PART TWO

9

Network capacity and technology

9.1 As is evident from the terms of reference, the inquiry had an outcomes focus—that is, what new or improved opportunities will be enabled by the NBN. In line with this, the preceding chapters have outlined how the NBN is likely to affect the Australian community and economy.

9.2 The terms of reference also required the Committee to examine 'the optimal capacity and technological requirements of a network to deliver these outcomes'. This has been addressed, to some extent, in each of the preceding chapters. For example, in Chapter 3 on health it is explained that fibre is a pre-requisite for advanced tele-health applications that require symmetric, high-speed, low-latency connections.

9.3 This chapter will outline the evidence the Committee received around capacity and technology in more detail without focussing on any particular sector. An overview of the NBN design and roll-out plan, as well as an overview of the various broadband technologies that are used in Australia, is provided at Appendix A.

9.4 Through the course of the inquiry there was overwhelming support for the NBN. However, it is fair to say that the majority of contributors did not come to the inquiry from a technical viewpoint. Most were simply in favour of the NBN because it promises to deliver broadband that is fast, reliable, and available everywhere.

9.5 The Committee did, however, receive a substantial amount of evidence about technical aspects of the NBN, and, in particular, the benefits of fibre over other broadband technologies. The Department of Broadband, Communications and the Digital Economy (DBCDE) submission suggested that the NBN design has five key definitive characteristics,

which can be summarised as: Speed; Symmetry; Ubiquity; Reliability; and National wholesale arrangements.[1]

Speed

9.6 The submission of the Australian Information Industry Association (AIIA) commenced with three quotes that demonstrate it is easy to dramatically underestimate how technology will be used in the future:

- I think there is a world market for maybe five computers – *Thomas Watson, Chairman of IBM 1943.*
- There is no reason anyone would want a computer in their home – *Ken Olsen, Present Chairman of and Founder of Digital Equipment Corp, 1977.*
- 640K of RAM ought to be enough for anybody – *Bill Gates, Chairman of Microsoft, 1981.*[2]

9.7 A number of submitters and witnesses made this point to the Committee, including Mr Maha Krishnapillai, Director of Government and Corporate Affairs at Optus:

> Historically, predicting the possibilities of the information, communication and technology sector has seen its fair share of mistakes and underestimations … [3]

9.8 One observable fact about past technology use is that demand for faster broadband has grown relentlessly. This point was made in the submission of National ICT Australia (NICTA):

> At no time has demand for bandwidth decreased. In fact, it has increased year on year by 50 per cent per annum.[4]

9.9 Making informed predictions about the future is, of course, a necessary component of planning processes. Most forecasters predict demand for data to continue to increase rapidly into the coming years. Cisco, for example, has predicted that that global internet traffic will quadruple in the five years to 2014.[5]

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1 DBCDE, *Submission 215*, p. 7.

2 AIIA, *Submission 184*, p. 2.

3 *Committee Hansard,* Hobart, 11 March 2011, p. 11.

4 NICTA, *Submission 198*, p. 5.

5 See Cisco, *Visual Networking Index (VNI): Forecast and Methodology 2009-2014*, pp. 1–2.

9.10 Dr Dean Economou, Technology Strategist at NICTA, told the Committee's Sydney hearing that there is nothing that would indicate demand for bandwidth will deviate from its upward trajectory:

> All we know is that it has never stopped and if I were a betting man, an investor, and I was looking at the curves, I would not be betting on it stopping, I would be betting on it going faster.[6]

Drivers of demand for speed

9.11 As has been highlighted throughout the earlier chapters, it is expected that video content will lead demand for bandwidth in the future. There are video-based applications across all sectors in the economy that can utilise more bandwidth than is currently available to most Australian premises, particularly if the application requires two-way video.

9.12 One of the biggest factors in the increasing demand for bandwidth is not just the speed required by the increasing number of advanced applications, but also the speed required to run many applications simultaneously. This point was made in the submission of the Institute for a Broadband Enabled Society (IBES):

> It is important to note that many applications … do not require high bandwidth in singularity. However the National Broadband Network should enable multiple applications to work at the same time, in the same way as we expect the electricity grid to supply power to all appliances in the home. [7]

9.13 There are also applications that exist in other parts of the world or that exist only in research laboratories and universities, but which are likely to be deployed more widely in Australia in the future. Dr Economou of NICTA explained how improving video quality is likely to be a significant driver of future bandwidth usage:

> At the moment what looks like HD looks really good compared to TV, but in 20 years it will look like a postage stamp and you will say, 'Why did we ever put up with that?' You will say, 'You really need it.' The thing is that technology is making it possible. Samsung screens get 20 per cent cheaper and 20 per cent bigger every year. The Japanese 15 years ago were working on what is called ultra high definition TV, which is 16 times HD …

6 *Committee Hansard,* Sydney, 29 April 2011, p. 58.

7 IBES, *Submission 84*, p. 11.

> So 16 times is coming and that, even compressed for broadcast, is 200 to 300 megabits [per second]. That is what we can perceive. All I can say in my time in this game and Dr Percival's as well, is that we have never seen demand for bandwidth go down and whenever you try to double guess that it is going to level out it just does not.[8]

9.14 Chris Hancock, CEO of AARNet, told the Committee about a high-definition video-conferencing experience requiring gigabits of data transmission per second:

> The first [example] is called an OptIPortal … Just picture one of your computer screens—a Dell or an Apple screen on your desk. It is 24 of those sewn together …
>
> If you look at an OptIPortal, it has the capacity for each of those small 24 screens to use 1.6 gigabits per second on their own for each screen. So we are talking about a 40 gigabit per second device—gigabits, not megabits …
>
> We have done linkages, for example, where we have shared health and climate change data between the University of Queensland, the University of Melbourne, Gwangju Institute in Korea and the Texas Institute. They each had OptIPortals and they shared some high-definition visualisations. That pushed the limits at between five to nine gigabits per second.[9]

9.15 Mr Hancock went on to describe how these university-based experiences might translate to the home:

> The point about that example is that it is a new and innovative service. Why is that important to this debate? We see that the homes of the future are going to have these as walls. That is what we are going to be doing. You will not have the video set from Harvey Norman; you will actually almost have an actual optIPortal in your living room that is bezel-less and is a flat screen … The question was asked earlier today: will it ever replace being there? Our belief is that it absolutely will, because the technology will allow us to do that.[10]

8 *Committee Hansard,* Sydney, 29 April 2011, p. 58.

