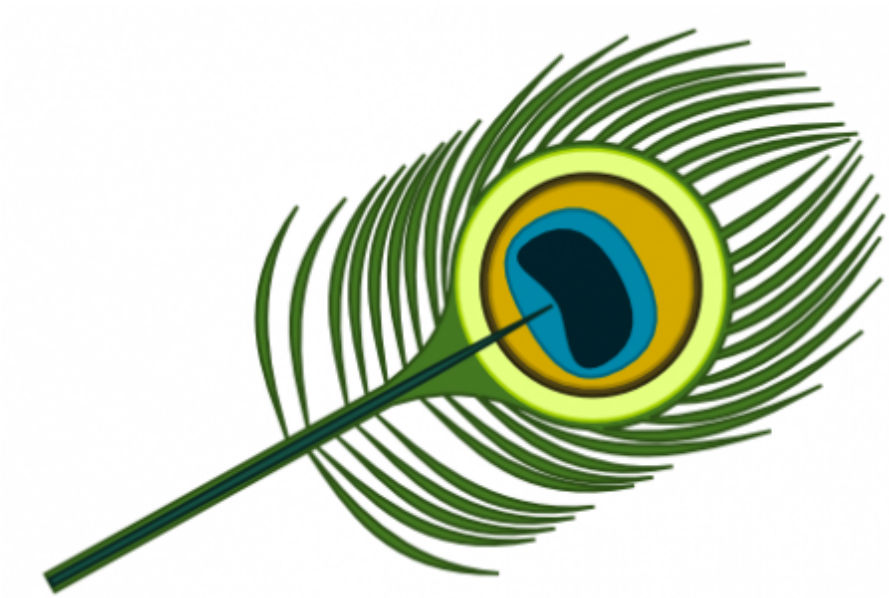
PAVONIS

Wireless Technology Comparison



Prepared for: *Primary Client*
On behalf of: *Sample client*

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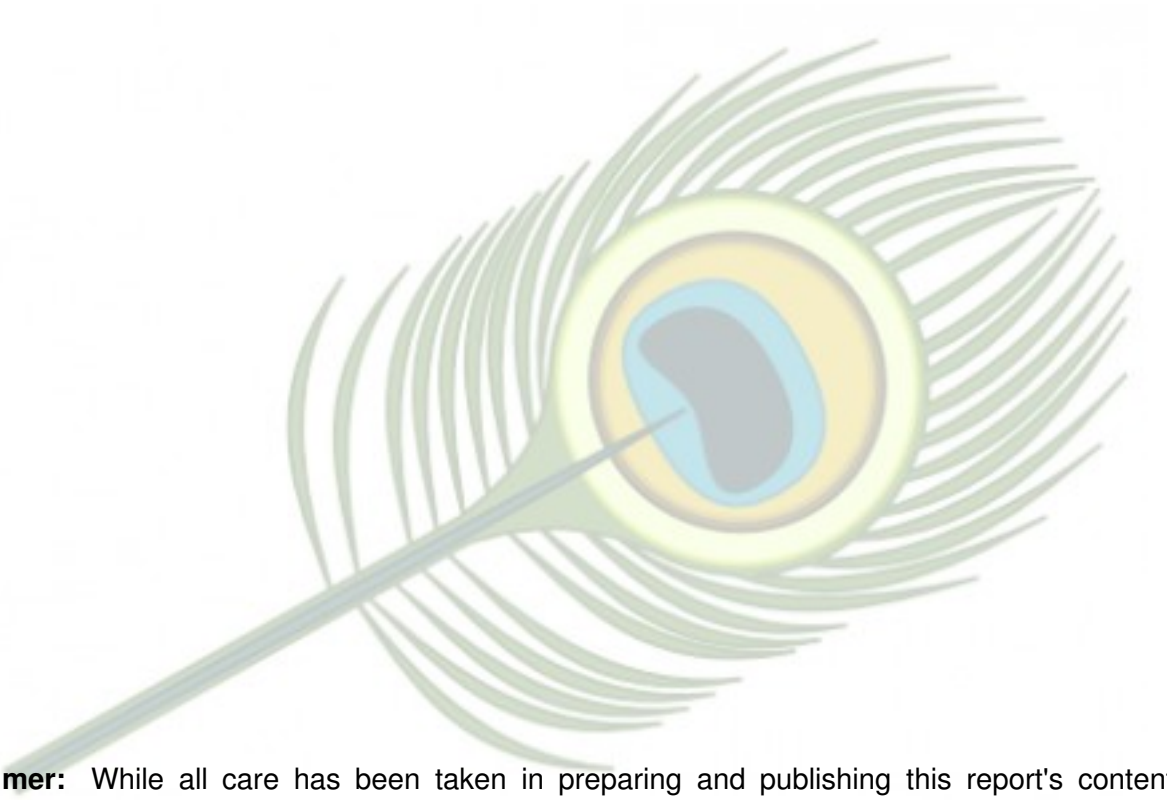

