An accurate assessment of the comparative costs of wireless access technologies in Australia

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0 Executive summary

The ACCC recently commissioned Analysys Consulting Limited ('Analysys') of the United Kingdom to assess the costs of using alternative wireless technologies – including WiMAX, 3G (HSDPA) and satellite – for local access networks in Australia.

We have reviewed the Analysys model and in this paper for the ACCC we summarise some of our major findings.

We found that the key conclusions of this study are likely to be invalid, or at least questionable, due to weaknesses within the cost analysis methodology and assumptions. These weaknesses include inappropriate assumptions concerning volumes and service quality of voice and other traffic, unsubstantiated geographic assumptions and incorrect modelling of some of the key physical coverage and capacity characteristics of WiMAX and 3G/HSPDA networks.

While Analysys states that the calculations are high-level in order to provide indicative costs, the problems we have identified are sufficiently substantial that they cast significant doubt on even the high level results of the model. We conclude that the Analysys results should not be interpreted as an accurate reflection of the comparative costs of wireless access technologies in Australia.

1 Introduction

Analysys has conducted an assessment of the costs of alternative next-generation access networks, to supply voice and data services, in support of the ACCC's current investigation into Telstra's undertakings in regard to the unconditioned local loop service (ULLS). The results from this analysis are described in Analysys' report to the ACCC, *Comparative Costing of Wireless Access Technologies in Australia* (5 May 2006)[1].

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[1] Analysys Consulting (2006) *Comparative Costing of Wireless Access Technologies in Australia*, final report for the ACCC, 5 May 2006.

Analysys developed a model, implemented in Microsoft Excel, which assesses the ULLS-equivalent costs of deployment of WiMAX, HSDPA and satellite technology:

> The results generated by our modelling are based on parameters for unit costs, assumptions concerning how each technology is likely to be deployed, and estimated market share and customer demand for services offered by both Telstra and a hypothetical new entrant operator.[2]

This paper outlines our findings from our review of the Analysys model. Following this introduction:

- Section 2 covers issues we have identified with voice traffic capacity/quality and voice demand inputs to the model
- Section 3 briefly discusses the lack of information provided by Analysys on model assumptions concerning the locations of customers within the study areas
- Section 4 describes the capacity and coverage characteristics of WiMAX technology and points out that the modelled network could not be built and operated in reality, given real world spectrum and coverage restraints
- Section 5 describes the realistic capacity and coverage of 3G/HSPDA networks and demonstrates why the model under-estimates infrastructure requirements in urban areas and incorrectly estimates coverage in rural areas.

Finally, Section 6 outlines our conclusions.

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2 *Ibid*, section 1.

2 Voice traffic characteristics and demand

Two key inputs to the voice component of the modelling are the network capacities needed to carry voice and an estimate of the total demand for voice traffic on the network. We identify that the network capacity set aside for voice traffic is likely to be significantly lower than what is realistically required, especially if the network must meet Universal Service quality requirements and carry other typical PSTN signals such as fax, modem and teletype.

Voice demand data (minutes) has been estimated by Analysys using proxy data from other countries, apparently ignoring Australian sources. Our tests indicate that the model significantly underestimates voice demand.

Allocated voice bandwidth is likely to be insufficient

In its modelling, Analysys has assumed that voice consumes 8kbit/s of bandwidth for a chosen type of encoding[3], and that the bandwidth is uncontended[4] (that is, the 8kbit/s bandwidth is dedicated to voice and cannot be shared with other traffic on the network).

The assumed 8kbit/s is the raw output of a voice encoder, which is employing compression systems to reduce the required voice coding rate from its normal 64kbit/s. To be transported over the IP network, the coded voice output must be converted to IP packets. This necessarily requires the addition of IP overhead, which can result in an IP network signal bandwidth in the order of 200% of the original 8kbit/s encoding. (even taking silence suppression into account, which means nothing is transmitted during periods of silence)[5] [6]. It therefore follows that with 8kbit/s (G.729) encoding, IP voice channels should be designed with a bandwidth of at least 20 kbit/s.

