BACKHAUL BLACKSPOTS INITIATIVE
STAKEHOLDER CONSULTATION PAPER

Alcatel-Lucent Australia Response

12th May, 2009

Overview

The backhaul blackspots initiative will need to balance the goal of short to medium term economic stimulus and the need to make an immediate impact on regional broadband services, with the longer term goal of meeting the future service needs of the National Broadband Network (NBN). It is important that funds are directed to investments that are fully reusable for the National Broadband Network.

In this paper, Alcatel-Lucent presents information on possible NBN network architecture, the types of services and their bandwidth requirements, evolving traffic usage patterns, and what this means for backhaul in terms of speed (bandwidth), quality-of-service and interconnection requirements. Discussion of backhaul transmission technologies is also provided – both fibre-optic and wireless. The intention is to help inform decision makers on these topics, and assist them select backhaul proposals which will support the National Broadband Network in the longer term.

About Alcatel-Lucent

Alcatel-Lucent (Euronext Paris and NYSE: ALU) provides solutions that enable service providers, enterprises and governments worldwide, to deliver voice, data and video communication services to consumers. It:

- has provided equipment and technology underpinning 80+ FTTx deployments in 90% of the top broadband economies including 20+ nationwide operators and 60+ municipalities and utilities,
- is the world's leading supplier of xDSL technologies, a position it has held since 1997,
- is the world's leading supplier of GPON FTTH technologies,
- is engaged with 25+ major telecommunications incumbents and competitors in IP end to end network transformations and in many more non end to end transformation projects,
- Everyday, more than 300 TeraBytes of data equivalent to around 3 billion web pages or 60 million songs, is delivered across our DSL technology platforms in Australia and New Zealand,
- Daily, more than 25 million calls are made across our technology platforms in Australia.

Alcatel-Lucent is proud to supply equipment and services to Australia's leading telecommunications incumbents and competitors. It has supplied the infrastructure for a significant portion of Australia's residential DSL community, making it a leader in helping Australians access the advantages of a digital lifestyle. Its solutions achieve advances in DSL, fibre optics, wireless and satellite access that help companies and individuals get maximum benefit from fast Internet services.

Alcatel-Lucent's commitment to Australia is not new. It has been part of the Australian telecommunications fabric since 1895.

Its leadership in the development of Australia's communications infrastructure has included the country's first undersea cable network, the introduction of broadband Internet, the country's first 3G mobile network (m-Net) and the world's longest optical link, between Adelaide and Darwin.

As a leader in fixed, mobile and converged broadband networking, IP technologies, applications, and services, Alcatel-Lucent offers the end-to-end solutions that enable compelling communications services for people at home, at work and on the move. With operations in more than 130 countries, Alcatel-Lucent is a local partner with global reach. The company has the most experienced global services team in the industry, and one of the largest research, technology and innovation organizations in the telecommunications industry. Alcatel-Lucent achieved revenues of Euro 17.8 billion in 2007 and is incorporated in France, with executive offices located in Paris.

Alcatel-Lucent wishes to continue to play a leading role in improving Australia's economic outlook and standard of living by ensuring that the community has access to a rich variety of broadband services, wherever they live.

For more information, visit Alcatel-Lucent on the Internet: http://www.alcatel-lucent.com.au

Or contact

Ric Clark, VP Solutions, Strategy and Technology: ric.clark@alcatel-lucent.com.au

Stefan Keller-Tuberg, Principal Engineer, Regulation and Access: stefan.keller-tuberg@alcatel-lucent.com.au