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Introduction

This report has been prepared in response to questions posed by the *Sample client* to the *Primary Client*. These questions were forwarded to Narelle Clark of Pavonis Consulting on 27 August 2010.

This report is based on information that is publicly available from a number of sources. Where the specific information relating to a private operator's network is not available, assumptions and inferences have been made. Where this is the case, the assumptions are referred to within the text.

NBNCo's Intentions

Of particular note is the fact that, at the time of writing, the NBNCo web site is silent on the specific technologies it intends to use to provide wireless services. The nearest it comes is within the coverage maps, where a statement is made that:

> *"The list is based on initial detailed modelling work done by NBN Co which may be subject to change following more detailed planning and design work. The wireless modelling does not take into account terrain modelling and clutter, and may not result in contiguous coverage of all locations within the indicated wireless footprint. " - NBNCo coverage map.*

This would indicate that some determinations have been made as to the type of wireless system intended, as footprint is essentially a function of frequency, the width of the available frequency band, number of users, performance target, frequency coding and data encoding standard (ie WiMAX, WiFi, 3G etc). Additional geographic factors then come into play to affect in-service coverage: terrain, presence of dust or water vapour and interference from other wireless systems.

An additional consideration is that the NBN Implementation Study commissioned by the Department of Broadband, Communications and the Digital Economy to give guidance on the construction and operation of the NBN, states:

> *"To ensure delivery of a wireless network capable of delivering a 12 Mbps peak data rate to a substantial portion of the final 10 percent in the near term, Government should run an open tender process for a provider (or providers) to build and operate a fixed-wireless network that meets specified broadband coverage targets. Detailed geospatial cost modelling conducted by the Implementation Study suggests this network should cover premises in the 94th to 97th percentiles, subject to confirmation based on NBN Co's own geospatial modelling and network planning."*

The implementation study then goes on to discuss the merits of both WiMAX and LTE technologies as suitable candidates for service delivery and in Recommendation 45 outlines the overall recommendations with respect to wireless deployment.

