and personal learning devices (such as laptops and iPads).

Cloud computing holds great promise for providing cost-savings and encouraging collaborative applications.

In 2010, Google reported that 1.2 million NSW school students' emails had been migrated to a Google App for Education, reducing total costs by 66%. Other benefits were that students email quotas were increased from 35MB to 7000MB, meaning students do not need to delete emails and all email became easily searchable. Furthermore, attachments of up to 20MB can be sent on each email, making collaboration much richer[21].

Another important area which requires symmetrical high speed is the use of shared spaces, allowing teaches to draw and point to remote students' work and vice versa. For example, commercially available solutions such as Adobe Connect & WebEx (a Cisco company) provide two comprehensive solutions for both web viewing and via mobile access, open source solutions such as Real VNC are also possible candidates (http://www.realvnc.com/). More details may be found at en.wikipedia.org/wiki/Comparison of web conferencing software.

The importance of multimedia cannot be underestimated, for example, more than 10,000 Australian schools, TAFEs and universities pay an annual license fee to Screenrights

[21] : http://www.google.com/apps/intl/en/business/case_studies/nsw_det.pdf

(http://www.screenrights.org/about/screenrights.php) for rights to reproduce free to air TV and radio programs for educational purposes. In an emerging fully connected environment this is only one of a multitude of sources of content.

Tools such as Moodle, Blackboards, MediaWiki platform and Wikipedia itself create a base for hosting the knowledge base for different learning and teaching topics all of which require large data transfers.

The enhanced classroom

The first area where the NBN will have the potential to improve our education system is enhancing the current classroom activities. Already many education systems are using virtually connected classrooms but have only just begun to scratch the surface of what is possible. Some examples are described below.

- Specialist subjects.
    - Often there are not enough students to justify running a class in a specialised area (such as a language) in a geographic area. Using a number of connected classrooms it is possible to obtain the critical mass required.
    - Students in a regional location can join a city-based class.
- On-line feedback during classes can assist teachers in monitoring progress
- On-line tests, assignments and quizzes can ease a teacher's work load and automated marking can give quicker feedback to students[22].
- Collaborative assignments; students often form groups to work on collaborative projects, new cloud based collaborative IT tools will make this easier and give students training for future careers.
- Students can have access to a much wider range of multi-media learning material using learning devices (such as laptops and tablets) and wireless connectivity in the class room.
- Extra curricular or after school tutorials involving multiple users.

New Learning Paradigms

There are a number of possible new learning/teaching paradigms when broadband connections are available to all students both at school and home. Some potential areas are described below.

- All schools can have access to the same high quality library material (not just e-books)through an education cloud. This in turn would reduce the need for expenditure on physical content in libraries, but increase the need for technology in libraries.
- Social class room interactions and information-sharing across the world. Schools which are connected to the current AARNet have already developed a worldwide network of international classmates. Each class has one or more shared classes with an overseas equivalent.
- Master classes. It is not possible to have outstanding cultural teachers at every school, however experiments[23] (e.g. during the CeNTIE Advanced Network Program) have shown that it is possible with very high quality two-way video and audio for a maestro to deliver a music master class across Australia. Similar activities could be used for acting classes (imagine our academy award winning actors from the Sydney

[22] NICTA's trial of learning devices at Merrylands High School http://www.cli.nsw.edu.au/partner_with_us/mcontext.htm

[23] http://www.archive.dcita.gov.au/2007/11/advanced_networks_program/advanced_network_program_projects#centie

Theatre Company giving the occasional master class to drama students in the outback) or ballet and even some indoor sports such as gymnastics.

- Cultural Institutions. With ubiquitous broadband it would be possible for students to undertake live tours of museums, art galleries and so on with either a guide answering questions and showing close-ups as required, or even by remotely guiding a camera equipped robot. An early form of this for non-live art gallery tours has been already been introduced by Google.
- Missed Classes
    - Students of all ages will be able to catch-up on missed classes or,
    - Attend a class when too ill or unable to travel to school
- Tele-presence. For many TAFE students travelling long distance for a one or two hour early evening lecture consumes a lot of time. With NBN connections they can attend remotely from home or their workplace. Instructors could view student on-the job projects done by apprentices without instructors having to drive to every workplace.
- Social Networking. The use of social networking for education is in its infancy. However future examples might be the use of background video conferencing to enable students to join special interest groups. This concept is sometimes referred to as the "virtual tearoom" as it allows for more frequent and natural student interaction across distance. Properly moderated such a system helps courses more easily reach critical mass because it becomes practical for distantly located students to participate and support each other's learning experience.
- Auditions on-line. The use of on-line auditions was popularised by the YouTube Symphony orchestra. These days there is a trend for students to apply for places in summer schools, overseas internships, or traditional auditions either in real-time or by directly recording videos onto servers.

Teaching the Teachers

It is important to ensure that teachers at all levels are able to upgrade their own skills and keep up with the latest in the education system. Using online tools and social networking, teachers are already starting to share content and teaching techniques with peers around the world. Given unfettered broadband access they will also have access to a huge variety of on-line learning tools and technologies.

The Future of e-education

As a world leading ICT research organisation NICTA is working on a number of technologies for e-education. These include: Artificial Intelligence, Video Analysis, Video Search/Index, Metadata Management (XML), Network systems, Operating Systems and mobile technologies.

The NBN will encourage a faster transfer of information to students, resulting in large volumes of video, audio and the need to manage ever increasing meta-data. This will need considerable improvements in the back-end systems supporting the educational applications. Such scalable system setups will need virtualisation and services hosted in "the cloud". For example, Monash University has migrated 58,000 students onto Google Apps - again giving them 7000MB email inboxes, but also the ability to edit and produce documents collaboratively. The increase in utility comes at a lower cost[24].

NICTA is also working on new methods for aggregating and delivering content especially for schools and TAFE. This mContext technology allows content to be adapted for use on Net-

[24] http://www.google.com/a/help/intl/en/edu/customers.html

Books and mobile devices and allows frequent updates and teacher interactions with the students.

These new technologies will let students take advantage of the capability of the NBN to download rich study material locally and around the world to provide enhanced learning experiences.

With increasing use of tablets, laptops and mobile devices, for example, mature-age students may interact with their online learning courses in their lounge rooms or when commuting, not being tied to a PC. So we need to consider how to make NBN based distance learning also mobile friendly.

NICTA's search and store technology, mContext may be able to deliver pre-recorded multimedia and pre-packaged learning materials to mobile devices such as Android based phones/tablets or IOS based iPhone/iPad. For interactive multimedia, Adobe or WebEx technologies can be used to provide mobile solutions.

NICTA can also lend its video search technologies to help students quickly locate educational video clips provided by government agencies and stream to their home via the NBN.

In an interactive learning environment, where video conference and audio are used, NICTA technology could help to deliver certification training courses ranging from first aid, hair styling, or any learning topic requiring visual demos. The video search capability can also be used to allow students to quickly locate the most relevant multimedia pieces to the search query.

The NBN and beyond

A question is does the NBN have the capacity to enhance our education and training systems? Provision of more than 50 Mbit/s symmetrical bandwidth to the home and small business will adequately cover the needs of the education sector for the foreseeable future. However the 1 Gigabit per second (using direct fibre connection not Passive Optical Network) option will be required for many schools and TAFEs as they will have many students accessing their resources on-line.

The other question is do we need a Research and Education Network as well as the NBN? Research and education organisations will always be pushing the boundaries, and already experiments using more than a gigabit per second have occurred, and many times that is required to the radio astronomy instruments currently being built[25]. So there is an argument that there is a place for Australia to retain an advanced Research and Education Network such as AARNet.

[25] http://www.atnf.csiro.au/SKA

The management of Australia's built and natural resources and environmental sustainability

Digital technology has the potential to improve the management of every aspect of the economy. It allows us to assess how we are using every kind of resource and asset and provides the tools and models to improve how we manage them. Pervasive broadband accelerates and supports the use of digital technology in this way by connecting the sensors, databases and computers we need to collect, store, and analyse the information to best effect.