Design and Operational Parameters

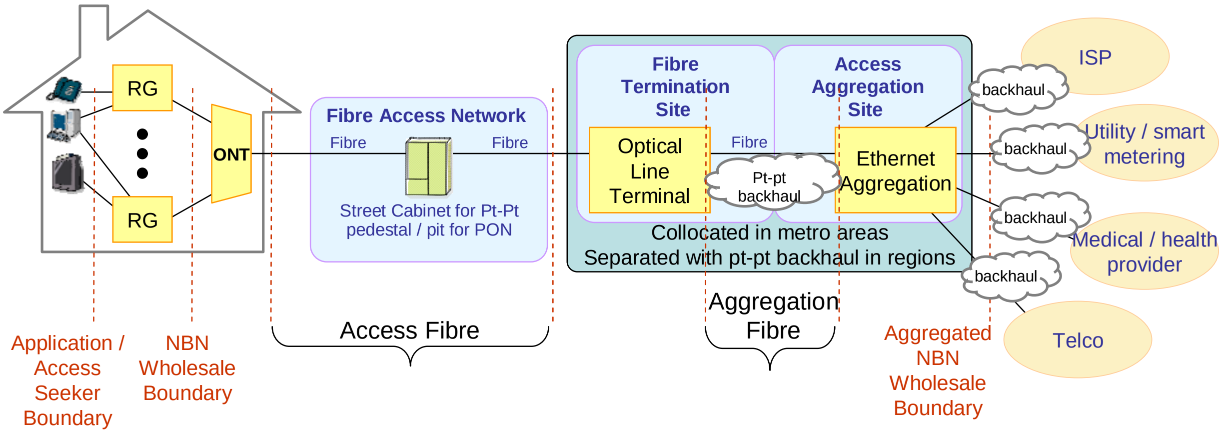
In this submission, Alcatel-Lucent is responding to section 4.2 'Design and Operation Parameters' of the government's discussion paper.

We first address generalities and then specifically look at the implications in a backhaul context and applying these ideas towards an Australian NBN.

Note: We frequently refer to the term 'access seeker' in our submission. In today's networks, access seekers are those who request access to declared services and services covered by undertaking. In some cases, access seekers request direct connectivity to the underlying infrastructure such as in loop unbundling. In others, it involves derived services such as layers 2 or 3 wholesale and PSTN and mobile interconnection. We use the term in both contexts in this submission.

The high level architecture of an FTTH deployment

Before the more detailed questions can be answered, it is important to first understand the manner in which FTTH is deployed. The following architecture addresses from the home or business all the way through to the access seekers.



The first important features of the access architecture are the various 'boundaries' highlighted in red.

- **The Application / Access Seeker boundary**: the point of demarcation between the consumer's in-home network and their chosen service provider(s).

  When consumers need to install boxes from their service providers, such as a set top box for IPTV or a voice adapter for telephony (labelled 'RG' (Residential Gateway) devices in the diagram above), this boundary depicts the limit of technical responsibility of the access seekers.

  The nature of the physical boundary interface will depend on the type of service supported (e.g. telephony, internet, TV etc)

- **NBN Wholesale boundary**: this is where NBN Co delivers connectivity for each access seeker in the consumers' premises.

  The physical interface is expected to be a wired Ethernet port on the ONT (the Optical Network Termination – the FTTH equivalent of a DSL modem).

- **Aggregated NBN Wholesale boundary**: This boundary is at the core network side of NBNCo's network. It is the data interface where access seekers purchase wholesale bitstream[1] access to the NBN. It is Ethernet based.

The next important feature of the architecture is the **Access Fibre**. This is the optical fibre network that connects each consumer premises to a **Fibre Termination Site**.

The Fibre Termination sites contain an **Optical Line Terminal** which is a shelf of electronic equipment that connects to the Access Fibres. It is the FTTH architecture's equivalent of today's ADSL2+ DSLAMs.

There are several common types of Optical Line Terminal device, each suited for different applications. Different types of Optical Line Terminal are required for each architecture. The architecture depicted in the diagram can support either. Normally, an FTTH architecture span will be optimised for the mass market but remains fully compatible for dedicated services required by businesses.

Passive Optical Networks (PONs) are capable of delivering substantial data rates. Today's GPON standard sustains an aggregate data rate of 2.5 Gbit/s which can be dedicated to a single consumer or shared between up to 64 consumers. A new version of this standard will deliver 10 Gbit/s and is expected to be commercially deployed well within the expected NBN roll out.

Even when many consumers share a PON, individual users can enjoy the entire capacity of the PON for short bursts. Individually, consumers can be expected to connect to GPON systems with (physically) 1 Gbit/s Ethernet interfaces, providing an order of magnitude greater capacity than the 100 Mbit/s objective set forth in the recent Australian NBN policy announcement.

Point to Point optical Networks (Pt-to-Pt, a dedicated fibre architecture) is typically deployed for medium to large business services. This architecture is extensively deployed through Australia's CBD districts today.