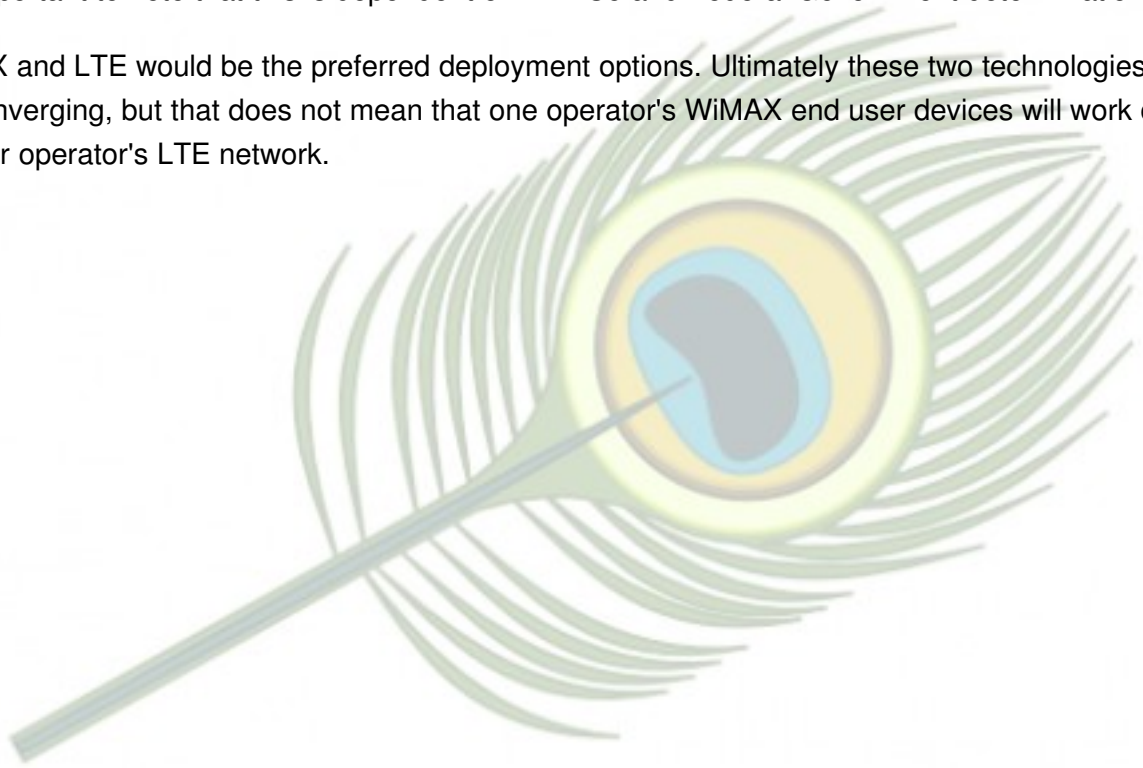
Thus it is entirely possible that NBNCo will not build its own wireless network, rather will outsource the provision of such to one or more providers. In that scenario, it would be expected that NBNCo will establish performance standards, and establish a service level agreement (SLA) with which its provider/s would have to comply.

Interestingly, the NBN implementation study also observes:

> *"Government will also need to decide whether to allow or require the network operator(s) to serve customers outside the 12 Mbps coverage footprint who prefer a wireless service to satellite. For example, a customer who is able to receive a low-latency 10 Mbps peak service over wireless may prefer this to a high-latency 12 Mbps satellite service. "*

In the above scenario, it is conceivable that NBNCo would allow for areas of coverage where the performance standards were not met. In that scenario, customer consent is implied within the text. It is important to note that this is dependent on NBNCo and Federal Government determinations.

WiMAX and LTE would be the preferred deployment options. Ultimately these two technologies are converging, but that does not mean that one operator's WiMAX end user devices will work on another operator's LTE network.



Responses

Fixed Wireless vs 3G Mobile Wireless

Question: For many Members of the Association, the 3G (for the purists 3.5G) wireless system is already placing restrictions on what they can achieve with their internet connection. *How is the NBN's fixed wireless going to be superior to 3G currently available?*

Response: Current 3G networks do not meet the minimum performance standard of the NBN, in that it is projected to supply 12 Mbps as a minimum speed to all concurrent users. Thus, NBNCo is expected to design the network to ensure that for the projected coverage areas, 12 Mbps will be provided to a specified number of endpoints.

In addition, the NBN is expected to comprise *fixed* wireless services, where an antenna is mounted onto the premises in order to send and receive communications. Antennas provide the opportunity to improve coverage through larger receiving areas and higher transmission power.

There are a number of components in commercial 3G/3.5G services contributing to network performance:

- handset/end user device capability;
- coverage (base station number and proximity);
- base station capability;
- backhaul (transmission capacity connecting the base station into the network); and
- network architecture (core network components).

For network operators, the decision on whether to build a particular base station, and how much backhaul it has, will be determined by commercial considerations. A major consideration will be whether the revenue from the site justifies a particular capacity, or perhaps whether it is a location of strategic importance and therefore merits greater capacity.

It is not uncommon in mobile networks for operators to install multiples of 2 Mbps links into a new base station, because that is what was available when the network comprised voice traffic, or because it is a readily available transmission unit to the site. In the 3.5G (HSPA+) world individual end user devices are theoretically capable of speeds greater than 14.4 Mbps: it is therefore easy for sites where large numbers of simultaneous users to quickly reach the capacity of the base station, if all that has been installed is a handful of 2Mbps links.