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3 *Ibid*, section 3.5.1.

4 *Ibid*, section 3.3.1.

5 Westbay Engineers Ltd, *Voice over IP Bandwidth*. Available at http://www.erlang.com/bandwidth.html.

6 Newport Networks (2005) *VoIP Bandwidth Calculation*, Available at http://www.newport-networks.com/whitepapers/voip-bandwidth1.html.

In testing the Analysys assumptions, it is also useful to compare the treatment of voice in WiMAX business case modelling by the WiMAX forum. We believe that the WiMAX forum assumes full rate 64kbit/s coding for voice, possibly to ensure normal PSTN voice quality and to ensure that the systems can carry other common traffic found on normal voice networks, such as fax, modems and teletypes for the hearing impaired. The WiMAX Forum in its sample business model for emerging markets has assumed 128kbit/s bandwidth for voice (in each direction)[7].

Analysys has assumed voice is an uncontended service. This means voice has a dedicated permanent channel rather than sharing the bandwidth with other users[8]. Given that voice is sensitive to delay and Internet traffic is not, it must be treated with a higher priority. Some wireless IP networks are currently not able to do this, and so carry voice on dedicated channels. However we do not believe this is the case with WiMAX, especially in the future as voice over IP standards evolve. Therefore in the future operators are more likely to assume voice is carried alongside data and use busy-hour traffic assumptions such as 0.1 Erlangs in their calculations in the same way traditional PSTNs are designed.

We note that the effects of the two modelling assumptions for voice (no allowance for IP overhead and dedicated bandwidth) may tend to offset each other to some extent, but conservative cost modelling practice would be to assume a network voice capacity of well over 8kbit/s. If, as is the case with Telstra, operators are required to provide Universal Service which includes support for non-voice services such as fax and teletypes, then an assumption of 128kbit/s may be more appropriate.

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7 WiMAX Forum (2005) *WiMAX: The Business Case for Fixed Wireless Access in Emerging Markets*, June 2005, available at http://www.wimaxforum.org/news/downloads/Business_Case_for_Emerging_Mkts_Rev1_2.pdf.

8 Operators assume an overbooking factor (or contention ratio) when planning their IP networks. Hence all customers share a certain amount of bandwidth which is less than the sum of their connection bandwidths. As a result a customer may will not always be able to transfer data at their connection rate. This takes into account users not all being active at the same time, and that users are not always transferring while they are active (on an IP network transfers often occur in bursts, such as when downloading web pages.

Voice minute forecasts appear understated

Analysys was not able to obtain local call information for Australia, and instead used New Zealand data as a proxy[9]. However, it is questionable how appropriate this is because New Zealand has free residential local calling which may distort the proportion of calls made to local numbers. Analysys applied the average ratio of local call minutes to national call minutes that occurs in New Zealand (calculated to be 1.42) to derive Australian local call minutes.

Furthermore, the model only includes local, national and international voice calls – traffic generated by fixed-to-mobile calls is omitted.

The Analysys voice traffic estimates may be readily checked against publicly available data for Australia. We find that Telstra traffic alone is more than double the Analysys projections (as shown in Exhibit 1) – however it should be noted that the Telstra traffic data would also include dial-up Internet calls as well as voice calls. Total PSTN traffic would be even higher once traffic from the other fixed line carriers was included.