In broad terms, the Access Fibre is the optical fibre equivalent of today's twisted pair copper access network but the analogy cannot be taken too far. If one was deploying an optimal fibre network from scratch, the dimensions and architecture of the Access Fibre network would be unlikely to be chosen to match today's copper network. You would optimise the deployed architecture to minimise whole-of-nation cost of deploying a fibre access investment.

The optimal span of an Access Fibre network deployed in 2009 is likely to approach 20km to 30km. Longer spans are technically feasible (up to 60km) with certain trade offs and the trade off is anticipated to evolve towards longer span distances as ongoing and routine improvements in optical components commercialise in coming years.

Because of lower living / population densities, regional fibre termination facilities will generally not pick up as many consumer premises as their urban counterparts. The architecture depicted in the diagram accommodates lower density regional FTTH deployments through the aggregation of several lower density fibre termination sites using **Aggregation Fibre** links – a form of 'backhaul' but within the domain of the NBNCo. These aggregation fibre links may span 100km and longer in regional and remote Australia. The factor governing their length is the accumulation of a sufficient number of consumers to the one physical **Point Of Interconnection** site so as it is commercially attractive for access seekers to connect to the NBN.

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[1] In this context, we want to make clear that the kind of bitstream services we refer to are different than those commonly available today. They might instead be called packetstream or framestream, to distinguish them however the issue is that they should support all of the additional characteristics outlined in this submission.

Backhaul into the Points Of Interconnection sites

To be cost effective for both the NBN Co and for access seekers, Points Of Interconnection should be able to reach a relatively large addressable market size.

With an Access Fibre span of 20km to 30km, metropolitan and suburban Point Of Interconnection sites will be able to directly pick up from 100k to 400k consumer premises.

In the rural and regional context, a Fibre Aggregation Site may only pick up a few thousand consumers, necessitating the need for further aggregation fibre backhaul to so that similar numbers of consumers can also be reached from regional Points Of Interconnection.

Aggregation Fibre, Backhaul Fibre – who will own it and provide these services?

When the FTTH architecture is understood as described above, it becomes clear that there are two different kinds of 'backhaul' that will be relevant to the NBN – the aggregation and the access seeker backhaul. It is important to understand that from a practical perspective, both kinds of backhaul require the same kinds of equipment, technologies and architectures. The practical distinction between the two kinds of backhaul has more to do with capacity requirements than functionality. Conversely from an architectural perspective, it is important to understand that the two kinds of backhaul might be separated by a Point Of Interconnection boundary. This could imply different ownership and operation requirements for the two kinds of backhaul and so they may be regulated differently.

We anticipate that regardless of how aggregation backhaul investments are made (whether by dedicated NBN Co build or by competitive outsourcing), it will be within NBN Co's network domain for wholesale bitstream access. Access seekers will either construct or lease their own 'backhaul' from each of the NBN's points of interconnection to their own facilities. Where competitive backhaul doesn't exist already, the government will have an important role to play in providing it.

Whether we choose these terms to describe the two kinds of backhaul or others, the nation will need to agree upon different names or we risk ongoing confusion!

Technical requirements for both kinds of backhaul

It can be safely assumed that future communications services, both fixed and wireless, will leverage 'Internet' technologies and standards (as opposed to the current Internet itself) and hence will be fundamentally packet based. As such, the focus of NBN backhaul investments should be to optimise for large scale, aggregate packet delivery services between the localised fibre termination points and each aggregation site where access-seekers will connect to the NBN Points-of-Interconnect.

Planning and managing the capacity of a backhaul network for the future NBN represents a unique and significant challenge. The NBN provides Australians with a generational leap in access capability, thus permitting the deployment of novel and as yet unforeseen applications and services. The challenge faced by the NBN's planners is to dimension the network to cater for future applications. They need to adequately plan for backhaul so that no future applications are ruled out because of inadequacies.

The NBN must intrinsically be designed to support all of today's and future services at the same time. Technically, access seekers and consumers will call upon the NBN infrastructure to provide multiple, differentiated service capabilities. The NBN requires these capabilities on day one to avoid the costly risk of having to reengineer it at a future date. It follows that NBN backhaul will need to appropriately support these differentiated service capabilities too.