Shared Service Delivery

Question: The user experience will always be second-rate on any "Shared Spectrum" service such as wireless, satellite or cable because they are not dedicated last link services. *Is this the case?*

Response: When service delivery is via a dedicated 'circuit', each end user can continuously transmit the total of that bearer's capacity, according to the encoding protocol used. Conversely, bearer services based on a shared protocol dividing the bandwidth up between the total number of concurrent users. In the shared scenario each end user's communication is scheduled according to the sharing mechanism in the protocol at the link layer. At higher layers, ultimately all networks are a shared resource: as each segment is connected together, assumptions are made of the utilisation requirements and aggregation occurs.

Protocols at the link layer which are shared include DOCSIS (used in HFC cable services), GPON (used in fibre-to-the-home systems), and wireless access networks (WiFi, WiMAX) and wireless mobile networks (GPRS, 3G, LTE). It is also important to note that whilst these services are all, in principle, shared at the link layer, the individual bandwidths achievable are quite diverse ranging from 9.6 Kbps for GPRS to 2.4 Gbps for GPON (download).

With wireless services sharing occurs at several levels: each transmission between end user device and the base station is scheduled in sequence, but also the frequencies allocated for communication are shared, hence the amount available for communication is inherently smaller.

Fibre optic communication and wireless communications use the same basic encoding mechanisms at the physical layer: however in fibre optic communications much broader ranges of the electromagnetic spectrum are available for use. Furthermore, the communications are contained inside the fibre optic cable and are not subject to interference with, or from, other communications taking place in the neighbourhood of the transmission.

Fibre vs Wireless – Future Services

Question: As more internet users have access to first-world services such as the fibre to the home or Digital Subscriber Link services (ADSL and its successors) those users limited to wireless only services will see the usefulness of their internet connection reduced. *As fibre technology will no doubt provide faster speeds than wireless, what assurance can be given that this won't lead to significant problems for wireless users?*

Response: Over the last twenty years we have seen significant advances in Internet technology. Fifteen years ago Internet communications largely comprised text relay from a mainframe computer to a remote terminal, file transfers and simple text based email messages, where people comfortably used Internet services over 9600 baud (9.6 kbps) modems. Contrasting this with today's live multimedia streams, where tens of megabit streams can be achieved, it seems entirely possible that in the future a corresponding difference in bandwidth consumption will occur.

Web pages of fifteen years ago, which could be viewed happily over a dial-up modem, typically consumed much smaller file sizes than those of today. In time we expect to see virtual reality systems and tele-presence systems where whole rooms and landscapes appear real as they are transmitted across broadband systems and projected onto large screens at the receiving end.

The main differences end users will experience in the medium term, however, will be in aggregate usage: the total simultaneous upload and download capacity of a household or business premises. Users with connections of 12 Mbps, or lower, will still be able to comfortably view web pages, transfer emails, and watch YouTube videos, but they won't be able to see high definition video streams, or have household members *simultaneously* watching separate videos, at the same time as a teleconference takes place with a remote doctor, and the household computers update their operating systems.

Fibre vs Wireless – Dedicated Use

Question: Wireless is used by intensive internet users as an adjunct to fixed DSL services. Its value is as a supplementary service. *Can it be replaced by a dedicated last link service?*

Response: Point to point wireless is quite common, particularly to connect remote base stations into commercial mobile networks. A similar system can be achieved with commercial mobile networks and specialised antennas. These are not widely available within Australia and do not form part of the standard commercial offerings.

Other commercial wireless networks do offer fixed wireless products and will install antennas onto a household as part of their services. These do not generally work as mobile services, that is when an end user moves throughout a coverage area the service will drop out and the user will need to manually reconnect. Software is available to manage a continuous connection, however WiFi and WiMAX services, unlike mobile technologies such as GSM and 3G, are not designed for continuous connection whilst moving.

[Note that there are several ways to interpret this question. The first is where individuals have a fixed service (DSL or cable), say in the home or business premises, and supplement this with a 3G connection to a laptop when on the move. The second interpretation is where a fixed service has a wireless access point in order to reticulate Internet services throughout the home. The third is a fixed wireless service where the last mile link is provided via an antenna.]