9 *Committee Hansard,* Canberra, 27 May 2011, pp. 26–27.

10 *Committee Hansard,* Canberra, 27 May 2011, p. 27.

9.16 The NICTA submission explained that 'True 3D' technology is currently being developed and could be a consumer product at some time in the future:

> 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 hundreds of megabits per second to transmit.
>
> The ultimate 3D representation is currently provided by holographic technology. The technology is complex but 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 hundreds of gigabytes of data.[11]

9.17 At the Committee's Sydney hearing, Dr Economou discussed 'true 3D' technology and also noted that::

> … 20 years or 30 years from now that may be mainstream and what appears to be trivial or hokey or some kind of child's toy, like Twitter or something, ends up changing the world.[12]

Scalable and future-proof technology

9.18 A common theme throughout the inquiry was the need to build a network that has capacity for the future—to support the sorts of advanced applications discussed above that may be common in the home before too long. Google Australia's submission argued that:

> Super-fast broadband gives us a platform—like the Trans-Australia Railway did—to connect to a new generation of opportunities. It has almost unlimited potential to deliver innovation in the types of content creation, delivery and consumption models that will be available to Australians.[13]

11 NICTA, *Submission 198*, p. 3.

12 *Committee Hansard,* Sydney, 29 April 2011, p. 58.

13 Google, *Submission 233*, p. [2].

9.19 The proposition of future-proofing through FTTP was advanced by several inquiry participants, including by Professor Paddy Nixon of the University of Tasmania:

> … where possible you put in the most future-proof technology you can. That is not always completely feasible. It would be very difficult, for example, to roll a fibre line out into the middle of nowhere in a relatively cost-effective way. But current wisdom would suggest that fibre is the most future-proof of the technologies available to give us the highest bandwidth to a particular point.[14]

9.20 NICTA's submission also expressed similar sentiments:

> 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.[15]

9.21 The Committee was often told about the effectively limitless capacity of fibre. The IBES submission outlined why fibre is the preferred technology:

> Work underway at the University of Melbourne has demonstrated that fibre-to-the-premises networks are the most future-proof fixed technology available. The next generations of fixed telecommunications networks will continue to rely on fibre optic cable, however much faster speeds will be achieved by improving the equipment in telephone exchanges, and in the home.[16]

9.22 The Communications Alliance submission explained in detail the upgrade path for NBN fibre:

> Fibre-to-the-premise[s], using the G-PON architecture being employed by NBN Co, is immensely scalable. The architecture and equipment being used in the initial roll-out effectively shares 2.5 Gbit/s of download capacity between each group of 32 users/premises, giving the capability to provide, in all practical senses, a download speed of 100 Mbit/s to each user and the ability for individuals to burst up to 1 Gbit/s.

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14 *Committee Hansard,* Hobart, 11 March 2011, p. 8.

15 NICTA, *Submission 198*, p. 35.

16 IBES, *Submission 84*, p. 11.

> End-equipment technology is already available to boost this download-per-user speed by a factor of four and is likely to be introduced by NBN Co at some stage during its roll-out program. With the incorporation of Wave-Division-Multiplexing (WDM) technology into the network and with the advent of 40 Gbit/s and 100 Gbit/s interfaces currently being trialled, it is likely that the fibre being laid by NBN Co today could eventually deliver download speeds of up to 100 Gbit/s to Australian consumers—all without any upgrade to the physical fibre link.[17]

Other broadband technologies

9.23 In commenting on the benefits of fibre, a number of contributors also considered the limitations of other current broadband technologies utilised in Australia—ADSL and its variants, HFC, and wireless. DBCDE's submission argued that:

> Once bandwidth requirements move beyond 20-30 Mbit/s, existing technologies such as ADSL and wireless 3G technologies are insufficient. While HFC can support data speed beyond 100 Mbit/s, the cable footprint in Australia is limited to approximately 2.6 million households, and like wireless technology, HFC is a shared technology and performance degrades when users share the available bandwidth in their area.[18]

9.24 Professor Nixon provided a technical explanation about the limitations of non-FTTP fixed line broadband services, including fibre-to-the-node:

> You always have this last mile problem. Let's say you take fibre to two offices from here, but then between the offices and here you put in a very thin line. It does not matter how fast it arrives at the office two doors away, it still has to go through the slower length to get to you. So if you are still providing from the hub to the houses you still have to multiplex over limited copper wires and you will still have exactly the same potential problem—irrespective of how fast it arrives at the hub.[19]

9.25 The DBCDE submission went on to explain the particular speed issues with ADSL technologies:

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17 Communications Alliance, *Submission 185*, p. 20.

18 DBCDE, *Submission 215*, pp. 86–87.

19 *Committee Hansard,* Hobart, 11 March 2011, pp 10–11.