Multi-service backhaul differentiation will be most important when, for example, a major network fault such as a backhaul fibre cut occurs. Under this scenario, high priority services such as voice and medical applications can continue to be supported without degradation via alternate routes - on the full understanding that those alternate routes may thus become congested and will therefore only be able to carry low priority traffic in a degraded, best-effort capacity. The NBN backhaul should provide point-to-point, aggregate packet delivery services, which utilise aggregate packet class markings to permit services to be differentiated by availability (a measure of operational readiness), reliability and timeliness of delivery (measures of operational performance). Such a multi-service architecture ensures that the infrastructure capacity is utilised in an optimal fashion by allowing competing access-seekers (and their corresponding user-bases) to purchase and utilise services appropriate to their budgets and needs. This allows for the greatest flexibility in delivering services such that, for example, in addition to supporting say video as a service, it is further possible to support 'best-effort' video services alongside 'premium-guaranteed' video services, despite both otherwise being 'identical' applications.

Dimensioning backhaul

Unlike ADSL2+ DSLAMs that typically support a few thousand consumers and interface towards their aggregation networks using 155 Mbit/s ATM or Gigabit Ethernet, typical Optical Line Terminals can flexibly support fewer or more consumers and they interface towards the aggregation network using multiple 10-Gigabit Ethernet links. Logically, if consumers are to be assured service rates of at least 100 Mbit/s and large numbers of consumers are to be served by a single Optical Line Terminal, it should be apparent that the kind of aggregation backhaul required for an FTTH deployment will be *substantially* greater than the kind of aggregation backhaul required for an ADSL2+ deployment.

We expect that in a mature NBN, access seekers offering high throughput applications will individually interconnect to the Points Of Interconnection with many 10-Gigabit Ethernet connections each. Access seekers not offering such high capacity services will still be expected to interconnect to the Points Of Interconnection using at least Gigabit Ethernet connections. The total data rate crossing the Aggregated NBN Wholesale Boundary in a mature NBN therefore is likely to exceed thousands of Gigabits per second.

How then should backhaul dimensioning and provisioning be implemented to most cost effectively meet Australia's NBN needs?

Today's Internet traffic models can be used to estimate the 'minimum' baseline capacity required for initial NBN backhaul but should not be used to estimate NBN backhaul growth. We refer the department to our summary of applications and their requirements later in our submission and note that in addition, the NBN is likely to promote new applications, new usage patterns, and will rapidly transform the way Australians use broadband. These factors all need to be weighed when planning the capacity of backhaul.

In the context of these unknowns, backbone capacity planning should avoid an overly theoretical approach and focus more upon a pragmatic. Capacity planning should start from the perspective that today's backhaul network capacities establish the NBN's baseline requirement. Where backhaul currently doesn't exist, new capacity needs to be built immediately at least in line with the capacity already existing elsewhere. When baseline backhaul capacity is available everywhere, the NBN's backhaul designers then need to accommodate the expected growth due to the availability of national high capacity broadband and the innovative new broadband marketplace.

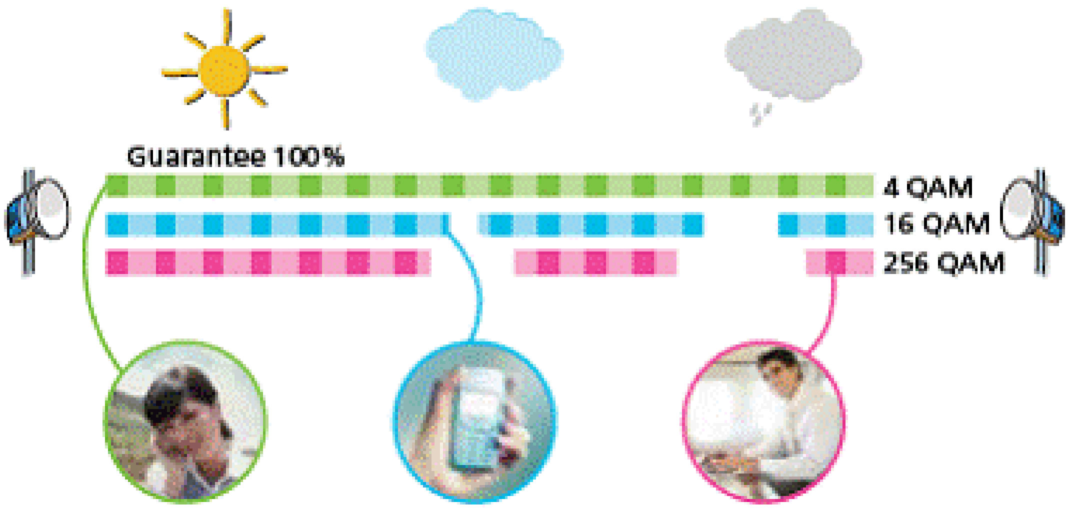
Initial backhaul investments should be optimised to minimise cost, however it is imperative that backhaul be deployed in a manner that allows its capacity to scale rapidly upwards (on demand, when demand materialises). The capacity of the initial investment should therefore be able to scale with minimal incremental cost and yet still be comparable to the cost of having implemented the greater backhaul capacity during initial deployment.