Network Speed

Question: Speed claims - These claims not only include the accounting and control data which must be broadcast on the network but assume that the user's modem is touching their pole (aerial), that there is no other user or phone call at the time, that they have sufficient backbone capacity and a perfect (in theoretical terms) radio transmitter and receiver. *NBN Co has told us that speeds quoted are minimum, and concerns such as these are not relevant. Is this the case?*

Response: This is a question where, to coin a phrase, the proof is really in the pudding. On the basis of the technology nominated – GPON – it is safe to assume that individual premises will be able to reach speeds of the order of tens of megabits per second, however how NBNCo ultimately dimensions its network, and how well the Internet Service Providers, and other Retail Service Providers, that actually deliver services to end users is something we must wait and see. This

applies equally to both fibre-based services and wireless services. Again, in the case of wireless services, radio and cell planning for known end points should ensure the network is dimensioned for the stated performance level.

Standard practice in high standard wireless operators is to conduct routine drive testing in order to measure wireless performance once the network is in service.

It is important to remember also that end to end network performance experienced by any particular user depends on what services they use, and the point from where these services are delivered. Transferring a photo or video file from a next door neighbour across a short local link should always be faster than transferring the same item across many network links geographically as far apart as central Australia to the northern Yucatan in South America or a remote part of Siberia. A local service provider may have large data centres with well dimensioned intermediate links or it may have thousands of users connected over small, underperforming links.

Cell Planning

Question: The data rate falls by the square of the distance from the aerial. For those not at the pole this decline in data rate is increased by more than the data rate of other users. The area of service provided by each base station also declines as the data load on the cell increases until service is only available to those at the aerial. *NBN Co has assured the Association that the speeds quoted are for the 'edge' of an area. Is this the case?*

Response: Once again, this is a question that runs to how effectively NBNCo designs and builds its network. The WiMAX and LTE technology is capable of the performance described, however how many base stations NBNCo, or its agent/s, installs to serve particular coverage areas is yet to be seen.

A further consideration is that at this stage LTE technology does not have the benefit of years in service that other technologies, such as WiMAX, do. On this basis it will be difficult to reliably plan the in service performance of LTE should NBNCo elect to deliver services via that technology.

Standard practice in high standard wireless operators is to conduct routine drive testing in order to measure wireless performance once the network is in service.

Network Performance

Question: 'Ping' times. This is primarily the fault of the control system (front end) of the wireless network. Newer versions such as LTE (Long Term Evolution) get some of their increased capacity from streamlining the front end. The methods of dealing with contention (two or more users sending data simultaneously) and the sharing of a limited bandwidth, still include significant delays for modern applications. These delays increase with more users on the system. *Do you agree with this summary?*

Response: Yes; see answers above for a complete explanation.

Symmetrical Services

Question: No wireless technology provides high speed symmetrical and simultaneous upload and download. *What issues will this lead to?*

Response: Symmetrical services are not essential to good network performance – what is essential is sufficient upstream and downstream bandwidth for the services in use.

Shortfalls in upstream bandwidths will affect video conferencing and overall (ie upstream combined with downstream) performance of services in use.

Price

Question: *Do you think that those accessing wireless (94th to 97th) will be discriminated in price and service? If so, to what extent?*

Response: It can reasonably be expected that regional and remote services will have the same access charges applied by NBNCo for access to the *local* network (ie the network segment in the immediate coverage areas, or locality), however service providers providing retail services will more than likely charge higher prices in order to recover the intermediate transmission costs. The range of retail prices could be substantial, but NBNCo has committed to providing additional backhaul where no competitive services exist, and this should enable a reduction in cost to service providers.

NBNCo's policy on aggregation could also have a significant effect on pricing. NBNCo has stated that for small localities the point of interconnect (POI) will be aggregated with other regions and presented at a regional POI. It is not known how many regions would be aggregated, for example all small and remote localities of NSW could be aggregated to the one location, or smaller regions could be presented in the nearest large town, leading to a significant range in the number of interconnect locations. In this regard, fewer intermediate links will be required but the overall difference this makes to the cost base of retailers is yet to be seen.