Water utilities, large transport, building, agriculture and mining ventures not only need to know what is going on in their network, but be able to act quickly on the information. The same is true of infrastructure operators around the world. Everyone is trying to turn their passive infrastructure into something more like a central nervous system[26]. The National Broadband Network through its backbone of fibre, wireless and satellite will enable convergence of the physical and the digital world needed to reach that goal.

NICTA makes the following observations on management of the built environment, natural resources and sustainability.

The Built Environment and Smart Infrastructure

As discussed in NICTA's 2010 submission to the Parliamentary Inquiry into Smart Infrastructure[27], pervasive broadband supports smart management of transport infrastructure, buildings, bridges, water resources and energy.

The key improvements NBN levels of performance and pervasive deployment will support are:

- Lower electricity use through the use of Smart Electricity Grids
- Lower fossil fuel use through Intelligent Transport Systems and better logistics for freight and non-passenger vehicles
- Reduction in both road traffic and energy peaks using demand management through smart technologies
- Reduced need for transportation through increased telecommuting (as an example, IBM expects staff to work from home 1 day per week). This can have a large impact on fuel use and congestion.
- Infrastructure protection - by automatically monitoring the physical well-being of infrastructure such as bridges, motorways and tunnels so that maintenance can be optimised and catastrophic failure avoided.
- Advanced video-surveillance to monitor ports, bridges and railways against malicious damage

NICTA is engaged in projects in the above areas in particular, areas of intelligent transport systems, infrastructure protection, intelligent fleet logistics and also smart management of water in the agricultural sector. Each of these areas has a positive effect on sustainability.

Broadband may also aid sustainability in more subtle ways. NICTA is developing advanced peer-to-peer computer communications technology which is applicable to distributed immersive reality and video content distribution which will provide better user experiences and reduce server costs. Pervasive broadband makes it possible to re-arrange the way the servers and home-users interact to reduce energy consumption. In this case bandwidth is used directly as a way to save energy.

[26] The Economist, Smart Water article, November 4 2010
[27] NICTA Background Paper for the Parliamentary Inquiry into Smart Infrastructure (available on request)

Smart Transport

The most common experience most Australians will have had of smart infrastructure is on our roads. Australia has been a pioneer in developing intelligent transport systems which adaptively control traffic signalling and speed limits to help manage congestion, reduce the number of starts and stops, reduce travel times and reduce greenhouse gas emissions.

Using networks of sensors across the transport network and, increasingly, sensors inside vehicles allows intelligent transport systems to control traffic signals, speed limits, ramp metering, variable tolls and other methods to manage road congestion, reduce delay and reduce the number of starts and stops.

In the early 1970's NSW Roads and Traffic Authority developed and deployed the Sydney Coordinated Adaptive Traffic System (SCATS), which is used across Australia and over 100 cities in world. Through the use of algorithms for coordinating traffic lights, his system is typically capable of reducing travel times by 20%, and reducing the number of stops by up to 40%[28]. These savings are directly reflected in reduced greenhouse gas emissions in Australia and across the globe.

NICTA is working with the NSW RTA to optimise the algorithms used in SCATS as well as developing traffic lights which can "see" cars and other vehicles approaching intersections to provide for more efficient traffic control and to further reduce road congestion. NICTA also has deployed technologies for better routing of delivery and service vehicles. These technologies, leveraging off the NBN, will provide a more efficient transport and logistics industry and overall a reduced carbon footprint.

Smart Grids

The NBN will provide a highly reliable and stable network connection which will be a platform for supporting smart technology applications like smart grids incorporating the use of sensors, meters, digital devices and analytic tools to automate, monitor and control the two-way flow of energy from power plant to plug. The use of smart technology by Australian households and businesses to track and manage energy consumption will contribute to improving energy efficiency and result in the reduction of greenhouse gas emissions[29].

Studies show that the smarter use of ICT-enabled systems in Australia could reduce this country's carbon emissions by 116.6 million tonnes annually, primarily through efficiencies made in power generation and distribution, intelligent building design and improved transportation networks[30].

Sensors and sensor networks used in smart building systems can contribute significantly to energy reduction. ICT company Siemens has estimated energy savings of 30 percent in buildings with smart ICT systems, because of more precise climate, air quality and occupancy sensors[31].

The Australian Government has partnered with the energy sector to develop the Smart Grid, Smart City demonstration project. The project will gather robust information about the costs and benefits of smart grids to inform future decisions by government, electricity providers, technology suppliers and consumers across Australia. The project will roll out Australia's first

[28] http://www.itsga.org/Knowledgebase/SCATS%20ITSGA%20Presentation.pps
[29] Intel NBN briefing document
[30] *Reducing Greenhouse Gases Through Intense Use of Information and Communication Technology*, International Data Corporation (IDC), 2009.
[31] *OECD IT Outlook 2010*, OECD, 2010.

commercial-scale smart grid and demonstrate an electricity system of the future one that uses information and communications to improve the efficiency of power production, delivery and use.

Water and Natural Resources

For our natural resources, a pervasive broadband network contributes to better water management in two ways. First, it provides a backbone to tie together climate, geospatial, hydrological and water resource databases so that we can form a clear picture of how to best manage our water resources. Second, high performance broadband gives us scope deliver compelling representation of our water use, habits and resources to consumers which may help shape demand[32].

In urban contexts smart systems can be developed to combine water utility data with sensor networks on urban water system to manage water reticulation to detect leaks, manage pressure and better manage ageing infrastructure. This is an important problem. London alone lost 1000 million litres to leaks in 2003/2004[33].

In Australia, some genuine productivity efficiencies have recently been achieved through the trialling of sensor network technology around farm based activities through research organisations like NICTA[34].

Observations and suggestions from the 2009 Broadband Future Summit

The following tangible ideas emerged from discussions on smart infrastructure at the 2009 Broadband Futures summit held in Sydney. There were strong recurring themes on electricity, transport and water.

The NBN was seen as an enabler of intelligent transport systems which will help solve road congestion and enable better traffic management, although it was recognised that mobile communications as well as NBN played a significant role in this space as well. There is also potential for how to use the NBN for streamlining cargo handling particularly in ports and railways.

Make it compulsory that when new services are constructed (such as water, gas, rail, electricity) in areas with no optical fibre backbone, allowance is made for optical fibre cables to be installed.

Direct quotes from the session included:

"The logical next step from this discussion would be to do a pilot implementation of a Smart City, Smart Transport project in a regional city with traffic problems and a major port such as Newcastle or Wollongong, This could be similar to the recent Smart City, Smart Grid initiative."

"The Australian economy would benefit greatly from liberal access to geospatial data".

"All future major infrastructure projects should be reviewed by an independent advisory group to check that appropriate use of smart technologies has been applied throughout the design process, not just at the end".

[32] http://www.slideshare.net/CeBITAustralia/ausinnovate-dr-rob-vertessy-bureau-of-meteorology
[33] http://news.bbc.co.uk/2/hi/uk news/england/london/4330721.stm
[34] http://www.nicta.com.au/research/project list/completed projects/water information networks

Impacting regional economic growth and employment opportunities

The impact of pervasive broadband will be felt most in those areas where broadband was poor and frequent physical travel to major population and wealth centres is impractical. Consequently, Australia's regional areas have great potential to gain from the NBN roll out. The benefits of broadband for Australia apply across all sectors, discussed in great detail in the other parts of this submission, but will be felt more strongly in regional Australia.

Connecting with the world

Rural communities are under serviced by broadband Internet and mobile phone coverage, frustrating their ability to connect with wider markets, and limiting the extent to which the rural population can leverage the online services that their urban counterparts take for granted. Furthermore, in 2007-08, less than 50% of Australian farms used broadband Internet for business operations[35]. This indicates there may be significant room for increasing efficiencies in the administrative, marketing and partnering aspects of their business, by moving to online tools and services - something made significantly easier by pervasive broadband.