Two fundamental backhaul technology options are available: wireless and fibre.

Microwave backhaul

The capacity of wireless backhaul systems is constrained by spectrum and propagation issues. Today, available spectrum is limited to relatively narrow channels of, for example, 7 / 14 / 28 / 40 or 56 MHz. The consequence of such narrow spectral windows means that the maximum transmission capacity of any one channel is restricted to around 300 Mbit/s as a maximum.

In rural areas, microwave is more practically deployed using the 64 QAM and 128 QAM modulation techniques. Taking the 6 GHz spectral window defined by ACMA as an example, these modulation techniques result in practical throughput of around 150 Mbit/s per channel. The maximum backhaul capacity available, if all spectrum was to be used, would be around 2.4 Gbit/s. This band would allow for typical rural path length of potentially 60 km, assuming a manageable parabolic antenna dimension of say 2.4m, and assuming reasonable mast heights.



To achieve the kinds of backhaul capacity referred to elsewhere in this submission, that is rates commencing at 1 Gbit/s and extending to tens or hundreds of times this rate, will require spectral allocations that could only being found in the very high microwave frequency range. Unfortunately these frequencies are not currently licensed in Australia. Additionally at such higher frequencies, physics makes an increasing impact and conspires to limit the practical path distance to only a few hundred meters in, for example, the 70 GHz band.

For these reasons, we believe that microwave / wireless backhaul should be deployed in the context of a more holistic approach to the NBN’s requirements. It most definitely will have an important role to play in the backhaul of NBN traffic, but the capacity constraints with wireless mean that there is an important requirement to consider fibre based backhaul technologies.

Fibre backhaul

Because fibre backhaul routes require the physical deployment of cables, involving trenching, splicing, and restoring the environment to its original condition, the initial cost of a fibre backhaul deployment is often greater than for wireless, and the project timescale is frequently longer. However once the fibre is deployed, its initial capacity is likely to substantially exceed that of a wireless installation, and the incremental cost and effort required to augment capacity is likely to be far lower than equivalent wireless augmentation.

The most common optical transmission technology for backhaul applications is Dense Wave Division Multiplexing (DWDM). DWDM allows very high transmission capacities to be achieved on a single optic fibre by using multiple signals of different colours (wavelengths). This allows the capacity of a fibre to be many times higher than if a single colour were used. DWDM also allows incremental expansion of link capacity over time (as needed) by adding additional transmitter and receiver electronics at each end and “lighting up” additional colours across the fibre.

Current commercially available technologies transmit 10Gbit/sec per colour or 40Gbit/sec per colour. By transmitting many colours over a single fibre, multi-terabit bidirectional capacities are practical over long distances on single fibres, including fibres that are already deployed today. Technology allowing 100Gbits/sec per colour will also become commercially deployable over the next 1-2 years. By combining DWDM technology to maximise the capacity of each single fibre and then ensuring that multiple fibres are laid along each route, massive backhaul transmission capacity can be achieved.

A fibre route might initially be commissioned by direct-connecting the fibre to the routing devices on either end of the link with a day-one capacity of 10 Gbit/s (assuming a maximum fibre span of say 80 or 120 km). As fibre cables are generally deployed with many fibre strands, additional capacity can be activated by simply direct connecting additional router ports. We note that particularly on long-haul fibre routes involving larger distances, optical transmission equipment may be required at the outset.