	2003/04	*2004/05*	*Source*
Local calls (millions)	9397	8469	Telstra annual report
Local call duration (minutes)	11.1	10.3	ACIL Tasman
Local call minutes (millions)	104 307	87 231	
Long distance minutes (millions)	8520	7743	Telstra annual report
International call minutes (millions)	651	580	Telstra annual report
Fixed-to-mobile call minutes (millions)	4226	4375	Telstra annual report
Total Telstra call minutes (millions)	117 704	99 929	
Outgoing monthly minutes per household	219	225	Analysys model
Estimated households	7 642 586	7 756 654	Analysys model
Outgoing monthly minutes per business	776	781	Analysys model
Estimated businesses	2 815 441	2 857 463	Analysys model
Total outgoing minutes (millions)	46 275	47 746	

Exhibit 1: *Comparison of Analysys voice traffic forecasts with Telstra traffic data, 2003/04 to 2004/05 [Source: Telstra, ACIL Tasman, Analysys, Network Strategies]*

9 Analysys Consulting (2006) *Comparative Costing of Wireless Access Technologies in Australia*, final report for the ACCC, 5 May 2006, Section 3.3.2.

We estimate that the actual voice traffic per household and per business location may be up to two times that estimated by Analysys. Furthermore, we note that the Analysys estimates for the number of businesses are relatively low in comparison with information from the Australian Bureau of Statistics, which states that as at June 2004, there were 3.0 million businesses in Australia[10] (compared to the Analysys estimate of 2.8 million). Also, instead of the number of businesses, the Analysys model should utilise the number of business premises, which would be substantially higher than the number of businesses as many operate from multiple locations.

While voice traffic represents a relatively small proportion of the total traffic, an understatement of this component may have implications for geotypes which are capacity limited, particularly in combination with the other problems we have identified.

3 Geographic assumptions

Analysys examined sixteen separate geotypes within its model. These geotypes comprise all the combinations of Telstra's four price bands for ULLS (Band 1 being the cheapest and Band 4 being the most expensive), and four population zones:

- urban (greater than 10 000 people)
- major rural (between 2501 and 9999 people)
- minor rural (between 201 and 2500 people)
- remote (200 people or less).

Detailed information was available for location of premises within 3944 (88%) of the 4473 exchange areas in Bands 3 and 4. For the remaining 12% of Band 3 and 4 exchanges, and for Bands 1 and 2, Analysys made (unspecified) assumptions as detailed data was not available to determine what proportion of premises were within specified distances of the exchange.

10 Australian Bureau of Statistics (2005) *Australian Bureau of Statistics Business Register, Counts of Businesses – Summary Tables, June 2004*, catalogue number 8161.0.55.001, 7 October 2005.

Without information on the nature of these assumptions, it is impossible to determine whether Analysys' estimates are appropriate.

4 WiMAX

We have identified a number of key weaknesses and errors with the Analysys WiMAX model that cast doubt on (and indeed may invalidate) its conclusions, as follows:

- the capacity-coverage relationship is ignored
- available spectrum is less than has been assumed
- the assumption of 100% coverage is unlikely in the real world.

The net result of these problems is an overall underestimation of the costs of WiMAX service delivery to the areas examined.

The WiMAX capacity-coverage relationship is ignored

Analysys has assumed the maximum channel bandwidth (namely 10Mbit/s) is available when the base station is at maximum coverage – encompassing a cell of 4km radius in urban areas and increasing to a cell of radius 12km in remote areas. In reality there is an inverse relationship between bandwidth and distance: the higher the bandwidth of the channel, the shorter the distance, and vice versa. This relationship is made more complicated by using a mix of indoor and outdoor CPE.

There are numerous sources reporting this relationship (for example Eurescom[11], Smura[12] and Siemens[13]) but perhaps the most comprehensive information comes from the WiMAX

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11 Eurescom (2004), *WiMAX – A new alternative for wireless broadband access*, in Eurescom mess@ge 4/2004 (December), available at http://www.eurescom.de/message/messageDec2004/.

12 Timo Smura (2004) *Techno-economic analysis of IEEE 802.16a-based fixed wireless access networks*, Master's Thesis, Communications Laboratory, Helsinki University of Technology, April 2004, available at http://netlab.hut.fi/u/tsmura/smura_thesis.pdf.