But the services supported by broadband are not just about business. As discussed in the other terms of reference, broadband enhances remote delivery of education, government services, health and entertainment. It also gives regional and rural businesses access to a 'level playing field'.

Global markets for regional business

Small Businesses can take advantage of the high-speed broadband, and the effect is especially sharp for businesses in regional Australia. Some examples of successful businesses quoted at a recent regional futures summit at the University of New England[36] in Armidale included the following:

Eastmon is a global photographic company run out of Glen Innes. It is one of Australia and New Zealand's largest players in the photographic market (employing over 300 FTEs or 700-800 in season). Eastmon has quickly developed into the largest digital wholesale lab in the southern hemisphere. Its products include digital prints, enlargements, photo books, canvas, and materials for large companies such Snapfish and Hewlett Packard in the USA, Big W, Harvey Norman, Apple, Dick Smith, Rabbit Photo, Camera House, Bing Lee, Kodak Express and many others. The company is poised to take advantage of the new higher speed broadband capacity to expand its business.

Petals www.petals.com.au is a world-wide florist online delivery network which distributes to over 70 countries and involves over 40,000 florists internationally. It has now established itself as a serious competitor to Interflora, given its low overheads and competitive business model. Its head office is based out of Armidale in regional N.S.W.

[35] *Australian Bureau of Statistics, Use of the Internet on Farms, Australia, 2007-08 (August 2009). Available at: http://www.abs.gov.au/AUSSTATS/abs@.nsf/mf/8150.0*
[36] http://blog.une.edu.au/news/2011/02/18/collaboration-emphasised-at-regional-futures-summit/

Reinvigoration

In Britain, the Commission for Rural Communities has said that regional districts see clear benefits from the introduction of broadband because[37]:

Some business owners had moved from urban to rural areas to enjoy a better quality of life;
The migration of people from rural to urban areas slowed as workers discovered the benefits of telecommuting;
Rural businesses tapped into international markets; and
These factors led to the rejuvenation of local shops, schools and rural services.
Australia's regions could equally benefit from the introduction of the NBN if accompanying policies are devised and implemented.

Smarter farms, safer mines

According to the National Farmers' Federation, Australian farms and closely related industry sectors generate $155 billion per annum in production, or roughly 12% of GDP[38]. Nevertheless, Australia's farmers are looking for ways to further improve their profitability, often turning to digital technologies for help.

The Grains BMP (Best Management Practice) program is one example of a successful online application used by farmers to simultaneously increase their profitability and reduce their environmental impact. Grains BMP is a tool that enables grain growers to "identify improved practices which can help improve the long term profitability of their enterprise."[39] An economic analysis shows that grain growers in the Fitzroy catchment could boost their profitability by 8.92% over a ten-year period by adopting farm machinery with a standard track width, GPS and auto-steering capability[40]. So the impact of digital technology here is two-fold: it enables a detailed analysis of farm management practices, and it features prominently in the solutions for improving farm productivity.
The mining industry is a major consumer and user of digital technologies. From exploration to extraction and processing, ICT is at the very heart of mining operations in Australia and around the world. For instance, Brisbane-based company iVolve deploys wireless networking solutions into open cut mines to support mine communications, personnel tracking and other crucial functions. NICTA's Queensland Research Laboratory is developing wireless networking solutions for underground mines, improving mine safety and increasing productivity by reducing mine communications outages. With mine operations increasingly carried out remotely, pervasive broadband becomes even more important.

[37] *Williams, Tim, Connecting Communities: The impact of broadband on communities in the UK and its implications for Australia (February 2011), Huawei. Available at:* http://www.huawei.com.au/connectingcommunities/
[38] http://www.nff.org.au/farm-facts.html
[39] https://www.grainsbmp.com.au/
[40] *Strahan, Rod & Hoffman, Alex, Estimating the Economic Implications for Broad Acre Cropping Farms in the Fitzroy Basin Catchments of Adoption of Best Management Practices. DEEDI. p. 12. Available at:* https://www.grainsbmp.com.au/reports/report1.aspx

Impacting business efficiencies and revenues, particularly for small and medium business, and Australia's export market

The NBN's potential to enable rich service and application development and delivery is not limited to social services with strong 'public good' qualities, such as health, education and government services. Critically, it can also reshape the immediate and longer term business landscape to generate benefits for all Australians.

Pervasive broadband brings many benefits to business. New cloud services remove the need for upfront capital investment and provide easy paths for scaling. Businesses in regional Australia can access Australian and global markets on a level digital playing field. Workers can be more mobile or located remotely, yet participate in high value business. Australia's support and attractiveness for global knowledge workers will increase.

Businesses, whether large or small, established, or just starting, must attain and sustain a measure of competitive differentiation and continuously build and improve operational execution capability. The ultimate measure of this capacity is sustained positive cash flow; revenues in excess of costs which exceed the invested capital and risks involved.

With the advent of the Internet, the World Wide Web and increasingly pervasive broadband, the last two decades has seen fundamental shifts in how economies, industries and businesses adjust and take advantage of a changed business environment. There are challenges, as well as opportunities to secure and sustain competitive differentiation. This is true locally, as well as globally. It is as true for Atlassian in Sydney, as it is for Ruddweigh International in the small northwestern NSW town of Guyra.

There is no doubting the international competitive dimension to the deployment and adoption of broadband. Broadband in the form of ubiquitous, accessible, wired and wireless coverage can improve the economic trading ability and experience of customers, globally. Paradigm shifts in where and how dollars are spent and how goods are distributed are underway. An electronic trade battle is happening and Australian companies, both large and small will need to adjust. A change in cultural mindset around innovation and business adaptability is being precipitated by the introduction of high-speed technology.

A business, and economy is arguable better when operates as efficiently yet strategically as possible. The following sections describe how the NBN underpins both these business imperatives.

New markets

Businesses can grow revenue by selling more of existing products or services into existing markets, expanding into new market segments or geographies, or launching entirely new products or services.

Selling more of existing products or services into existing markets can be a function of better targeting of customers, refining messaging, service and support, pricing models and incremental product evolution to achieve better sales. The NBN allows this by opening up a larger window into the global Internet market.

Digitisation not only allows new ways to do old things (like storing and sending documents and photos) but allows entirely new markets to be created and launched from an existing market.

The relatively new market of 'e-discovery', with smart tagging of documents and algorithmic search over those tags, is transforming litigation practices around the world. An Australian company, Nuix (http://www.nuix.com) is a recognised world leader in this domain.

The notion of a 'virtual' courtroom, with video-based sessions of expert witnesses, counsel and judges, with full access to all relevant material, is not far off[41].

Similarly, Canberra based Funnelback (http://www.funnelback.com/) provides the search engine for many Australian government department web-sites and internal document searches, in addition to the ASX, Westpac, ABC and many others. The idea of a market for "search" in this form was fanciful two decades ago. Then came Google. A clear leader in the next generation of broadband content around video is yet to emerge but will clearly benefit from a pervasive broadband network.

The NBN, as part of a connected global network, also allows Australian businesses, wherever they are, to open up and address markets outside their traditional territorial reach. It becomes possible to serve and lead global markets which barely exist in Australia. Atlassian (http://www.atlassian.com/) begun in 2002 by two young graduates from UNSW. It now sells tools for enterprise collaboration and development to more than 22,000 customers from 138 countries.

A gradual increase in connectedness and the increasing ability to connect easily, as part of a particular group or cohort and in real time is behind the latest wave of internet based wealth creation that is part of the longer term trend of global market shifts enabled by ICT. The dramatic rise of Facebook, Twitter, Groupon, Zygna, Linkedin and countless others, while initially seeming trivial in a traditional business sense, are non-trivial in a "whole new market" sense. Australia might hope to have leading participants in the next wave (or the one beyond that) of new technology, but many infrastructure and mindset 'dots' need to be joined, including understanding the scale and scope of possibility an NBN provides.

