HIGH BANDWIDTH PORTABLE TRANSMISSION SYSTEMS FOR FIELD LAN DEPLOYMENTS

DEFENCE AND INDUSTRIAL APPLICATIONS OF SPECIALISED RADSL EQUIPMENT
- OR RESURRECTION OF COPPER CABLES -

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ABSTRACT

This paper examines breakthrough applications of the new patented product and its major benefits in military and industrial field LAN deployments, including the Australian Army Report of the recent operational deployment of the new equipment and their finding.

A modern military force depends on rapidly deployed and reliable communications to ensure field success. That's why it is vital for a communications system to be fully capable of handling high data rates, be simple to install and offer flexibility of a wide range of applications. That is where the new patented Portable xDSL System, designed in close collaboration with the Australian Defence Force, offers a way forward for secure field transmission equipment.

In this paper a brief xDSL technology overview is followed by the detailed introduction of the new 'P3' concept (Portable 3 channel Rate Adaptive DSL [RADSL] Transmission System). Several typical 'P3' applications are highlighted and are emphasized in the reproduced report of the Australian Army, detailing its recent equipment deployment operations (including the current East Timor operations).

I. INTRODUCTION

The xDSL technology, simply put, offers fast transmission rates over standard copper cables. However, common telecomms xDSL equipment has a number of limitations. A new design of a portable xDSL-based transmission system, specifically tailored for defence and industrial applications, offers major advantages for tactical deployed LAN extensions in terms of speed and distance between each node, ease of deployment of the copper, as well as retrieval and wide range of additional features. These features, such as remote sensors, data encryption and other telemetric applications, transparently running on the LAN, to date are not available in the market in one self-contained portable product.

The strength of xDSL in defence and industrial applications is that the technology effectively provides viable high-speed communications links over a sturdy physical infrastructure (copper cable; plain or reinforced). In fact, copper remains the preferred infrastructure in many military and industrial applications. While fiber-optics may offer more bandwidth, the cable often breaks under strain and its repair is often unpractical in the field environment. Wireless technology offers "easy" solutions but only where the radio waves can safely propagate. Copper, on the other hand can be rolled-out rapidly and inexpensively and, used with xDSL transmission technology, offers fast transmission speeds (up to 8Mbit/sec). Also, xDSL being a balanced transmission lends itself into Defence applications where 'EW' may be a factor.

In a collaboration with the Australian Army, Defence Communications Industry, a small Australian R&D company designed a portable ***Rate Adaptive DSL*** *(RADSL, an xDSL variant)* transmission device, poised to be deployed widely in defence, mining, utilities and other industrial applications.

Although clearly 60 to 80% of world's DSL market remains a domain of incumbent operators, based on the ownership of copper in the ground, there is a widely unexplored market of specialised applications for DSL. This scenario is particularly relevant to those 'customers' who own copper cables and is specifically relevant in defence and some industrial applications where copper cables are rolled as operational comms infrastructure.

The new concept of a portable RADSL-based system has been designed to occupy this niche.

In the next chapter of this paper we briefly review the DSL technology, compare it to other similar broadband technologies and identify several potential non-telco applications.

Chapter IV resumes the paper's main focus - the new Portable RADSL system.

II. xDSL – TECHNOLOGY OVERVIEW

xDSL is not a new technology it has been invented by the BELL Laboratories some 15 years ago but, only recently has become economically viable.

xDSL modulation technique that takes advantage of the unused bandwidth or frequencies spectrum existing in telephone copper cables. Data rates achievable are in the order of 8Mbit/sec for one direction and 1.5Mbit/sec in the other. This modulation technology is asymmetric due to

the signal interference arising at such high data rates – hence ADSL (Asymmetric Digital Subscriber Loop).

These transmission speeds are well above the speed of conventional dial-up modems; in fact more then 50 times faster and require no new cabling and since xDSL modulation frequencies are above voice telephony spectrum; it leaves the phone services unaffected. The same telephone *(or copper)* line is used for both; high-speed data applications and standard telephony. This is in fact, xDSL's main attraction to service providers – *no need to install new data-comms infrastructure.*

Telcos' main xDSL applications are fast Internet and LAN extension applications. There is a distance limitation (2..4Kms subject to line conditions). ***Importantly, both of these limitations are overcome with the new Portable RADSL Systems – 'P3' described in the later chapters.***

A. XDSL Standards

Two main standards bodies in association with the industry are deriving xDSL standards; ANSI and ETSI. In addition, the ADSL Forum, established in December 1996 actively promotes the ADSL concept, facilitating development of system architectures and protocols. The ADSLForum@adsl.com web site offers wide ranging information including links to numerous ADSL manufacturers.

xDSL has two main modulation techniques:
- CAP (Carrier-less Amplitude/Phase Modulation and
- DMT (Discrete Multi-tone).

