Digital radio extension of DSL for rural New Zealand

White Paper

John Yaldwyn
Chief Technical Officer
4RF Communications Ltd
New Zealand
www.4rf.com

26 July, 2004

Digital radio extension of DSL for rural New Zealand

Introduction

The rural and remote areas of New Zealand have been blessed with relatively good telephone service as a legacy of the pioneering efforts of the New Zealand Post Office, and later Telecom, in the expansion of the access network by means of radio. Equipment such as single subscriber country set links and multi-access systems, often combined with digital microwave radio connected rural exchanges, have all played a vital part in connecting this country.

These solutions were designed for providing voice service and most implementations provide poor performance when used with the modems necessary for dial-up Internet access. Despite this, radio remains the rural access method of choice, covering difficult terrain effectively.

Radio options

Subscriber multi-access radio, or SMAR, is a radio concentrator technology that provides broad-brush coverage suitable for low subscriber densities, but dial-up rates are limited to less than 30 kbps in even modern versions of these systems. The technology relies on statistical behaviour of subscribers to concentrate telephone calls on to a limited number of radio circuits. However congestion can result as calling patterns alter when customers access the Internet and call hold times increase significantly, upsetting the advantages of concentration.

Newer broadband wireless systems offer convenient urban service, but can't reach distant rural subscribers and usually have no voice service available. In the future, 3G cellular systems may provide some rural coverage but the premiums charged for mobile broadband are not a good fit with user expectations for fixed access charges.

At the other extreme in terms of complexity are country set subscriber radio systems. While these low-power analog systems are cost effective for connections for one or at most two voice circuits, dial-up performance is typically limited to 19.2 kbps and often much less. Something like 800 of these systems are in service in New Zealand.

A lot of this country set technology was actually developed in New Zealand. Most systems were installed in the seventies and eighties before cellular phones were invented and wireless was just an old fashioned word your grandfather used to use.

Since then metro and urban New Zealand has gained relatively easy access to broadband via cable, DSL (Digital Subscriber Loop), and recently, fixed wireless systems. While fibre optic cable now connects much of the larger rural centres, many individual subscribers and small rural communities are beyond the limited reach of DSL, the underling technology of Telecom New Zealand's wired broadband service *JetStream*. It is fair to say that rural subscribers wanting broadband Internet access are not well served by technology available to date as distance and economics continue to limit broadband options.

The extension of broadband access to rural subscribers is as much a technical challenge as it is economic. Project Probe has provided a welcome focus on this issue and recent events have shown just how difficult the challenge really is.

Satellite options

While satellite has its place in serving the most isolated areas, satellite-based systems suffer from performance, ownership and cost issues. One-way and two-way satellite systems suffer from latency and often fail to meet response time expectations of customers using more interactive applications. Internet game players in particular consider satellite-based systems unusable, as a review of online user forums will show.

The satellite segment of a typical Australasian service provider has an in-country delay some 20 times the delay of the equivalent terrestrial path. One-way satellite requires a dial-up modem return path and so does not have the 'always-on' advantage of cable or DSL.

Two-way satellite, such as that offered by Telstra in Australia, has been proposed as a solution to Probe's Region 15. However two-way service requires an expensive transmit-capable satellite terminal. Low costs are often touted, but on inspection the cheaper systems have a number of limitations. While downlink rates are good with light system loading, rates fall as more users come on-line because all users share the downlink capacity. Compression algorithms are often implemented to speed web browsing, limiting the protocols used for video conferencing, VPN, and other applications.

Existing consumer satellite broadband services are asymmetric, a pool of uplink slots are shared by all users on a contention basis. While adequate to convey mouse click or keyboard entries, the uplink capacity is insufficient for a web server.

Perhaps the biggest drawback for a network operator such as Telecom New Zealand is that customer revenue must be shared with the satellite's owner.