Cloud based applications are still a nascent global industry and Australia has an opportunity to participate and lead in various niches of cloud based service provision. A company such as IPScape (http://www.ipscape.com.au/) could be one such example, providing "pay-as-you-go, contact centre in the cloud". Google even offers video-conferencing over the cloud (though not in Australia due to the international bandwidth limitations).

Going from idea to execution faster

A major impediment to starting any business is the operational support and services required to get going. From accounting to payroll to inventory control to call centre functions, the time to master these necessary business operations is exhausting and daunting. Alternatively, the cost of hiring professionals is often prohibitive so the business may not even get started (and by implication no professionals secure revenue from this client either). The NBN provides a physical platform for "cloud" or software-as-a-service providers to address these start-up issues and hence lower the up-front costs, and speed time to market. Further comments on the cloud follow later in this document.

Australian companies such as Aplicor (http://www.aplicor.com.au/), Saasu (http://www.saasu.com/news/) and Sybiz (http://www.sybiz.com.au/) are harbingers of the eco-system of providers which make it easier, faster and cheaper for new businesses to start whether they are online businesses or not.

[41] http://www.stanford.edu/~bailenso/papers/Courtroom%20VR.pdf

Distance is less a barrier to entry (but also to competition)

As previously mentioned, companies such as Atlassian sell into 138 different countries even where the home country (Australia) market is actually very small. Sybiz, based in Rose Park, South Australia, has thriving businesses in Ireland, Sri Lanka and New Zealand. Downloads of their software products do not get held up at the border or join the queue at Port Botany.

An example of a rural-based business reaping the benefits of access to global markets is Ruddweigh International Pty Ltd (http://www.ruddweigh.com/) from the small town of Guyra in north-eastern N.S.W. Ruddweigh has become a world leader in electronic agricultural weighing systems and the Internet has been critical for their marketing activities, handling sales enquiries and distributing upgrades. Their success in moving from being a simple engineering service company in a small town to an innovative developer and marketer of sophisticated equipment exporting to 38 countries led to them being noticed by and ultimately acquired by the Gallagher Group based in Hamilton New Zealand.[42] Everyone with a broadband connection can live, work and compete in a global economy.

Increased ability to ramp up a business

Many businesses are currently limited in their ability to grow beyond a certain point. For example, the proprietor of a small business baking and selling puddings in Newcastle has only so many hours in the day, some of which need to be devoted to accounting and inventory management rather than seriously investigating a franchise opportunity. A local Geelong winery relies on weekend cellar door traffic for sales. A Tambourine Mountain Bed and Breakfast establishment in south-east Queensland puts its brochures into the local "Tourist Information Office". While these are all useful activities more could potentially be done to ramp each of these businesses through use of high-speed broadband.

Whether is accessing cloud services to relieve the accounting burden (e.g. http://myob.com.au/), establishing an e-commerce facility (http://www.emarketservices.com/) or presenting an engaging video of the facilities and surrounds of Mount Tamborine to a wide range of travel consultants (http://www.tmbb.com.au/mt-tamborine-resources-links/), the ability to market and more cost-effectively run a business is increased via NBN enabled technology.

Serving existing markets in smarter ways

The mortgage industry in Australia costs in the order of $1 billion a year to service 28 process steps and many parties involved (up to nine separate organisations communicating in various proprietary ways) . Over $200 million of the $1 billion is due to rework and tracking physical documents moving among mortgage brokers, lenders, valuers, home buyers and title authorities. Between 2005 and 2008 NICTA partnered with several banks and lending institutions in a project, called LIXI (http://www.lixi.org.au/), to standardise this multi-party process and incorporate the lending steps into a simple digital participation platform.

This platform has been adopted in part by nearly all major banks and aggregators (80% loan origination and 50% of the mortgage insurance applications are using LIXI) with cost savings to the industry and clients of about $120 million per year. The *speed* of business has increased dramatically. The Commonwealth Bank of Australia now takes 14-15 *minutes* to approve a home loan, down from 14-22 *days.*

[42] : Hunter, A. 1999, Opportunities Through Communications Technology for Regional Australia, Paper presented to the Regional Australia Summit, Canberra, October. [Online]

Materials and ongoing research produced by NICTA in the LIXI project provide the foundations for innovative business models in a broad area of online applications and processing. NICTA's architecture approach enables more efficient, wider and organically grown use of existing and expected digital infrastructure. Our modelling approach has now been extended to support the new National Electronic Conveyancing System (in progress now).

Connected economy

Over the last decade the quantitative and qualitative value in 'networking' or, in broader terms, becoming and staying connected has been increasingly realised. Terms capturing this trend include Web 2.0, Social Media and Personalisation.

Connections have always been important to business. For remote and regional businesses the ability to get and stay in the loop with industry trends, with industry debates, with sharing of knowledge about what works and what does not has been a critical locational disadvantage.

The Internet and the Web have lessened this disadvantage as online tools allow some of this to happen virtually - for example, through, LinkedIn. And those online tools work best if broadband is fast and pervasive. The NBN's reach into regional and rural areas will lessen the disadvantage for those previously without high quality broadband.

Dealing with markets and customers online allows rapid feedback, interaction and improvement. It also provides information to sharpen product offerings, improve business performance and spark new, creative, ideas. Today many businesses are developing online and social media marketing strategies. .

Developing an innovation mindset

As the countries of the world enable their economies with broadband, the opening up of new markets, new revenue streams and smarter ways of doing things is available to a growing and global set of competitors and their time, attention, goods, services and finance. The investment in the NBN gives Australia the chance to be part of that broadband-enabled global community.

As the digital economy approaches and lowers the cost of starting and running a new business and scaling it, it becomes possible to try innovations cheaply and quickly, so that failures can be borne more easily and valuable innovations discovered more quickly. . The Bay Area in California, which includes Silicon Valley, is an exam[;e of this kind of environment and is the place that Cisco, Google, eBay, Amazon, YouTube and Twitter were born. Australia has yet to produce a technology with that kind of impact, but the NBN should raise the odds.

Cloud Computing

Digital tools are constantly lowering the cost of doing business and bringing economies of scale previously only available to large businesses to even very small businesses.

One of the biggest changes that high-speed broadband will enable - particularly for small business - will be to provide higher performance access to 'the cloud' or Cloud Computing.

Cloud computing is broadly defined as Internet-based computing, whereby shared resources, software and information are provided to computers and other devices on- demand, like electricity[43].

[43] *en.wikipedia.org/wiki/Cloud_computing*

The 'Cloud' is created through a massive data centres in a single physical location, where many computers are joined together to create a large amount of power and large data storage capacity. This creates economy of scale.

Remote users from regional areas, for example, can access this 'cloud' to store their information and run their business for a fraction of what it would have previously cost them to run their own servers and software systems.

Cloud computing can make small business far more productive by giving employees the ability to work and collaborate from anywhere, at any time and on any device. Webmail services such as Hotmail or Gmail are simple cloud applications. But customer relationship management systems, video-conferencing and even entire customer contact centres (IPscale.com.au) can also be run as a web service. These more valuable business applications require much higher bandwidth but reduce the need for individual businesses to maintain their own computer systems and business applications.

From 2009-2014, Goldman Sachs predicts expenditure on the cloud to grow by a compound rate of 20%, four times the rate of spending on traditional desktop applications[44]. Cloud Computing has a total cost of ownership 5-10 times less than that of installed desktop software, and is typically 50-90% faster to deploy than traditional desktop software[45].