> ADSL2+ has a nominal peak download speed of 24 Mbit/s and upload speed of 1 Mbit/s. On average, however, speeds delivered to the end user are considerably below this and is largely dependent on how far the end user is from the telephone exchange …
>
> The key distinction between DSL technologies and the fibre technology proposed by NBN Co is that the transmission signal within optical fibre does not degrade as rapidly with distance as DSL technology.[20]

9.26 The CSIRO submission also highlighted fundamental speed limitations with HFC and ADSL:

> In typical HFC networks, bandwidth to the subscribers is in the range of 50 Mbit/s downstream and 10 Mbit/s (or 30 Mbit/s for DOCSIS2.0) upstream. However this bandwidth is typically shared among 100 to 400 subscribers in the local loop. Competition for available bandwidth may rise during peak times, reducing effective bandwidth to individual subscribers …
>
> ADSL typically offers 10 Mbit/s downstream and 1 Mbit/s upstream (up to 24 Mbit/s down and 3.3 Mbit/s up for ADSL2+) to individual subscribers without sharing bandwidth with other subscribers. However, ADSL can generally only be distributed over short distances from the switch office, typically less than 4 km, and beyond that its capacity may be reduced.[21]

9.27 Mr Krishnapillai of Optus—one of the largest owners and operators of HFC networks in Australia—outlined the advantages of fibre over HFC:

> A HFC network clearly is a shared network. The more people who use it in a particular street, the lower speeds you end up getting. That is different from a fibre network. The second issue is that the physical limitations of HFC as a technology are very different from the almost unlimited potential for pure fibre. Effectively [HFC] is a fibre-to-the-node.[22]

9.28 Aside from fixed line technologies, the other current primary method of providing broadband services in Australia is through '3G' mobile wireless technologies. As outlined at Appendix A and throughout evidence to the inquiry, mobile wireless usage continues to increase rapidly in Australia.

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20 DBCDE, *Submission 215*, p 89.

21 CSIRO, *Submission 171*, p. 18.

22 *Committee Hansard,* Hobart, 11 March 2011, p. 25.

The Committee heard that demand for wireless is expected to continue as the proliferation of mobile devices requiring connectivity intensifies. This process will be assisted by the implementation of next generation LTE wireless networks, which provide significant speed improvements over 3G services.

9.29 The Committee received extensive evidence that despite the increase in demand for mobile wireless connectivity, fixed line networks remain important and will continue to be the primary method by which Australians download data-intensive content. As mentioned in Appendix A, even though wireless now accounts for 40 per cent of all Australian broadband connections, these connections only account for nine per cent of total downloads.

9.30 The central proposition heard in evidence was that wireless and fixed networks are complementary. This position was put forward by the Communications Alliance:

> [We] believe that fixed and wireless technologies are complementary and that both will be important components in meeting consumers' communications needs and desires going forward. Increasingly, the emphasis will not be on which network technology is used, but rather whether the device being used is capable of connecting seamlessly to whichever network is the most effective for the consumer at that time, irrespective of their location.[23]

9.31 The IBES submission made a similar point and also highlighted the limitations of wireless:

> Wireless technologies are complementary to fixed networks, however it should be recognised that spectrum is a limited resource and [wireless] networks cannot provide the bandwidth of fibre networks.[24]

9.32 Professor Nixon advised the Committee that wireless will always provide inferior speeds to fixed line fibre services:

> There are fundamental physics limitations that mean that that is not viable. Communication through the air and communication through light are just different approaches to things and they have certain limitations. So no, there is not likely to be at this stage such a wireless communication [that has the capacity of fibre]. As

23 Communications Alliance, *Submission 185*, p. 20.

24 IBES, *Submission 84*, p. 11.

> wireless gets faster, the technologies that provide down the fibre will also get faster, so there will always be a discontinuity between the speeds available over fibre and the speeds available over wireless.[25]

9.33 Mr John McGee of the Tasmanian Department of Economic Development, Tourism and the Arts, and a former radio-frequency design engineer, also told the Committee about the limitations of wireless:

> Why is wireless limited? Wireless is limited because of channel allocation. It is a real estate issue in an open, shared environment. … Deploying wireless as a 100 per cent solution, what do you end up with? You end up with a lot of fibre—you end up fibre to base stations.[26]

9.34 A recent research report by IBES demonstrated the problems with using LTE wireless as the sole broadband solution in urban areas. The research found that to allow users to download 50 gigabytes of data in a month in an urban area, there would need to be at least 29 base station towers per square kilometre. To allow 200 gigabytes of data per month would require 51 towers per square kilometre. The report also noted that there would be a large amount of interference caused by having so many towers in a small area. This means that each individual tower is much less capable of delivering a fast speed than it would be in a less densely populated rural area.[27]

Beyond the NBN fibre footprint

9.35 The same IBES research report found that wireless networks work well in less densely populated areas—the sorts of areas that will receive a fixed wireless service under the NBN:

> The results demonstrated that fixed wireless networks are a good substitute for fixed cabled networks in rural areas. Users can access a wide range of services and download large amounts of data without overloading the network, while experiencing a good level of performance.[28]

9.36 Mr McGee of the Tasmanian Government confirmed that fixed wireless can provide a good service if managed correctly:

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25 *Committee Hansard,* Hobart, 11 March 2011, p. 11.

26 *Committee Hansard,* Hobart, 11 March 2011, p. 73.

27 Institute for a Broadband Enabled Society, *Where Wireless Makes Sense,* June 2011, p. 32.

28 Institute for a Broadband Enabled Society, *Where Wireless Makes Sense,* June 2011, p. 35.

> … a relatively high proportion of Tasmanian premises will be connected by wireless … A well-designed fixed point to multipoint capability is important. It is a capability that is fourth generation, whether it is LTE or WiMAX. The base station capability is a gigabit per second. If the points to multipoints are well managed, the notion of increasing bandwidth in a wireless environment can occur.[29]

9.37 Mr Mike Quigley of NBN Co commented on the quality of service that can be expected in areas serviced by an NBN fixed wireless service or an NBN satellite service:

> I would also like to put on the record what we have developed for the remaining seven per cent. In fixed wireless—and it is not a mobile service—four per cent; and a satellite service, three per cent. These are radically improved services over what people would be getting today. For example, on the satellite we anticipate launching two large Ka-band satellites—these are six-and-a-half ton satellites each—which will provide 12 megs down, one meg up with what are called average busy-hour throughputs—in other words, how much people can download effectively without congestion of very high dimensioning—much greater than what is available today. People in the bush in the seven per cent will get services that are at least equivalent to what they can typically get in cities on ADSL 2+ today.[30]

9.38 He then provided further detail about the design processes that will ensure a high quality fixed wireless service.

> We will keep up with the latest technology developments as they take place, and with the potential vendors for that technology—we have already had discussions about what is the evolution path for higher speeds. I would also make the point that you will hear some very large numbers about wireless that say LTE can do 100 megabits per second. It is true. From the centre of a cell with only one person on it, even if you turn off the error correcting coding that goes on you can get high throughputs, but that is not what the engineering is about. The engineering is about what you can provide to everybody at the edge of cells. That is why we have

29 *Committee Hansard,* Hobart, 11 March 2011, p. 73.