13 Siemens (2005) *WiMAX Market and Strategy,* August 2005.

Forum[14], which provided the information for the graph in Exhibit 2 below. Specific values will vary according to the system, but the important point is the maximum capacity of 10Mbit/s cannot be achieved at the maximum range of 4 or 12km.

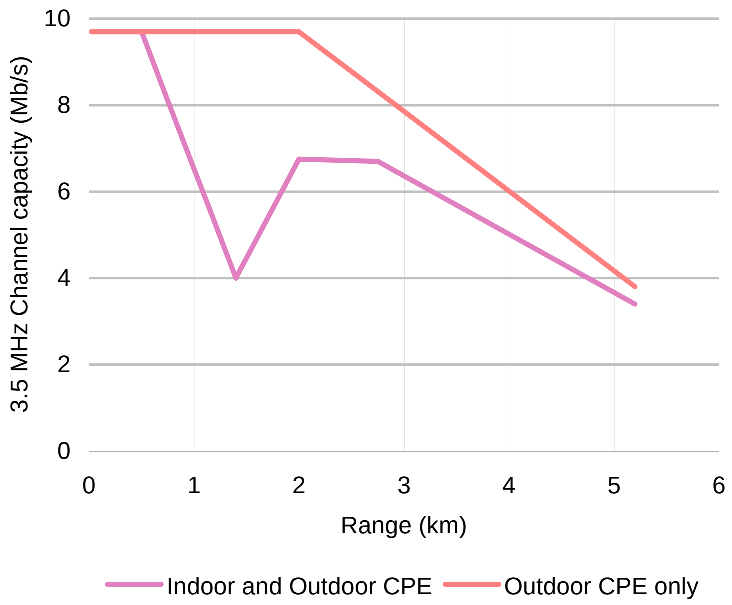

Exhibit 2:

3.5 MHz Channel capacity versus range – 3.5 GHz band in a rural area [Source: WiMAX Forum]

Depending on the traffic density (Mbit/s per km^2), this could have a major effect on commercial viability by increasing the number of WiMAX base stations required, which in turn significantly increases costs.

When representative maximum radii and capacity values were tested in the Analysys model, the results all changed significantly. The NPVs are, on average, halved and several positive NPVs became negative.

14 WiMAX Forum (2005) *WiMAX Deployment Considerations for Fixed Wireless Access in the 2.5GHz and 3.5 GHz Licensed Bands*, June 2005, available at http://www.wimaxforum.org/news/downloads/DeploymentConsiderations_White_PaperRev-_1_4.pdf.

Spectrum available to operators is less than that in the modelled network

In the model base case, Analysys assumes 10 Mbit/s per sector[15], three sectors per base station, and 15 channels per base station. This gives a total base station capacity of 10Mbit/s × 3 × 15 = 450Mbit/s (row 358 of the WiMAX sheet of the model).

With three sectors, each channel (single sector) on the base station would require a different frequency[16]. To achieve 45 channels the operator would need 45 × 5MHz[17] = 225MHz, which is more than twice the spectrum actually available: Australia has 98 MHz available in the 3.5GHz band, divided into 28 3.5MHz bands (many of these bands are paired). The most bands any one operator owns is 18 (nine paired bands), giving a total spectrum range of 63MHz[18].

We note that the above spreadsheet calculation could be an error and it may have been Analysys' intention to model a 15 channel capacity as three sectors with five channels each. This would be more consistent with the available spectrum.

A more appropriate assumption is to allow at most 6×3.5MHz channels in each sector (rather than 15×5MHz), which would correspond to 18×3.5MHz in a one-base station reuse pattern, or 63MHz. This would correspondingly reduce the maximum sector capacity which may mean fewer customers can be served on each site. This will in turn require more sites and reduce the return achieved per site.

100% radio coverage is unlikely in the real world

The coverage achievable by a site is not likely to be 100% of the customers within its nominal coverage area. Due to geography, buildings and vegetation, it is likely that some

15 We presume the model assumes one channel supports three sectors, and this figure is actually the capacity of one channel sector.