For small businesses cloud computing means

- The data centres that house cloud computing facilities have greater reliability than local systems, provide automatic data backup and have diesel generators preventing outages (such as the recent Virgin Blue check-in outage).
- Automatic backup of data in the cloud can help business quickly recover from natural disasters (such as the recent floods).
- No software installations and updates required instead, word processors, spreadsheets and email are all accessed through a single web browser;
- The cloud is platform agnostic. It doesn't matter whether it a Mac or PC or a Linux box
- It is much easier to collaborate online on reports, spreadsheets and presentations using services such as Google Docs[46].
- Business IT costs can be reduced fixed to variable expenditure, fluctuating as the operational demands of the business change[47];
- Many aspects of running a business are simplified, like keeping important documents and data, paying bills and so on;

Examples of services which can be offered by Cloud Computing include customer relationship management, enterprise asset management (see www.mincom.com a Brisbane based company) supply chain management, fleet management, web hosting, data storage (or any other business software, see www.salesforce.com and www.sap.com etc). This model is sometimes referred to *as a Service* (SaaS), or *Infrastructure as a Service* (IaaS).

The benefits of cloud approaches are clear, but even with the NBN, there are some obstacles Australia faces in its adoption. To get the needed economies of scale cloud service providers such as Amazon and Google have built huge data centres in densely populated regions, but not in Australia. Consequently, the cloud services which might benefit small business most are accessible only via our international data connections which are currently adequate but are

[44] *Tech Sector Barometer January 2011 (January 2011), The Economist Intelligence Unit. p. 8. Available at: http://www.eiu.com/public/topical_report.aspx?campaignid=tech_baro*
[45] *Furness, Victoria, The Future of Software Delivery (February 2009), Business Insights. p. 43. Available at: http://store.business-insights.com/Product/the_future_of_software_delivery?productid=BI00029-025*
[46] *http://docs.google.com/*
[47] *http://www.cio.com/article/484429/Capex_vs._Opex_Most_People_Miss_the_Point_About_Cloud_Economics*

unlikely to be as the NBN is rolled out. It would serve Australia well to encourage the development of major cloud infrastructure in Australia, and also to bolster the performance of our international data links.

Interaction with research and development and related innovation investments

Australia's public research and development community is served with world class facilities through AARNet to the campuses of those facilities. Nevertheless, the NBN can bring some additional benefits. But the NBN may have a stronger effect on how research, development and innovation occurs in the private sector and also in how the private sector interacts with public innovation system.

Interaction with the public innovation system

Currently universities, CSIRO and NICTA are well served by a world class network provided by AARNET (www.aarnet.edu.au)

All main university campuses are connected by optical links running at between 1 and as much as 3x10 Gigabit per second, as well major sites for CSIRO and NICTA. AARNet is also connecting some schools and TAFEs to the AARNet network.

On-site facilities connected to AARNet have performance far in excess of current NBN premise services. However, the NBN will provide the following benefits:

- Improved performance for connecting smaller, outlying sites for universities and the CSIRO
- Connection of staff and students from their homes providing higher performance access to AARNet facilities than is currently available in the Australian market. This means researchers can be as productive at home as they are at university
- Potential provision of backbone or long-haul capacity in areas not currently served by AARNet backbone
- More options for connecting K-12 institutions where no fibre currently exists.

Other interactions, public and private innovation sector mixing

Australia lags the OECD average for the amount of private sector Research and Development investment[48] though there have been increases in recent years.

By upgrading broadband access to every premise, the private sector will begin to have access to the kinds of broadband performance and digital tools currently available largely to the public sector innovation system. When connected, smaller private organisations engaged in research could have affordable access to massive public sector computational research clouds[49]. This may encourage better operation of ecosystems which mix the public and private sectors, most notably the ARC Cooperative Research Centres and Industry Linkages programs.

As digital technology lowers the cost base, innovation can move to smaller companies or even to private homes as the consumer becomes an innovation co-inventor[50]. The NBN will bring richer digital tools to consumer and small business and make it easier to collaborate with

[48] *OECD: Science and Innovation Country Notes for Australia* http://www.oecd.org/dataoecd/31/0/46663563.pdf
[49] http://www.csiro.au/science/cloud-computing.html
[50] *Innovation in Business* http://www.innovation.gov.au/Innovation/Policy/Documents/NISChapter03.pdf

others in an innovation ecosystem and provide a more powerful platform to share the results. This kind of effect is already being seen in the media industry where graphic designers, musicians, video-producers and visual effects artists can now run their micro-SMEs from home.

Facilitating community and social benefits

Communities and individuals stand to derive numerous indirect benefits from the rollout of a high-speed broadband network pervasive due to the advantages it provides to commerce, health, education, government and other sectors.

Family and Community Cohesion

With Australia's economy increasingly knowledge-based - by some measures approximately 50% of Australia's GDP is derived from knowledge-based industries. A high-speed national high-speed network may make it unnecessary for workers to move from their home-towns to large urban centres to carry out many of their work duties. This may have a direct effect on lifestyle choices, and improve family and community cohesion. Some potential effects, extrapolated from a study performed by Huawei on the UK experience, could be :

- Slowed migration from rural to urban areas, further mitigated by inflows from urban to rural areas of people seeking lifestyle changes;
- Increased ability for Australians to choose the communities in which they reside based on non-work-related factors;
- Reduced incidence of long-distance family relationships;
- Richer long-distance family relationships when there is no alternative;
- Increased care options for the elderly, who may choose to stay longer in their own homes if they know they are being monitored over the Internet by family or close friends;
- Stronger communities developed through retention of citizens resulting in more robust community structures;
- Reinforced local relationships through online social networking;
- Emphasised connection with *place* through the ongoing collective digital documentation of significant locations, objects and events; and
- Continued and accelerated growth of officeless enterprises and "micro-multinational" companies, enabling more people to stay with their families and communities in their home towns.

The growth in the number of office-less enterprises and "micro-multinationals" here and overseas is evidence that many people value the ability to remain in their local community rather than emigrate. 37 signals (creators of the popular Basecamp project management tool) is a prime example of this. It employs fewer than twenty people across eight cities on two continents, many of whom work from home.

A high-speed broadband allows knowledge workers to base themselves anywhere in Australia, and participate in office-less enterprises and micro-multinational organisations. Thus, one effect of the NBN may be to indirectly strengthen relationships and connections at the local level, since it could reduce the need for knowledge workers to be uprooted from their (physical/geographic) community. This effect will have particular benefits for regional centres, which have suffered a net population exodus in recent times. Also, the capacity to operate a business without a physical office generates large savings, so the notion of a "virtual" enterprise should be attractive to business owners from the viewpoint of profitability.

However, when there is no alternative but to move away from family and friends to pursue a career, a high-speed broadband Internet connection is a good alternative link to home. Instant messaging, Skype video chat, photo sharing and social networking sites help families and friends stay connected despite great distances.

The elderly, too, can often find themselves separated and isolated from family and friends. In the UK, for instance:
Three million people over the age of 65 go more than a week without seeing a friend; and
For 1.8 million of those, the gap is a month.

In Australia, this problem will mount as the population ages, but can be mitigated by educating the elderly about the benefits of being online and providing them with access to social networking tools that can make a real difference in their lives. These tools, coupled with other broadband-enabled remote monitoring services facilitate independent living for the elderly, reducing pressure on aged care facilities.

Civic Engagement and Participation

A national broadband rollout will facilitate simpler and greater participation in community debates, engagement with local events and more informed decision-making on local issues. Fast Internet connections for all will also enable anyone to participate in the dissemination of important information from credible sources during large emergencies, a phenomenon observed during the Queensland floods. Pervasive broadband will enable and augment:

- Live, open and transparent participation in government or community forums from anywhere in Australia;
- The rapid and widespread dissemination of important information from credible sources during emergencies (more rapidly than traditional news channels like TV, radio and newspapers can disseminate important announcements);
- Bottom-up coordination of the community response to emergency situations;
- The emergence of grass roots community organisations;
- The continued coordination, growth and sustainability of such organisations;
- The ability of the public to document (with images and video) damaged or decaying public property such as park benches, toilets, road signs, fences and so on; and
- A more vibrant democracy through better access to information and greater ability to participate in decision-making.