30 *Committee Hansard,* Sydney, 29 April 2011, p. 4.

> taken a very conservative engineering approach to dimension for 12 megabits per second at the edge of a cell, not in the centre. [31]

9.39 Contributors to the inquiry acknowledged that it is uneconomic to provide FTTP to some areas, and therefore that fixed wireless and satellite become important alternatives. Professor Nixon made this point:

> There are places where wireless is an important component of a broadband rollout, maybe for reasons of access because you cannot roll fibre out, or maybe for additional ubiquity …[32]

9.40 The submission of the IT Industry Innovation Council also acknowledged the importance of non-fibre solutions:

> The Council's position remains that the speed and capacity of a fibre based network is unquestioned and required, but that given the geographic distribution of Australia's population and the consequent costs of providing fibre access to all, it was always going to include the appropriate wireless technologies to provide ubiquity of access. [33]

9.41 The AIIA submission provided further support for the NBN's chosen mix of technologies:

> NBN is using the best available combination of technologies. It has not chosen one type of technology, recognising that different population densities dictate the economics of particular technologies. A simplistic comparison to the US 4G initiative is highly inappropriate because the US already has a very high penetration of high speed cable (which we do not) plus a geography with many closely spaced cities. Our geography is very different and requires a technology solution designed for us. Fibre optic, PLUS wireless PLUS satellite will all be required to achieve 100 per cent coverage … Satellite is and will be the most suitable for delivering broadband to remote communities, and wireless to more densely populated rural communities … [34]

9.42 Another aspect of speed is latency—the delay in data transmission caused by the time it takes for data to get from one designated point to another. Latency is an unavoidable feature of satellite services because of the vast distances involved in a signal travelling between earth and a satellite. The

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31 *Committee Hansard,* Sydney, 29 April 2011, p. 5.

32 *Committee Hansard,* Hobart, 11 March 2011, p. 8.

33 IT Industry Innovation Council, *Submission 111*, p. 12.

34 AIIA, *Submission 184*, p. 26.

Committee heard that latency makes satellite services unsuitable for applications that rely on very low delays, such as remote surgical applications in the health sector.[35] Low latency is another important advantage of fibre over other fixed line networks.

9.43 The Committee received evidence from communities that are likely to receive a fixed wireless or satellite service and, in particular, from communities that are going to be located on a fibre backhaul transit route but will not receive a fibre connection.[36] These communities raised concerns about the quality of their prospective services and the divide that will be created between those with fibre services and those without.

9.44 Notwithstanding the points made above about the economics of providing fibre to remote locations, and the good service quality that can be expected with the NBN's non-fibre services, NBN Co is trialling a fibre extension program that allows rural communities to pay to have fibre connected. This program is discussed in more detail in Chapter 11.

9.45 At the Committee's Sydney hearing, Mike Quigley of NBN Co responded directly to the queries of communities on fibre backhaul routes:

> If I can draw a distinction between the fibre that is the access fibre that goes out to every premise[s] and the fibre that is the backhaul, which has aggregated literally thousands of traffic streams onto it. It is possible that people will see a fibre going past which is the backhaul fibre. If I can draw an analogy, it is a bit like a high-speed train rail link. If you have the TGV running past your home, you will say, 'Why isn't it stopping?' The reason it is not stopping is it is going 200 kilometres an hour. We have that same issue where you cannot just break out to drop something off. You can actually break it out, but you need a whole exchange to break it out and connect it up.
>
> I know it is frustrating for people. They see a fibre. They say, 'There it is. It is only over there. Why can't they just drop it in to me?' It is for that very reason; you just cannot do that in an engineering sense. We are trying to make sure people understand that. But in laying out the network to get to 93 per cent of premises with fibre, we have tried to make sure that we have picked up every town in the country with 1000 or more premises; we will

35 Northern Territory Government, *Submission 209*, p. 7.

36 See, for example, Ms Ally Mercer, Dorset Council, *Committee Hansard,* Launceston, 10 March 2011, p. 6; Get Connected, *Submission 43*; McKinlay Shire Council, *Submission 31*; and Regional Development Australia Townsville and North West Queensland, *Submission 202*.

> fibre it. If a town is on one of the backhaul routes and it has more than 500 premises, we will fibre it.[37]

International backhaul capacity

9.46 While the NBN will focus on improving networks within Australia, the ability to link into international networks is also a very important issue. This was identified by the University of Newcastle:

> An end user will not experience the benefits of fast broadband in their premises or business if the networks that carry the data between network hubs (commonly known as backhaul) do not have sufficient capacity. This includes inter-region, national and international links.[38]

9.47 The Committee heard some concerns that Australia's international backhaul capacity is not sufficient at present. Smartnet, for example, commented:

> … we believe that a major weakness of the current NBN program is its lack of recognition that Australia's internet access depends on a handful of international submarine cables, most of which terminate in Sydney. The majority of all current and foreseeable internet traffic travels through these cables, including many of the services that the NBN plans to deliver. There are not enough of these cables and their capacity is limited.[39]

9.48 Others noted that international capacity would clearly need to increase over time as the NBN is rolled out, but also noted that adding additional capacity is not especially problematic. Mr Quigley of NBN Co stated:

> I think as we see more content being used, particularly video content, there is no doubt that those overseas links are going to have to be increased in size … I used to work for a company that had some 45 per cent share of the undersea submarine optical system. I can tell you for certain the prices of those systems have plummeted in the last decade or so. Compared with the overall cost of delivering high-speed broadband to end users, the costs of the overseas links are not great. You can upgrade capacities on

37 *Committee Hansard,* Sydney, 29 April 2011, p. 4.