If more backhaul capacity is required than direct-connection of router equipment can support, substantial capacity augmentation is still possible at incremental cost through the installation of optical wavelength division multiplexing transmission equipment.

Having deployed a fibre cable, its capacity massive. The cost of each individual augmentation is likely to be fractional when compared with the initial investment in the physical installation of the fibre cable.

The lessons for the backhaul blackspots initiative are thus straightforward:

- For a particular backhaul route, cables with as many fibres as possible should be laid within the constraints of cost and physical space. The incremental cost of laying extra fibres now in the initial deployment (so-called ‘dark fibre’) will be very much lower than digging up the ground later and deploying additional fibre cables.
- Care should be taken in the technical selection of the fibre types and in specifying transmission characteristics. The aim is to select a fibre which supports the widest frequency band practical, to permit the maximum number of colours (wavelengths) to be added on each fibre in the longer term.
- Optical transmission equipment should be chosen which supports an incremental upgrade approach to adding colours and additional fibres (this last point is normal practice for most vendors in the industry).

This approach should allow both an acceptable cost and timetable outcome to be achieved in the short term to reach backhaul blackspots now, but will also establish infrastructure which meets the needs of the NBN by providing links capable of major incremental capacity expansion over a long period of time.

The coexistence of wireless and fibre

The discussion paper invites respondents to comment on the need for ring architectures and alternative links. We think there is a more fundamental issue that underlies these questions: that is the design of resilience and robustness into the backhaul network. Determining the right architecture involves several steps.

Firstly, the network's applications need to be identified. Availability targets need to be established for each. Some applications will inevitably be considered to be more important than others – for example basic voice connectivity is likely to be treated with a higher priority, with additional robustness and availability requirements, than pay television or Internet traffic.

Secondly, the maintenance and service restoration plans for the proposed network need to be thoroughly understood. Questions to be addressed include where workforce will be located, where critical test and repair plant will be stored, how many staff are available on call, how much travel time should be allowed to reach the site requiring repairs, and how long the repairs will take to implement.

Thirdly, the reliability of each proposed network route must be factored. What is the probability of failure of any particular route – that is, how frequently are individual routes expected to fail?

Only with firm answers to these questions is it feasible to start to address the department's underlying questions regarding transmission architecture. One approach to assuring robustness is to adopt ring architectures so that every site has diverse outgoing transmission paths. However deploying rings doesn't eliminate the probability that two or more simultaneous failures could occur in different parts of the network. It doesn't eliminate the problem of having directed the repair team to address one particular fault and then a second fault developing elsewhere within that repair team's domain of responsibility. And spurs, where appropriately deployed to meet geographic constraints, can provide alternate paths with lower investment cost.

Appropriately deployed wireless backhaul might therefore play an important role in the assurance of a robust and resilient backhaul deployment. Even if the available wireless capacity is less than the commissioned fibre capacity, an appropriately engineered multiservice backhaul network with appropriate prioritisation of traffic can still leverage wireless backhaul connections to carry high priority traffic (without degradation) and lower priority traffic (with engineered and predictable degradation) during conditions of network failure.

Alcatel-Lucent therefore urges the department to look beyond the superficial issue of transmission architecture, beyond the question of spurs and rings, into the more important issues of robustness, reliability, availability, service restoration and traffic prioritisation. The architectural answers should become apparent once the more fundamental issues are better understood.

Upgrading capacity

Capacity upgrades within the NBN backhaul should be planned and executed such that no access-seeker is denied any reasonable request for additional capacity, at least during the initial decade of NBN deployment when the applications and services are expected to still be rapidly evolving. This requires careful monitoring of the existing network capacity utilisation during peak demand periods along with detailed tracking of all failure incidents as they occur.

Incremental NBN backhaul capacity should then be added just ahead of demand to ensure that the risk of significant or prolonged congestion is kept as low as possible. This capacity upgrade policy should remain in place for as long as the network utilisation continues to grow beyond a threshold of approximately 4-5% per annum (the typical growth rate of any mature networks, such as the PSTN). Once the network growth rate begins to stabilise, it is anticipated that advanced traffic models will be developed to provide more appropriate long-term growth estimates for capacity planning.