While the Queensland floods were a traumatic experience for many and their effect is still being felt economically and socially, they did provide a glimpse of the way in which social media, facilitated by network connectivity, can be used in a positive way to inform communities of rapidly developing events and to mobilise large numbers of people in the aftermath.

The Queensland Police Service's use of Twitter and Facebook during the floods, particularly, showed how social media can be used to disseminate controlled messages to large numbers of people. The Brisbane City Council also used social media, amongst other communications media, to coordinate volunteers in the flood cleanup.

However, much of the response to the floods was coordinated in bottom-up by ordinary citizens through Twitter and Facebook, and the event itself was documented by hundreds of people on blogs, YouTube and other Web 2.0 sites. Baked Relief, a movement started during the Queensland Floods, is just one example of this. Harnessing the emotion, community spirit and the general need to contribute felt by many, Baked Relief coordinated the baking and delivery of hundreds, if not thousands, of baked goods to cleanup volunteers, police, emergency services personnel and those in need, right across Queensland using Twitter,

Facebook and its own website, www. Bakedrelief.org. Baked Relief has grown to become an international movement, working with other organisations to provide baked goods to people in Christchurch in the wake of the February 2011 earthquake. While these sorts of bottom-up grass roots movements are by no means a new phenomenon, social media tools and the networks that enable them have unquestionably aided in the growth of the organisations and in their coordination.

This example shows the importance of network ubiquity. A network of any kind (people, telephones or computers) becomes more useful and powerful as more people or devices are connected. This has been expressed mathematically in Metcalfe's Law [ref: http://en.wikipedia.org/wiki/Metcalfe%27s_law]

In essence, Metcalfe said that if you double the number of connections you get four times the usefulness. If you increase the number of connections by 10 times, you get 100 times more usefulness and so on. What this means is that the NBN, by adding and upgrading millions of new broadband connections, will provide a massively more powerful experience and value for the people connected to it. Organisations like Baked Relief, social media platforms like Twitter, Facebook and YouTube, and the communities that evolve around them, very much rely on network effects for their continued viability. Broadband will underpin the growth of these online communities into the future, as they begin to consume more bandwidth through increased use of real-time updates and communication, rich media and so on.

Public and Private Safety

Safety and security is one area that will benefit heavily from the deployment of nationwide broadband. It will enable:

- Outsourcing of the monitoring of council public safety cameras to centralised, dedicated facilities, reducing costs;
- Remote monitoring of a home by the homeowner or someone trusted by the homeowner, like a friend, family member or specialist home security firm; and
- Remote access control, whereby the homeowner can remotely allow or disallow access to their home by tradespeople or delivery people.

Ipswich City Council has established itself as a world leader in public safety surveillance monitoring with its Safe City program. Several regional councils in Queensland and interstate are considering outsourcing the monitoring of their own surveillance cameras to Ipswich City Council's monitoring facility. The NBN can simplify and greatly reduce the cost of these kinds of inter-council collaborations, not only in the area of public safety and surveillance, but in any data-intensive application including automated water metering, where one council is seen as having established a comparative advantage and is able to reduce costs for other councils through economies of scale. NICTA is working with the Ipswich City Council to automate some monitoring tasks, such as detecting road rage or dangerous driving behaviour on highways. (See http://www.qt.com.au/story/2010/02/23/ipswich-to-keep-eye-on-regions/ and http://www.zdnet.com.au/road-rage-graffiti-in-upgraded-cctv-sights-339305803.htm.)

Similarly, the NBN brings greater opportunities for homeowners to remotely monitor their homes, and for security companies to offer smarter home monitoring solutions. While some home security firms already use the Internet to enable "back-to-base" monitoring, these solutions do not collect and transmit rich data of the kind that might be usable in a prosecution. Low bandwidths also inhibit the ability for homeowners to conduct their own remote video surveillance of their residences, and curtail the growth of certain "smart home" applications. For example, NICTA's SAFE technology is being applied to the domain of independent living, potentially enabling the elderly to remain in their own homes for longer.

Niche Interests and Choice

One of the markers of a free society is the ability for the individuals within it to choose and practice their religion, their hobbies and their friends. A ubiquitous broadband network goes some way in ensuring that this freedom to choose is extended to all citizens, and that all citizens can associates with groups of their choosing (within reason), no matter where the other members of this group might be in the world. The NBN will support:

Diversity, by enabling people to connect with others who share the same religions and cultures;
The pursuit of niche interests, hobbies and pastimes by enabling individuals to connect with people around the world who share similar interests; and
The creation of online communities that relate to various niche interests, founded upon the sharing of rich media.

Imagine a person who has chosen to move to a rural community for lifestyle reasons. While gaining many benefits in doing so, but without reliable and fast Internet access, they potentially lose many of the conveniences a former urban lifestyle afforded.

For example, a design student might have cultivated an interest in collecting and designing Asian ball-jointed dolls during her time at university. This is not a hobby easily pursued without broadband access, as it requires links into the international online forum and marketplace that has evolved around this niche interest (see http://www.denofangels.com/). Members of the community collaborate on doll designs, involving the upload of graphics and other media files used during the design process, and then coordinate the manufacture of the dolls to the agreed specifications. Ubiquitous broadband enables individuals to connect with people around the world who share similar interests, it promotes freedom of choice and enables "long-tail economics".

Hyperlocal Media

NBN will enable people to create, contribute and share as easily as they can consume. Current high-speed broadband services, notably ADSL, are asymmetric in their download and upload speeds. Upload speeds are typically much slower than download speeds, making the user experience of uploading a homemade high definition movie to YouTube or some other web site less than ideal. Participation is a two-way street: it requires content production as well as consumption on the part of the end-user. Symmetric high-speed broadband will enable and encourage:

- User-generated content creation and dissemination;
- The collection and dissemination of environmental and other data by "citizen scientists"; The Sunlight foundation in the USA is an example of this.
- Citizen journalism;
- Diversified local news sources;

When it is possible for anyone with a laptop and camera or even just a smart phone to capture events as they unfold in their home towns, you have the beginnings of hyperlocal news publishing for and by the citizens: citizen journalism. But this also requires that would-be news reporters have the means to upload their stories, complete with rich video content, to the online news service, a scenario made possible only by adequate broadband networks. The NBN has the potential to catalyse this nascent activity.

e-Community

E-community groups can offer a myriad of possibilities including health support groups (Diabetics, cancer or lupus sufferers, mothers, disabled groups and so on) There is also a role for training the elderly and disadvantaged to participate more fully in a digital environment

NBN service levels could support social networks in a number of ways (real-time video, sharing of content like photos and video, and things that may evolve). An example might be much richer virtual family reunions and more useful services provided by local governments.

Some ideas include

- Public digital literacy training and education. Topics to be covered could include the use of social networking tools, Internet safety, e security and on-line ethics. Australia could set up a programme similar to the U.K.'s Race Online 2012 programme to educate those people who have never used the Internet.

- Development of mechanisms to enable local communities to create and archive their own content. A follow-on from this is the potential need to identify and reserve appropriate domain names for such communities.

- Australia could also consider some form of perpetual e-mail address/digital identity for all its citizens similar to the number portability that was introduced for mobile phones. *(Privacy and identity theft issues would need to be considered.)*

The optimal capacity and technological requirements of a network to deliver these outcomes

NICTA's view is that the capacity the network needs to deliver should, to the greatest extent possible, anticipate growth in bandwidth into the premises, and an increasing demand for up-link capacity. There is no optimal capacity since there is as yet no evidence of demand for bandwidth reaching a plateau. This view is based on the assumptions of past bandwidth growth trends continuing, proliferation of currently popular high bandwidth applications, growth of emerging applications and applications which are known to be under development in research environments.