38 University of Newcastle, *Submission 93,* p. 17.

39 Smartnet, *Submission 134,* p. 7.

> overseas links relatively cheaply compared with rolling out a high-speed access network.[40]

9.49 Mr Krishnapillai of Optus observed that demand for international capacity has been increasing quickly, but was confident that the private sector would provide additional capacity as it is required:

> … the forecasts we put in place for our usage of international capacity were overrun very quickly. We think we know a thing about forecasting but the demand over the last two to three years for data usage internationally has been higher, I think, than anyone really expected in the industry if we are honest about it. Therefore, the need for additional international capacity I think will certainly emerge again in the future, but we do not see that as being an area that certainly requires government intervention. We think there will be solutions in place in years to come that increase that capacity.[41]

Symmetry

9.50 In the past, debates about broadband speeds have been focussed on download speeds. This is because until relatively recently most people's internet usage was one way—viewing web pages, watching videos, and downloading files. The Committee received a large amount of evidence during the inquiry suggesting that there is increasing demand for upload and download speeds that are more equal, commonly referred to as symmetry.

9.51 Faster upload speeds are a prerequisite for many of the services discussed earlier in this report. For example, the ability tele-work on multimedia projects is dependent on the capacity to upload large files in a timely fashion. The importance of symmetry was described in a number of submissions, including NICTA's, which also provided a list outlining the drivers of demand for symmetry:

- **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.
- **Cloud services—…** The network characteristics needed are low delay, high reliability and high bandwidth.

40 *Committee Hansard,* Sydney, 29 April 2011, p. 3.

41 *Committee Hansard,* Sydney, 29 April 2011, p. 22.

- **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 …
- **Facebook**—By the end of June 2011, 100 billion photos had been uploaded to Facebook … It is probable that this is the beginning of a much larger trend.
- **Peer-to-peer traffic**—by its nature this traffic is symmetrical.
- **Immersive, 3D environments including haptics**—Immersive environments in which the user is literally immersed in an electronically created environment requires many high quality video streams and associated audio.
- **High-quality printing of images**—Professional photographers can generate image files that may be 100 megabytes for a single image.[42]

9.52 Mr Quigley outlined how video is not only a key driver of demand for download speed but also upload speed:

> There are a lot of drivers, but overwhelmingly it is video. The world is simply becoming more video oriented … We are using an increasing amount of video and it is not just about entertainment. It is about video-conferencing. It is about medical imaging. It is about education and remote education. We are seeing the level of resolution of screens increasing. The screen sizes are going up. These are multiplier effects, which all have an impact on the bandwidth that is required. Unlike a normal voice call where you can transmit high-fidelity voice on relatively low bandwidths, you simply cannot do that with video. It is directly proportional to screen sizes and resolution. They are simply increasing regularly.[43]

9.53 A key benefit of fibre is that it can provide a symmetrical broadband connection in a way that other technologies cannot. This point was illustrated in CSIRO's supplementary submission:

> HFC and ADSL are either bandwidth limited (ADSL) or shared medium (HFC) asymmetric technologies, and therefore not suitable for symmetric two-way multimedia applications, such as high quality, high bandwidth two-way video-conferencing applications. Optical fibre access is symmetric by its nature,

42 NICTA, *Submission 198*, pp. 37–38.

43 *Committee Hansard,* Sydney, 29 April 2011, p. 3.

> although it can be configured to be asymmetric to some extent if required.[44]

9.54 The DBCDE submission illustrated the relative capacities of the available fixed line broadband services, noting that the initial NBN services will still be asymmetric but to a lesser extent than other technologies:

> Broadband technologies which are 'asymmetric', such as … ADSL, have a bandwidth capacity downstream which is greater than its upstream capacity. The optical fibre technology proposed by NBN Co is also asymmetric but not nearly to the same degree. The theoretical upstream capacity of ADSL, for example, is 1 Mbit/s compared with NBN Co's top level fibre service which will be able to deliver up to 400 Mbit/s upstream.[45]

Ubiquity

9.55 Many submitters and witnesses argued that the most important benefit of the NBN is not the speed and scalability of the fibre solution, but that it will make available a good-quality broadband service to all Australian premises. This point was made during the inquiry by, for example, Dr Terry Percival, Director of Broadband and the Digital Economy at NICTA:

> There are five important things about the National Broadband Network that I want to raise. Those five things are ubiquity, ubiquity, ubiquity, ubiquity and ubiquity.[46]

9.56 The CSIRO submission commented that having access to more people online enables new methods of service delivery for government and industry:

> The immediate impact will be to bridge the 'digital divide', supporting greater inclusiveness by making available a guaranteed level of broadband connectivity to all Australians. As a result of being able to reach all, or a greater part, of the population, new forms of service delivery become feasible. Government and industry will have the potential to reach all Australians using current and yet-to-be-developed electronic services. The NBN also has the potential to create the opportunity for all Australians to

44 CSIRO, *Submission 171.1*, p. 1.

45 DBCDE, *Submission 215*, p. 85.

46 *Committee Hansard,* Sydney, 29 April 2011, p. 56.