A way forward

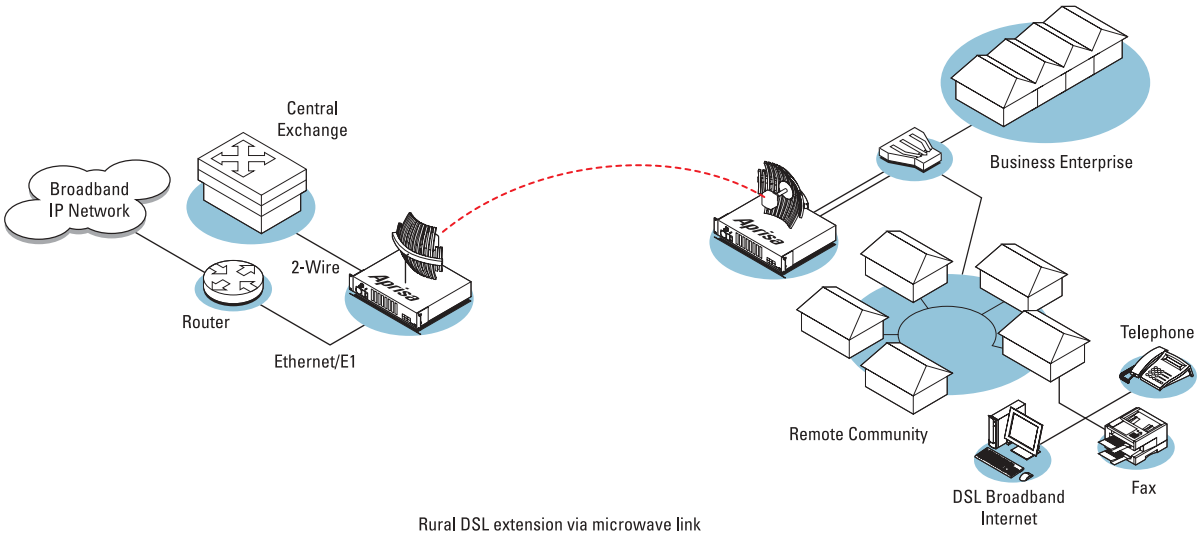
Ernie Newman, TUANZ Chief Executive, noted in the 16th Edition of Telecommunication Review, "DSL is still the stand-out technology as the broadband revolution sweeps the world like a bushfire". This technology is an ideal way of providing broadband if you control the local loop or have an unbundled access arrangement.

Let's look at how Telecom might leverage its existing DSL and local-loop assets via low-capacity digital radio to give a new addition to New Zealand's rural broadband toolbox.

Conventional DSL service is implemented by DSLAM (Digital Subscriber Access Multiplexer) equipment located at an exchange feeding individual subscriber DSL modems over the local loop to the customer. Service range is limited to about 5 kilometres by cable conditions and current technology. The digital transmission is carried by modulation at frequencies above the voice band, allowing telephone and data service to operate independently. The DSLAM connects to the core network via a high capacity ATM connection.

The modulation used by DSL on the local loop cannot be directly carried by radio-based access equipment but if the DSLAM function is moved to the remote end of the radio link then a common digital radio bearer can accommodate both the digital coded voice and ATM/IP data. The rapid development of DSLAM technology has enabled the implementation of compact DSLAM equipment suitable for remote installation and economic support of as few as eight subscribers.

This miniDSLAM technology can be combined with a thin route point-to-point digital radio system to provide normal DSL service over paths in excess of 100 kilometres. Subscribers can use standard DSL modems and need not even be aware that their service is provided by radio.



Rural DSL extension via microwave link

Recent advances in radio frequency design, electronic integration and the implementation of high performance QAM (Quadrature Amplitude Modulation) techniques have resulted in a new breed of integrated low capacity point-to-point digital radio systems developed here in New Zealand to provide highly efficient, reliable and cost-effective transmission solutions.

Techniques of feed-forward decision-feedback adaptive equalizers and forward error correction have made radio systems using QAM practical and economic, allowing them to be designed for low cost subscriber access. These equalizing techniques help minimize potential transmission degradation due to multi-path and other interference sources.

Selectable modulation, high system gain, and the choice of operation in the UHF or low microwave frequency bands offer working ranges of 70 kilometres. Depending on terrain and antenna height, distances of more than 100 kilometres can reliably be covered. The use of 64 QAM allows spectrum efficiencies more than 5 bits per hertz, making best use the valuable low frequency microwave bands most suitable for long distance rural links.

Modest speeds of up to 100 to 200 kbps are possible in the narrow UHF channels used for existing individual subscriber country set links. These old systems can now be replaced by digital radios giving telephone and broadband service in the same radio bandwidth as presently used for just voice.

For small to medium sized rural clusters the line interface cards within today's integrated radio products can be used in combination with miniDLSAM technology to implement rural broadband over DSL and telephone service. Data rates in excess of 2 Mbps can be accommodated in the wider channels of the Ministry of Economic Development's 800 MHz KK and 1.4 GHz LL bands.

The use of licensed UHF or microwave bands ensures reliable service as the Ministry's Radio Spectrum Management Group manages the frequency allocation and interference control. The performance of these radio solutions is not subject to the uncontrolled environment of shared spread-spectrum allocations.

The solution concept is quite scalable; for larger populations new DSL enabled roadside cabinets available from major switch maker Alcatel can be connected to the core network via higher capacity versions of these long haul digital radio systems.

Conclusion

Broadband service can be provided to single and multiple rural subscribers by thin route radio equipment supporting DSL type connections. In many cases existing analog radio access systems can be directly replaced. It's not a universal panacea, but a useful solution that would allow rural access opportunities to be realized that were previously considered uneconomic.

John Yaldwyn is the *Chief Technical Officer* and founder of 4RF Communications Ltd. 4RF provides carriers throughout the world with high-performance Aprisa™ digital UHF and microwave wireless access solutions for the transmission of voice and data in remote broadband applications. www.4rf.com