Technological requirements relate to the ability to upgrade network capacity cost-effectively, to support low-cost distribution of media, multiple services, delay and error characteristics which will support all conceivable applications.

These growth scenarios impact on the technical requirements of the network. Specifically:

- The network needs to be able to deliver 1 Gigabit per second and beyond with little added cost.
- The uplink should be upgradable at low cost to have symmetrical bandwidth (for example, 1 Gigabits per second up/down) at little added cost i.e. no upgrades of expensive electro-optical components.
- Even at 100Megabits per second, care needs to be taken to dimension the backhaul to ISPs to ensure that users are able to experience throughput equal to the data rates of the access networks.
- A formula separate to charging based on volume of data use needs to be canvassed
- In areas where fibre is not deployed, wireless links may cause bottlenecks, and in these cases it may be necessary to implement traffic management for data and related 'quality of service' procedures.
- The NBN will provide a step increase in domestic broadband capability. This may highlight some limitations in Australia's international connectivity. This is especially important for Australian citizens and businesses accessing internationally based cloud services, and for the ability of Australians to host such services.
- Consideration should also be given to the ability to deploy wavelength services to customers. Research users such as AARNet and CANARIE have been experimenting with wavelength services for around 5 years, so demand for such services may occur within the lifetime of the NBN. A wavelength is a colour of light carried over the optical system to the user which can carry 1, 10 or more Gigabits per second.

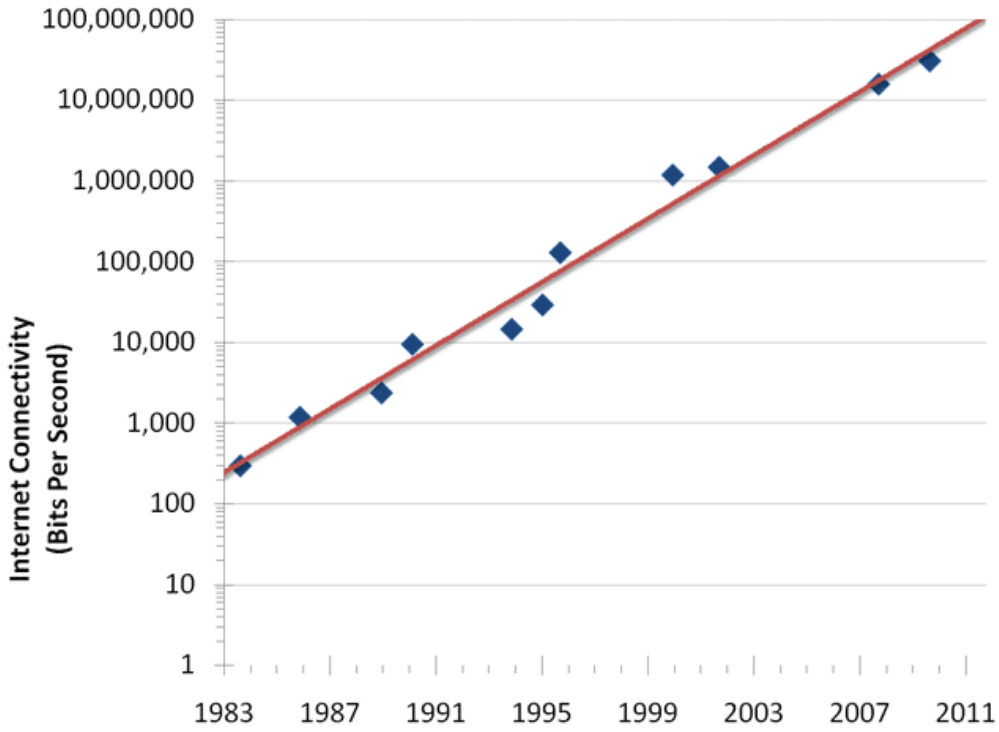
Some attention also needs to be paid the access point and how different services are deployed reliably in premises.

Bandwidth growth trends

In our view, demand will quickly grow to fill 100 Megabits per second perhaps within 5 years for advanced users, with an increasing proportion of data carried on the up-link. It is conceivable that lead-users could consume 1 Gigabit per second by 2020 if current trends continue.

Nielsen's Law of Internet bandwidth[51] states that a high-end user's connection speed **grows by 50% per year**.

The dots in the graph show the various speeds from an early acoustic 300 bits per second modem in 1984 to an ISDN line, updated to show a 31 Megabits per second cable modem in 2010. NBN's intended access specification sits exactly on this curve.



Nielsen's Law is similar to the more established Moore's Law (which is really an ongoing design goal which drives the industry). Comparing the two laws shows that bandwidth grows more slowly than computer power.

		Annualized Growth Rate	Compound Growth Over 10 Years
Nielsen's Law	Internet bandwidth	**50%**	57x
Moore's Law	Computer power	**60%**	100x

This means that it is likely there will be constant upwards pressure on bandwidth, assuming increasing computer power is linked directly to the amount of bandwidth needed. "Computer power" can be considered a combination processor speed, screen resolutions, disk capacity and how fast data can move in and out of the machines. By these estimates leading-edge users in advanced markets will need 1 Gigabit per second (1000 Megabits per second) to the residence around 2016. Given the proliferation of large, network-connected High Definition screens, IP-enabled TV and IP-enabled High Definition cameras it is not hard to imagine rapid increases in demand for domestic download bandwidth and up-link bandwidth.

[51] http://www.useit.com/alertbox/980405.html

Over the 30+ year life of the network demand for bandwidth could reach 10 Gigabits per second (10,000 Megabits per second) per household. While this seems unimaginable now, those who remember ISDN 20 years ago may have thought a need for 100 Megabits per second unimaginable, yet for some leading edge users today 100 Megabits per second is barely adequate.

Applications and other drivers for bandwidth growth

There are several trends which are driving bandwidth growth. While it is not possible to quantify how much demand for bandwidth these applications will produce in future, it seems clear there is scope for a great deal more growth beyond current levels.

Applications which will increase demand for up-link capacity

Video (on-demand, two-way service)

Good quality video needs anything from 5 Megabits per second and upwards per channel to stream in one direction. Video-on demand for education and entertainment is expected to be a major user of downlink bandwidth. As noted later in this section, Japan's national broadcaster has been trialling video broadcasts at 16 times High Definition levels, which is likely to translate to over 100 Megabits per second per channel.

Sometimes termed "telepresence", excellent quality two-video, such as would be needed for medical applications and home care visits, would be closer to 10 Megabits per second as low delay is needed and this necessarily limits the amount of compression possible. Given our ageing population and congested traffic conditions this is likely to be in high demand in the future. Each video conversation could potentially generate 10 Megabits per second or more from the residence into the NBN.

Home video monitoring with multiple camera views and sensors will also drive use of up-link bandwidth. In Japan such systems are used to keep an eye on elderly relatives by their younger family members.

Cloud services (applications, storage, consumer and SME)

As noted in the sections on government and business, cloud computing makes a full range of software and services available over the Internet. The network characteristics needed are low delay, high reliability and high bandwidth.

Cloud services will drive up-link bandwidth as they are used for remote storage and back-up. With the cloud there is no real need to keep local copies as long as the networks links are sufficiently reliable.

Services such as Voice over IP telephony and web-based video-conferencing can also be supported as a cloud service over the network. In these cases bandwidth demands will be similar to other kinds of video services

The Internet of Things

Smart transport systems, smart phones, networked cars, smart homes, wireless digital video cameras, sensors and as yet unforeseen devices connected to the Internet will contribute to an increasing base load of "machine to machine" communications, which will mainly be carried on fixed networks.

Facebook

By the end of 2010 60 billion photos had been uploaded to Facebook. This number is due to reach 100 billion by June 2011[52]. This probably represents over 400 Petabytes of data. A Petabyte is 1000 Terabytes and a Terabyte is 1000 Gigabytes. To put this in perspective, that is around 1 Gigabyte per Australian Facebook user. If these still images were videos there would be an avalanche in terms of the quantity of up-loaded content. It is probable that this is the beginning of a much larger trend.