16 Assumes a base station frequency reuse of 1.

17 Analysys assumes 5MHz channels (section 3.5.1).

18 Australian Communications Authority (2000) *Table of 3.4GHz Lot Prices at Auction*, October 2000. Available at http://auction.aca.gov.au/auction_results/3.4ghz_results_page/34_pdf/lot_prices.pdf.

potential customers will be in 'black spots' and will not receive a satisfactory signal. In flat areas, the proportion of such customers may be quite low – 0% to 5% – but in hilly locations it could be much higher – 10% or more.

Taking black spots into account will reduce the potential number of customers able to access the technology, and so providing coverage to these customers will incur additional cost. Analysys' assumption that there are no black spots results in a lower bound for cost.

5 3G/HSDPA

Like WiMAX, with HSDPA there is also a relationship between the maximum user bandwidth and the maximum cell radius: the closer the users, the better the signal and therefore the higher the possible bandwidth.

Analysys has assumed a capacity of 8Mbit/s per sector in all scenarios. In reality this capacity is only likely to be achievable in small hotspot cells, with radii of only several hundred metres. Analysys has assumed radii of 0.5km for urban, 3km for rural and 8km for remote areas.

Qualcomm has determined expected maximum cell sizes[19] – these are determined by the WCDMA uplink (which is the limiting factor) rather than the HSDPA downlink. The maximum cell sizes at a 2GHz[20] wireless operating frequency are listed in the following table, along with the equivalent sizes at the lower 850MHz operating frequency. Cell radii are much larger at the lower frequency; we used a path loss model to determine that the radii at 850MHz are around 1.4 times the radii at 2GHz. Therefore half the number of sites are required at 850MHz to provide the same coverage as at 2GHz.

19 Qualcomm (2004) *HSDPA for Improved Downlink Data Transfer*, October 2004, available at http://www.cdmatech.com/download_library/pdf/hsdpa_downlink_wp_12-04.pdf.

20 Qualcomm does not state the frequency at which these cell radii have been determined, but we assume it to be the 2GHz 3G band.

Zone	*Cell radii at 2GHz (km)*	*Equivalent radii at 850MHz (km)*
Dense urban	0.5	0.7
Urban	0.8	1.2
Suburban	2.0	2.9
Rural	6.3	8.8

Exhibit 3: *WCDMA cell radii [Source: Qualcomm, Network Strategies]*

Qualcomm has also estimated the sector capacity under a practical environment to be 2.2Mbit/s for HSDPA in its basic configuration, and up to 4Mbit/s when using CPE with higher specifications (such as receiver diversity and equalizer). Such CPE are likely to be significantly more expensive than basic CPE.

When the updated capacity and coverage figures are inserted into the Analysys model, the results change significantly, with reductions in the NPV for all urban scenarios (because the urban scenarios are capacity limited, the lower capacity increases the number of sites required to carry the traffic). The decreased NPV is significant for all urban cases. For the rural and remote scenarios, some NPVs have increased and some have decreased, depending on whether the sites are capacity limited or coverage limited (the increased radii mean fewer sites – base stations – are required to cover the area). Again, the change in NPV is significant, with some changing from positive to negative, and vice versa.

6 Conclusions

We have reviewed the Analysys model and have provided in this paper a summary of some of our major findings. The Analysys modelling does not estimate the costs of a realistic network in the key areas of:

- voice service and demand to meet Universal Service requirements
- WiMAX coverage and capacity restrictions
- spectrum allocations and availability in Australia
- real-life engineering of the coverage of wireless access systems
- capacity and coverage of 3G/HSPDA systems.

In addition, the modelling has not made use of detailed local data which could have removed the need for a number of traffic and geographic assumptions.

Our overall conclusion is that the NPV analysis and service costs provided by the model are unreliable in many instances.