> generate content, a benefit that will support new businesses and enable greater sharing of information with the broader community.[47]

9.57 Mr David Buckingham, the Chief Financial Officer of internet service provider iiNet, described the fundamental change that the NBN's ubiquitous coverage will engender:

> When the world knew that all the homes had power sockets, it was able to mass produce electrical appliances. When we know that every home has a grey NBN box attached to the wall, what will start being created? If we have more certainty then our academics, researchers, hackers and businesses will turn their eyes to that vision. As attractive as it might be for us as a company and our customers, the NBN network is not the objective; the potential use is the real objective. For iiNet, the fibre network is an important enabler of improvements in the way personal, commercial and government transactions will drive communications over the next five, 10 or 15 years. It will be intrinsic to our way of life just as electricity is or any other utility that we use.[48]

9.58 The Committee heard that there are many applications that benefit more from the ubiquitous availability of the NBN than its fast speed. For example, many health monitoring, environmental monitoring, and 'smart' infrastructure monitoring applications are not data-intensive, but do require a connection that is firstly available, and secondly reliable. There are, of course, great benefits in having a network that is both ubiquitous and fast, because it will enable widespread access to the more advanced applications outlined in earlier chapters.

9.59 As described in Chapter 4 on education, the Committee received evidence in Sydney from Mr Gary Ballantyne of Huawei, who commented on how ubiquity could enable students to keep learning in the event of an disaster or epidemic. Mr Ballantyne stressed that ubiquity of participation needs to be the key goal, not just ubiquity of coverage:

> A network like the NBN, which has not only got ubiquitous coverage but also ubiquitous participation, would enable that kind of situation to be very effectively dealt with where the kids do not miss out on three weeks of classes and are able to continue their

47 CSIRO, *Submission 171*, p. 5.

48 *Committee Hansard,* Perth, 5 May 2011, p. 2.

> education remotely via the NBN facility. I think that the ubiquity of participation is the key thing.[49]

9.60 Issues around encouraging the uptake of broadband services are discussed in Chapter 11.

Reliability

9.61 The NBN represents a once in a generation upgrade of Australia's communications infrastructure. Fixed line services such as DSL and HFC are in many cases relying on infrastructure that is decades old. With the age of the infrastructure comes a degree of unreliability; a point made in the DBCDE submission:

> Compared to the ageing copper network infrastructure, the NBN will be more reliable thereby giving households, businesses, and service providers greater confidence to use the network for services and applications which demand a high quality of service.[50]

9.62 In Adelaide the Committee heard from Professor Reg Coutts, a telecommunications expert and former Telstra employee, who also commented on issues related to current ageing infrastructure:

> … the actual costs of just maintaining the copper infrastructure—not improving it; just maintaining it—are in the order of $1 billion per annum, although I do not recall the current figures. In certain areas along the coastlines—in Queensland, for example—there are endless problems with the copper. I left Telstra back in 1993, and we were talking in Telstra then about how we were going to replace the copper network with an optical network …
>
> When people talk about why we are [building the NBN], I remind them that the copper network was built through public expenditure and it was built to support black, bakelite telephones. Yet here it is supporting our broadband. Why will they not let it retire?[51]

9.63 The submission of Mr Alun Davies, a former Telstra countrywide employee, highlighted the frailties of the copper network, arguing that

49 *Committee Hansard,* Sydney, 29 April 2011, p. 14.

50 DBCDE, *Submission 215*, p. 7.

51 *Committee Hansard,* Adelaide, 4 April 2011, p. 45.

'copper is severely affected by water and lightning, [therefore] requiring constant maintenance'.[52]

9.64 Mr Krishnapillai of Optus commented on the ageing nature of the company's networks that will be superseded by the NBN's infrastructure:

> … some of the networks that we have developed, such as HFC networks, are 15 years plus old, and they are by their very nature using older technology to deliver those sorts of services.[53]

9.65 The Committee heard that the fibre components of the NBN will provide a robust network with a considerable lifespan. This point was made by NICTA's Dr Percival in Sydney:

> This is a national infrastructure project. You really need to think 30 to 50 years ahead—a 50-year lifetime at least for optical fibre or maybe more. In fact, it is so long that we are not quite sure. I built an optical fibre communication system linking several telescopes and the Australia Radio Telescope at Narrabri in 1986, and they are still chugging away quite happily, so who knows how long they are going to last.[54]

9.66 Mr John McGee of the Tasmanian Government made a similar point to the Committee :

> Fibre to an end point is always the endgame. It is a suite of applications and services that will become available once the endgame is achieved. This is an infrastructure setting that has a 30- to 50-year life cycle.[55]

9.67 The result of the new infrastructure roll-out will be a service that is not only faster but also more reliable. The Committee heard that reliability of service is becoming more important as technology is further integrated into daily activities. Reliability is especially important for certain types of services. For example, businesses who have wholly adopted cloud-based storage and application delivery are completely reliant on a constant broadband connectivity. Another example is the various monitoring applications that have been outlined in earlier chapters, which rely on round-the-clock connectivity to be effective.

9.68 The NBN will also provide a more reliable service because contention will be less of an issue than it is on current fixed line and wireless networks.

52 Mr Alun Davies, *Submission 226*, p. [3].

53 *Committee Hansard,* Sydney, 29 April 2011, p. 23.

54 *Committee Hansard,* Sydney, 29 April 2011, p. 53.

55 *Committee Hansard,* Hobart, 11 March 2011, p. 72.