Multi-service capabilities at the Points Of Interconnection

At the very least and to maintain compatibility with today's wholesale broadband access offerings, the Aggregated NBN Wholesale Boundary at the Points of Interconnection should have the capability to efficiently support this kind of simple service. However the capabilities of FTTH and next generation access technologies are far superior than Australia's current first generation broadband deployments.

The government's investment is unlikely to achieve its full potential unless additional wholesale capabilities are anticipated and appropriately defined and designed. These capabilities should encourage access seekers to rapidly innovate to evolve away from today's simple services towards sophisticated multi-service offerings, which are capable of offering distinctly different price/performance characteristics.

The underlying characteristics of the NBN wholesale interface should be founded upon well understood principles such as managed contention ratios (also called overbooking) and should include support for intelligent handling of tagged (relative-priority marked) traffic. These capabilities combine to offer access seekers the flexibility they need to implement sophisticated next generation services within a traffic-managed, multi-service environment.

We believe the most appropriate way of defining a 'multi-access-seeker point of interconnection interface' and a 'multi-access-seeker NBN wholesale boundary at the consumer premises' is to formally define the appropriate use of VLANs (Virtual Local Area Network S-Tag and C-Tag identifiers). In order to take full advantage of assured quality, access seekers should be expected to appropriately condition their subscribers traffic through a combination of prioritisation, metering, shaping and marking (Ethernet frame priority field marking in accordance with 802.1ad) to ensure aggregate traffic conformance with the agreed Point Of Interconnection and Network Boundary policies where handover occurs. The NBN Co could optionally also accept untagged traffic, to which basic policies may be applied, as a transitional or possible value-added arrangement.

A specification will also be required as to the maximum allowable size of tagged Ethernet frames (after tags have been added as described above). As an example, a frame size of at least 1548 bytes should be supported at the Point Of Interconnection, however the final number should be determined following detailed technical specification of the protocols which are expected to operate most commonly across the boundary. (We note that the maximum frame size exchanged across the consumer's NBN Wholesale Boundary will likely be different – for example1526 bytes per the IEEE 802.3ac standard.)

The NBN Co has a responsibility to enforce the agreed aggregate traffic policy at the Point Of Interconnection in order to assure contracted service quality can be achieved simultaneously for all access seekers. Non conforming frames should either be discarded or handled in another documented and predictable manner which assures the integrity of NBN wholesale services.

Appropriately defining the multi-service wholesale capabilities of the NBN is vitally important. Alcatel-Lucent is actively involved in more than 25 major next generation transformations for the world's leading operators. It has accumulated extensive experience in defining, designing and deploying the kinds of capabilities described above and is willing to work with Australian industry and the department to help define appropriate requirements for multi-service NBN wholesale capabilities.

An indication of capacity requirements for particular consumer applications

The amount of capacity that the NBN will ultimately need will depend on usage patterns during its 'busy hour' (a term that traffic engineers use to refer to the busiest period the network is likely to encounter, regardless of its duration).

Determining busy hour traffic levels will require analysis of the applications to be delivered over the NBN and the way this will evolve over time. Each application has unique traffic requirements. Different application may be popular at different times of the day (that is, they may have their own busy hours and the busy hours of different applications may not coincide).

Over recent years, Alcatel-Lucent has noted a change in consumer preferences towards applications that involve a more sophisticated and immersive experience. Such applications include video and high definition video. There is also an increasing trend towards consumers individualising the streams they watch, rather than tuning in to broadcasts or 'linear' programming. These trends imply that the aggregated requirements for access seeker backhaul could be substantial, and additionally, backhaul requirements are likely to continue to grow.

Application requirements

Pre-encoded high definition video: A 'true HD' (1080p) stream can typically be encoded at an network rate of around 8 Mbit/s per stream using the most advanced codecs such as H.264.

Typical connection hold times will range from 30 minutes through to several hours. This is an important dimensioning consideration and applies also to the video content mentioned below.

Real-time-encoded high definition video: A 'true HD' (1080p) real-time stream (such as a sports broadcast) typically requires greater capacity than a pre-encoded stream. This can lead to encoding at a network rate of 12 Mbit/s per stream.