Peer-to-peer traffic (P2P)

By its nature this traffic is symmetrical. In 2004 peer--to-peer traffic was the dominant type on the Internet (www.caida.org). It has since been overtaken by "web" traffic, and most lately by video, probably from sites like YouTube. However P2P is a very cost-effective way to distribute media and its use in this way will continue to grow. Computer games may increasingly use this technique as centralised servers have trouble scaling.

Immersive, 3D environments including haptics (games are an example)

Immersive environments in which the user is literally immersed in an electronically created environment requires many high quality video streams and associated audio. Such systems are ideal for exploring museums remotely, or sharing workspaces. Due to the currently high cost of the end equipment and prodigious bandwidth needed they are not commonly used. In the simpler case of online games, a computer-generates the immersion, reducing bandwidth demands, but low delay is critical for game performance to be maintained.

High-quality printing of images

Professional photographers can generate image files that may be 100Mbytes for a single image. These may be remotely transmitted to an high quality printer used to produce large, professional quality prints.

General bandwidth drivers

Increasing use of mobile and fixed wireless

The 802.11n wireless LAN standard is already widely available at over 100 Megabits per second. This means that devices wirelessly connected in the home can already match the bandwidth delivered by the NBN. NICTA has demonstration wireless LAN technology which can operate at 1 Gigabits per second, so it is unlikely wireless bandwidth inside homes will constrain the demand for NBN bandwidth.

Mobile wireless is increasing at exponential rates as smart phones and mobile data devices proliferate and mobile wireless standards jump from hundreds of kilobits per second to megabits per second, to beyond 100 Megabits per second per mobile device in the LTE standards[53]. While this may seem disconnected from the NBN, in a few years 10 million or so Australians may have 100 Megabits per second devices in their pockets and that enormous aggregate demand (1,000,000 Gigabits per second) will at some point have to be carried over fixed network infrastructure.

[52] http://www.pixable.com/blog/2011/02/14/facebook-photo-trends-infographic/
[53] 3GPP - 3G Partnership Project www.3gpp.org

Ultra high definition video

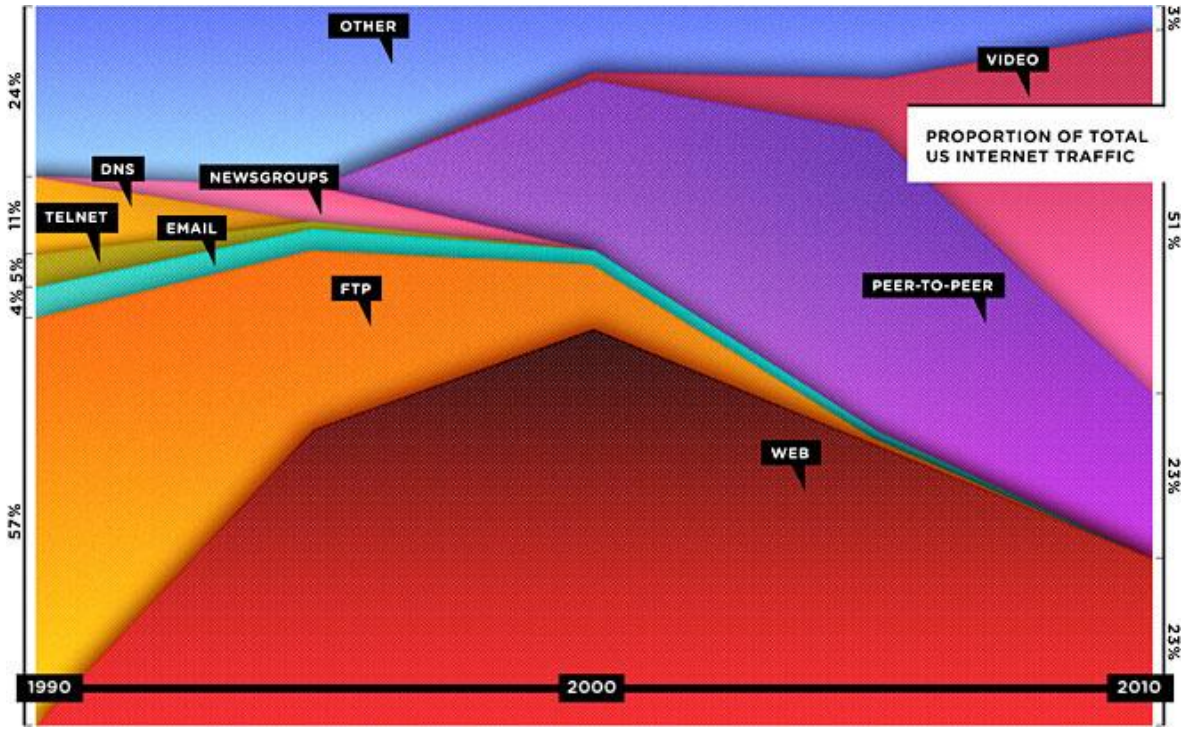
Japan's national broadcaster NHK, has developed standards for broadcast video which provides over 16 times the resolution of conventional HDTV. Recent test broadcasts have started. Bandwidth needs are around 250 Megabits per second per channel[54].

True 3D and holography

Current "3D" TV is actually stereo TV, meaning only two video channels are used - one for each eye. The 3D effect provides only one viewing perspective. To ensure backwards compatibility the two video streams are encoded into the same bandwidth as a single HDTV stream.

True 3D allows the viewer to move around and see different perspectives, for example being able to look around an object. This can be approximated convincingly by recording 16, 32 or more different perspectives. Such systems would require 100s of Megabits per second to transmit.

The ultimate 3D representation is currently provided by holographic technology. The technology is complex[55] but in can provide a continuous view of an object from any perspective. Primitive videos have been demonstrated but the data involved is vast. A one litre volume still image uses 100s of Gigabytes of data. Video multiplies this many-fold. Holography is probably 20-30 years away from mass consumer deployment.



The figure above shows the growth of different traffic types on the web, compiled by Cisco, using estimates from CAIDA, the Cooperative Association for Internet Data Analysis (www.caida.org). Note the remarkable growth in video traffic in the last 5 years (since YouTube).

[54] BBC News http://www.bbc.co.uk/news/technology-11436939
[55] http://en.wikipedia.org/wiki/Hologram

About NICTA

National ICT Australia (NICTA) is an Australian research and development organisation working at the forefront of information communication technology. Established in 2002, NICTA has built up an organisation of almost 700 specialised research scientists, engineers and PhD students working in five research laboratories in Victoria, New South Wales, the ACT and Queensland. NICTA is supported by the federal, state and territory governments, and works closely with university members and partners such as the Australian National University, University of NSW, University of Sydney, University of Melbourne, Monash University, University of Queensland, Griffith University and Queensland University of Technology.

NICTA's research projects focus on break-through research and development in complex areas where things are changing quickly and technology is making differences, such as improving health, safety and security, communications, reducing waste and pollution, and contributing to building knowledge, wealth and national benefit for Australia.

To bring real world impact to our research, NICTA develops research in partnerships with leading public and private sector organisations, government, universities, road traffic authorities and industry bodies such as the NSW RTA, Intelligent Transport Systems (ITS) Australia, SAP, Qualcomm, Ericsson, Intel, Google, Sensis and IBM. Where relevant, NICTA's focus is also on developing these technologies into exports worldwide.

In March 2009 NICTA announced an international Research partnership with one of the world's leading ICT research organisations, the Fraunhofer ICT Research Institute in Germany to set up a world-leading research group in freight, transport and logistics. NICTA's secure micro-kernel technology (through its spin-out, Open Kernel labs (OKL)) is now in over 1 billion mobile phones which use Qualcomm chipsets.