Professor Paddy Nixon of the University of Tasmania explained where contention becomes a problem:

> With the current technologies you have a local exchange and it has a wire to everybody's house and you have to try to provide for—let's say—10 houses that share one connection or 50 or 1000 houses sharing one connection. Whatever number it is, you have to share the connections out, and depending on how many people are active at a given time you effectively get a smaller share of the wire.[56]

9.69 Under the NBN, the majority of premises will be served by a shared 'GPON' fibre architecture. However, because of the high capacity of fibre and the fact that fibre services do not rapidly degrade over short distances, GPON architecture can guarantee each user receives a high minimum speed in the busiest parts of the day—provided that the ISP has purchased sufficient capacity. The NBN's fixed wireless and satellite solutions will also be shared services and therefore subject to contention issues. However, Mike Quigley of NBN Co explained that the dimensioning of these services will ensure a more consistent speed than current ADSL services:

> We are designing it to have a lot of capacity. On today's ADSL services, different operators dimension things at different levels, but you could say it is somewhere around what we call the average busy-hour throughput … Normally ADSL is dimensioned somewhere around 35 up to 70 kilobits per second. We are dimensioning the satellite at 300 kilobits per second and the fixed wireless at 500 kilobits per second. That is the capacity we are building in. If everybody tried to stream high definition video it could not be done. But will they get a very good service? I think the answer is, yes. [57]

9.70 The Committee heard particular concerns about the reliability and quality of the satellite service that can be expected, given the often poor experience remote communities have had with satellite in the past. This point was acknowledged by Professor Reg Coutts at the Committee's Adelaide hearing. However, Professor Coutts also expressed confidence that reliable and good quality satellite services are possible:

> Unfortunately, Australia has broadly had a poor experience with satellite. I think the experience has, shall we say, not been

56 *Committee Hansard,* Hobart, 11 March 2011, pp 10–11.

57 *Committee Hansard,* Sydney, 29 April 2011, p. 5.

> at international world's best practice due to a whole number of reasons. So when you mention satellite to some people in various states and regions it is like you are somehow suggesting they are going to hand over their first born. They certainly consider it a technology of last resort. At the conference last week I was saying that, in part, that is because the satellite community—that is the suppliers, international suppliers et cetera—do not communicate what they can do …
>
> NBN Co, are well aware of the background to satellite in Australia to date. In many ways they want to see the satellite service as it is introduced very much as 'satellite gold'—in other words, what satellite could be as opposed to what the previous experience has been.[58]

National wholesale arrangements

9.71 The Committee heard evidence of the benefits of NBN Co's role as a single national wholesale provider, as well as some concerns.

9.72 There was strong support for NBN Co's wholesale-only role because it avoids the issue of vertical integration—where the wholesale provider also provides retail services, as has been the case with Telstra for many years. A number of submissions highlighted the importance of maintaining the principles of separation so that the mistakes of the past are not repeated. This point was made, for example, in the Optus submission:

> The NBN is a critical component in reforming the fixed line telecommunications sector. However, it must stay faithful to the principles of true competition, open access, and transparency with a robust reporting and oversight structure. Compromise on any of these principles risks the failure of the competition and innovation aims of the reform.[59]

9.73 The Committee received evidence that the NBN's commitment to national wholesale pricing for basic services is beneficial to regional areas. The Gold Coast City Council submission argued that 'equality of wholesale pricing of the NBN will help to ensure that the viability of services and applications does not depend on geographical location.'[60]

58 *Committee Hansard,* Adelaide, 4 April 2011, pp. 43, 45.

59 Optus, *Submission 179*, p. 3.

60 Gold Coast City Council, *Submission 71*, p. 2.

9.74 The DBCDE submission similarly proposed that 'uniform national wholesale pricing … will allow Retail Service Providers using the NBN to provide all communities in Australia with access to affordable high-speed broadband'.[61]

9.75 The submission of the Victorian Government raised concerns about the cross-subsidisation arrangements that are inherent in the national wholesale pricing commitment, suggesting that the plan:

> … risks additional inefficiencies by employing market distorting financial arrangements, including internal, non transparent cross subsidies (such as universal national wholesale pricing) and through public sector financing at non commercial rates of return.[62]

9.76 The Committee also heard concerns about the NBN pricing model whereby Retail Service Providers are charged a $20 'CVC' charge for every Mbit/s of bandwidth which they require. Internode, for example, argued that this will make faster services prohibitively expensive for most people, and also make it difficult for small ISPs to provide nationwide services. Internode instead suggested raising the per port cost and reducing the CVC charge to $1 per Mbit/s of bandwidth.[63]

9.77 There was general support for NBN Co's role as a monopoly wholesale provider of a 'layer two' access network. This view was expressed by Ms Rosemary Sinclair, Managing Director of the Australian Telecommunications Users Group (ATUG):

> … we have had some real world experience in terms of infrastructure competition and just how much infrastructure competition you can get in Australia, given the size of the market and the geographic nature of this country. The conclusion that we came to was that to get from copper to fibre into every premises in Australia, which is the outcome that we believe is needed, we need a single infrastructure builder in the local access market.[64]

9.78 Other contributors noted the benefits inherent in having a single infrastructure provider. Mr Quigley of NBN Co, for example, argued:

> … if you had underlying multiple wholesale platforms, an operator who wanted to supply services over here would have to

61 DBCDE, *Submission 215*, p. 7.

62 Victorian Government, *Submission 234*, p. 13.

63 *Committee Hansard,* Adelaide, 4 April 2011, p. 4.

64 *Committee Hansard,* Sydney, 29 April, p. 39.

> interface to that wholesaler. If they wanted to provide services in another part of the country they would have a different set of interfaces to reach customers over there. With one national network at the wholesale level they would just have one set of interfaces to do testing with and make sure their systems can cope with it. This is not an easy job. It is about aligning the two systems together so that they can talk to each other seamlessly, which is what we are aiming to do, such that a retail supplier, for example, iiNet, will from their terminal be able to see our network as if it were their own. In other words, they can test the performance of end-to-end connections without having to ask us. They can do it automatically. [65]

9.79 Mr Quigley expanded on these comments, stating:

> If you draw an analogy, it is similar to a rail system. If you have a patchwork of rail systems it clearly does not work as efficiently … I am not suggesting that the entire telecom network should be one standardised ubiquitous network. But I believe there is an argument for having the lowest level, what is called layer one and layer two, standardised across the fixed line network in the country and then having free and open competition above that. We just will not get two private enterprises building a new fixed line infrastructure. I do not think it will ever happen.[66]

9.80 Mr Krishnapillai of Optus put forward a similar proposition in respect of the need to have a single provider at the basic infrastructure level:

> … as we have said many times in the past, we [are] reluctantly accepting that there is a monopoly. Ideally you would want to have multiple different technologies in some ways. You want that competitive dynamic … We have reluctantly accepted that you need a common standard interface and common standard piece of infrastructure. As long as that is kept down at the, to use the technical term, layer two level, basic roads, and then you have competition at layer three and above, then that will be a good outcome …[67]

9.81 Mr Krishnapillai also commented on the equity and efficiency benefits inherent in the NBN model:

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65 *Committee Hansard,* Sydney, 29 April 2011, p. 7.