When delivered over a network, video streams are particularly sensitive to packet loss errors. Because packet loss is a typical and normal characteristic of all broadband networks, even when the networks are performing well, most service providers employ error mitigation techniques involving retransmission. That is, when a particular consumer's set top box identifies a missing (lost) packet, it quickly contacts an appropriate server within the network to request a duplicate copy. This approach can be used (and is typically deployed) for both multicast and unicast video services. Similar approaches are used to accommodate 'fast channel changes' in multicast television services, that is, set top boxes treat each channel change as if it was a gross packet-loss event. The technical implementation of these approaches is not important in dimensioning backhaul requirements. It is the burst nature of these unicast retransmission requests which is important.

Typically, operators dimension their networks on the basis of two or more simultaneous video streams per household.

Three dimensional high definition video: Although not commonly available today, Alcatel-Lucent believes this application will emerge into the mass market during the deployment lifetime of the NBN. Demonstration systems are available today in 2009.

Although not yet popularly standardised, video encoded for 3D can be conceptualised as a 2D stream (with similar characteristics as noted above) plus an additional stream conveying the depth component. The average bit rate of an aggregate 3D video stream is around twice that of a 2D stream.

High definition video conferences: Typically, 'high definition' video conferences will not be transmitted in the same fidelity as 'true HD' video noted above. Applications of HD video conferencing include business conferencing, remote medical consultations and tele-education. Symmetrical bit rates of between 2 Mbit/s and 6 Mbit/s are to be expected. If there are more than two parties to the call and the multi-point bridging is performed locally, this bit rate needs to be multiplied by the number of remote end points.

Depending upon the specific context, this traffic might be expected to either be carried as best efforts (eg. via an service provider transmitting "Over-The-Top" of the Internet) or in a higher priority / higher value traffic class.

Three dimensional high definition video conferencing: This application is also largely unknown today but we believe it will emerge during the deployment life of the NBN. It will be particularly important in remote learning and medical application contexts and therefore, can be expected to emerge in all parts of Australia connected to the NBN.

As noted above, the bit rate requirements can be anticipated to be around double the requirements for regular two dimensional conferencing. As an estimate, we believe the requirements will be in the order of 4 Mbit/s to 12 Mbit/s per remote end point.

Web video: Today's You-Tube video is typically inferior to even standard definition video although there is a clear trend indicating consumer demand for higher definition. Today's web video typically requires an average bit rate of around 300-400 kbit/s. So called 'High Definition' web video may require one or two Mbit/s in the future.

Typical connection duration can vary from 30 seconds to several minutes and has an impact on backhaul dimensioning when many consumers are simultaneously accessing web video services. The best effort traffic class is typically considered appropriate for this kind of content. It is anticipated that a capable multi-service standard for NBN interconnection will enable and encourage future innovations such as the emergence of consumer choice between 'standard' over-the-top Internet video or a tariffed NBN service portal offering better experiences and quality.

Low bit rate / high availability applications: Applications in this category include Smartgrid, remote medical monitoring (as distinct from other medial applications such as remote diagnostics and consultation), home security monitoring and basic voice telephony. These kinds of application stand out as requiring 'premium' or 'highest priority' and generally, the lowest average bit rates. Traffic is often bursty. It is not uncommon for average rates to be in the range of a few kbit/s and often much lower, but bursts might reach many times this for very short periods.

The overriding consideration when dimensioning backhaul is that backhaul is deployed in a manner where it is possible to deliver future important applications to all Australians.

Conclusion

The evolution of applications and more demanding consumer usage patterns will drive ever increasing demand for backhaul bandwidth. In the context of the National Broadband Network optical backhaul technologies are well-positioned to provide long term capacity expansion to meet this demand. Wireless backhaul technologies will provide a useful alternative where it is most important to deploy very quickly and where population densities are lower. It will also provide a useful backup path for critical voice and medical services in the event of network fault.

Two types of backhaul are foreseen – “aggregation backhaul fibre” and “access seeker backhaul fibre”. Alcatel-Lucent believes a firm understanding of this demarcation and a preliminary view of this aspect of network topology will be useful in guiding selection of fibre routes, termination points and interconnection points. By properly understanding the reliability, resilience and robustness requirements of applications that will benefit from the NBN, backhaul can be appropriately designed and dimensioned to meet Australia’s needs.

Alcatel-Lucent thanks the department for this opportunity to have participated in the discussion of backhaul blackspot issues. We look forward to ongoing engagement with the department and other industry participants as we work towards deployment of Australia’s NBN.