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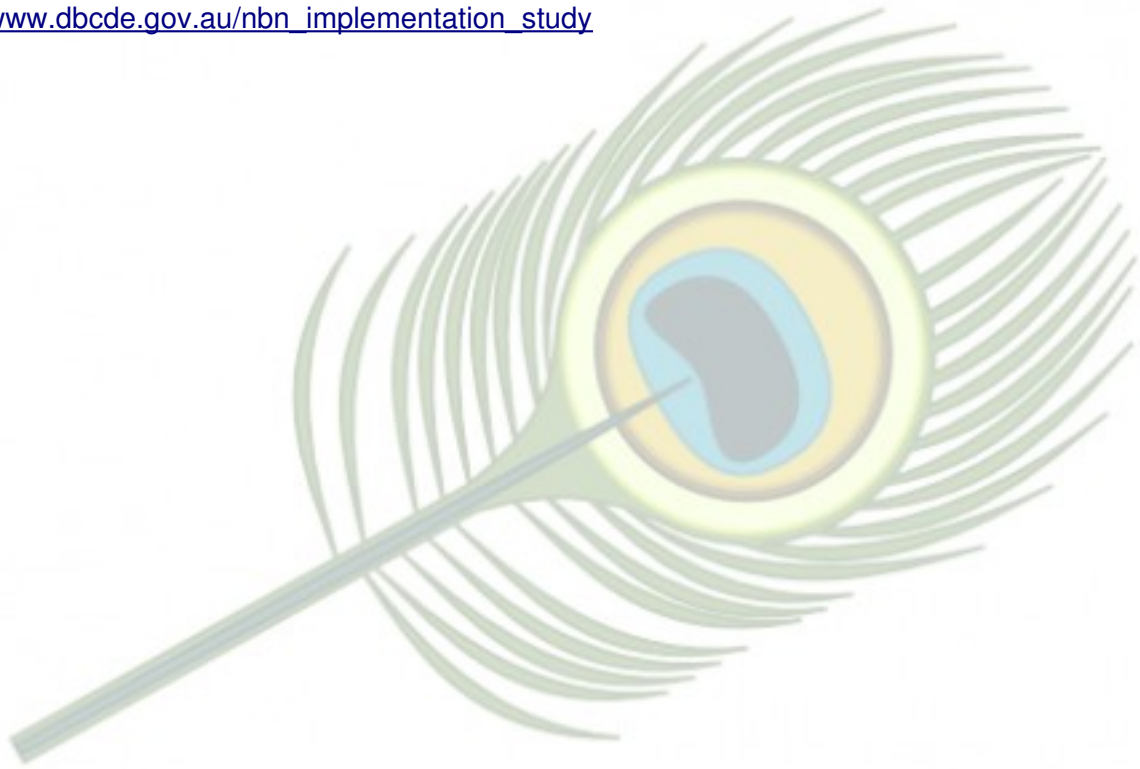

Glossary

3G	A mobile wireless technology
3GPP	The 3rd Generation Partnership Project, the standards body bringing together relevant technical standards for evolved GSM core networks and the radio access technologies that they support
Gbps	Gigabits per second transmission rate
GPON	Gigabit Passive Optical Network
GPRS	General Packet Radio Service also known as 2.5G
HSPA	High Speed Packet Access, also HSPA+
IEEE	Institute of Electronic and Electrical Engineers, a standards and professional body
Kbps	Kilobits per second (1024 bits per second) transmission rate
LTE	Long Term Evolution, the standard proposed by the 3GPP
Mbps	Megabits per second transmission rate
NBN	National Broadband Network
WiFi	IEEE 802.11 based wireless access technology
WiMAX	IEEE 802.16 based wireless access technology

Background

About the Author

Narelle Clark has over twenty years experience in the telecommunications sector, specialising in Internet systems architecture and management. Starting in the early days of the Australian Internet, Narelle has an impressive track record in both the public and private sector. Prior to her work for Pavonis, she was the Research Director for CSIRO's Networking Technologies Laboratory. As head of Optus' Advanced Network Architecture group, she led the build of Optus' flagship Internet data centre and the technology strategy and selection for its voice and data networks for a number of years.

Narelle is the current Vice President of the Australian Chapter of the Internet Society, and was recently elected as a member of the Board of Trustees for the global Internet Society.

Narelle has a bachelors degree in applied physics; a masters degree in engineering (telecommunications); a postgraduate diploma in management; and holds professional memberships in the Institute of Electrical and Electronics Engineers (IEEE) and the IEEE Communications Society.

About Pavonis Consulting

Pavonis Consulting is a small consulting house specialising in telecommunications technology strategy, design and review. Our consultants have extensive experience in many aspects of telecommunications management.