66 *Committee Hansard,* Sydney, 29 April 2011, p. 7.

67 *Committee Hansard,* Sydney, 29 April 2011, p. 24.

> You do not have waste or duplicate infrastructure into homes where there are high capacity to pay and then have nothing left over in a broader sense; you have a level playing field for that basic infrastructure.

9.82 There were some concerns about NBN Co's monopoly and threats posed to competition in the telecommunications sector. For example, the Victorian Government submission argued:

> After over two decades of national economic and financial reform the NBN proposal in its present form represents a very serious threat to the long term competition in the telecommunications sector and an impediment to the most efficient use and allocation of resources and investment …
>
> Decisions made now could potentially result in unnecessarily higher broadband costs or put in place barriers that hinder infrastructure based wholesale competition to the NBN. This could do long term damage to the development of Australia's broadband market, and create market structures that are difficult if not impossible to unravel.[68]

Committee conclusions

9.83 There is almost universal agreement that Australia's broadband infrastructure is sub-standard at present, and that an upgrade is necessary to enable a thriving digital economy and the ensuing benefits. There are different perspectives on what form the upgrade should take. The Committee's view is that the necessary approach is to extend fibre to as many premises as is practicable, and then to make use of other appropriate technologies in remote areas. This is the approach being pursued through the NBN.

9.84 The benefits of fibre over other fixed line broadband technologies are indisputable. The capacity to deliver bandwidth is significantly better and there is an ability to upgrade to much higher speeds as required in the future. Fibre has the capacity to deliver fast download *and* upload speeds—symmetry—in a way that other technologies do not.

9.85 The dominant fixed line technologies in Australia—ADSL and its variants and HFC—rely on ageing copper lines for the 'last mile' connection to the

68 Victorian Government, *Submission 234*, p. 10, 13.

premises. The Committee heard that the capacity of copper to transmit data is inferior to fibre, and that speeds delivered by copper-based networks are acutely affected by contention and distance from the exchange. The Committee also heard that the age of the copper network has an ongoing impact on the reliability of services that can be delivered.

9.86 Mobile wireless technologies have become an important way for Australians to connect to the internet and this will certainly continue in the future. However, like copper-based networks, contention issues mean that mobile wireless networks are not capable of delivering the reliability and speed necessary to run high-bandwidth applications, particularly in urban areas. For this reason, mobile wireless networks will always be considered as complementary to fixed line services.

9.87 The earlier chapters in this report outlined the evidence the inquiry received about current and potential future uses of broadband. Many of the advanced applications discussed rely on a symmetric high-speed connection. The Committee's view is that there is not an 'optimal capacity' required to support these uses—particularly as all evidence suggests that the required capacity will continue to increase. This will be primarily driven by the need to run many applications within premises simultaneously, and by the ongoing increase in the use of video and its quality. The uses for high quality video are not just in entertainment—there are important applications in all of the sectors discussed in earlier chapters.

9.88 While there is not an 'optimal capacity', fibre is undoubtedly the 'optimal' technology because evidence suggests it will be able to support increasing demand for bandwidth over a long period. The Committee was reminded during the inquiry that this is an infrastructure project with a lifespan of 30 to 50 years, possibly longer.

9.89 In providing universal broadband coverage in a country as large as Australia, it is impractical to deliver a strand of fibre to every premises in remote areas. NBN Co has committed to providing broadband to seven per cent of the Australian population using a mix of fixed wireless and satellite technologies. While fixed wireless and satellite networks do not have the capacity of FTTP networks, the Committee was assured that remote areas would still receive a good quality service that is considerably better than what is received today. NBN Co told the Committee that it is trialling a fibre extension program whereby local councils and other organisations can pay to have fibre extended to premises that would otherwise be receiving wireless or satellite. This is discussed in more detail in Chapter 11.

9.90 Moving away from the debate about technology, ubiquity of coverage is clearly a very important goal to be achieved. The NBN will for the first time make a broadband connection possible for every Australian premises. The Committee heard that having a ubiquitous network will enable new methods of service delivery for business and government and will encourage innovation. The important point was made that the while ubiquity of coverage is an important goal, ubiquity of access is an even more important goal. Issues around encouraging uptake are discussed in Chapter 11.

9.91 Given the terms of reference, the Committee has not sought to explore governance and pricing issues in great detail. Nonetheless, these were identified as important issues during the inquiry relevant to the broader NBN debate. The Committee supports the structural separation of Telstra and NBN Co's role a wholesale-only provider. There are obvious benefits in having a single provider at the access network layer and then open retail competition above that. This structure is particularly important for regional Australia as it will provide a level of broadband infrastructure that would not be economic for a private company to provide. Also important to regional areas is the commitment to national wholesale pricing. The Committee agrees that this would not occur if left to the market.

9.92 The Committee notes the evidence received in relation to NBN Co's pricing model. Affordability is clearly one of the factors that will affect the uptake of broadband services. It will be important for the Government and NBN Co to ensure that base-level services are affordable for as many Australians as possible, while at the same time ensuring that the wholesale pricing of high-bandwidth plans is not at a level that discourages the development and uptake of advanced broadband applications—the sorts of applications which are the long-term justification for building a national FTTP network.