CAP *is a version of QAM in which incoming data modulates a single carrier that is then transmitted down a telephone line. The carrier itself is suppressed before transmission (it contains no information, and can be reconstructed at the receiver), hence the adjective "carrier-less"*

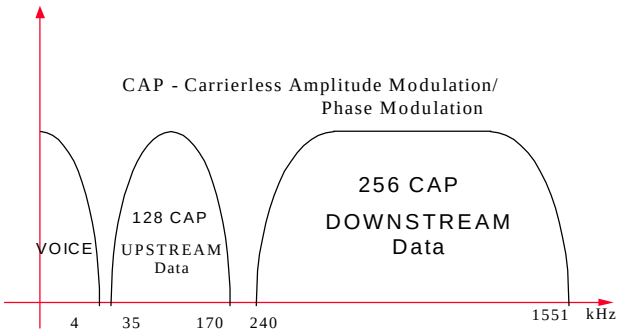


Figure 1. CAP Frequency Transmission Spectrum

Figure 1 illustrates CAP frequency spectrum. It can be seen that voice channel occupies the smallest part of the spectrum (0..4.3KHz) and can be separated (filtered) from the data frequency spectrum.

DMT *(see below)* is a version of multi-carrier modulation in which incoming data is collected and then distributed over a number of small individual carriers, each of which uses a form of QAM modulation. DMT is the basis of ANSI Standard T1.413 and is becoming the prevailing standard, considered to be more resilient to electrical noise *(DMT is the preferred standard in Defence forces).*

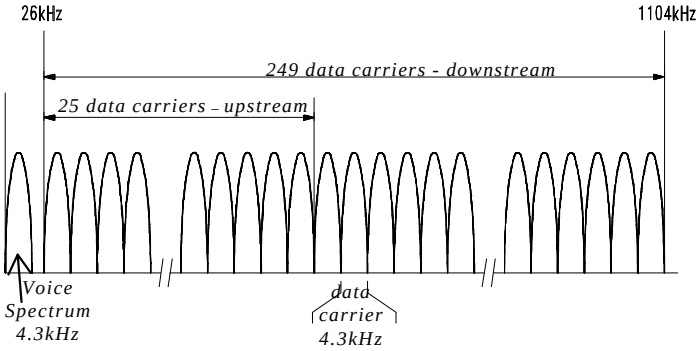


Figure 2. DMT Frequency Transmission Spectrum

Technology Variants and Acronyms

ADSL - **A**symmetric Digital Subscriber Line
RADSL - **R**ate **A**daptive DSL *(adjusts the best (fastest) possible transmission rate on any given copper cable link)*
HDSL - **H**igh Data Rate DSL (*symmetric)*
SDSL - **S**ymmetric DSL *(typically 640Kbit/s available in both directions)*
VDSL - **V**ery High Speed DSL *(up to 52.8Mbit/s over short distances of up to 300m)*

Comparable Transmission Technologies

Voice Modems - offering maximum speed of 56 kbit/sec and typically are 33.6 kbit/sec. These days voice modems are considered obsolete technology especially when graphic intensive files are involved.

ISDN – digital telephone lines with standard speed of 56 kbits and variants of up to 128 kbit/s. Requires special Terminal Adapters and availability of a digital switching network. ISDN is a better alternative to a 33.6 kbit/s modem but in the long term this technology is poised to be considered in the same league as voice modems.

Satellite – offering down-link speed of up to 400 kbit/s and requiring up-link transmission via a voice modem (*ie. only up to 56 kbit/s).* Satellite reception will require a mini-dish antenna. Its main advantage is wide availability in rural areas.

Cable – Offering Internet transfer speeds of up to 30 Mbit/s. Typical speeds achievable are 1.5 Mbit/s for downstream and 300 kbit/s for upstream. Importantly however, this service can only be available where existing Cable-TV *(coax cable)* passes. The other important consideration is that the bandwidth on the Cable is shared with other users. Meaning that at peak times transfer speeds would decrease. *Cable* is comparable with xDSL in

functionality and the two technologies are likely to coexist.

III. RATIONALE FOR THE NEW PRODUCT

In this chapter we review origins of new product and reasons behind the new product invention.

The customer ownership domain is changing rapidly. New operators are entering the market all the time. Telcos, whilst maintaining a majority market share *(based on the copper ownership)* are gradually regulated to share or lease this infrastructure with competitors *(i.e. "copper loop unbundling")*. Meanwhile, many established businesses *(such as business parks, large office buildings, shopping complexes, universities, large hotels, medical hospitals and similar)* already own copper infrastructure and are ideally positioned to become broadband service providers at least to their own customers.

Defence organisations around the world are a classic example of an independent establishments that own their own copper cables, either within bases or in mobile, filed deployments.

General utility companies *(electricity, gas and oil as well as mining)* are another typical example of independent customers that can benefit from the use of xDSL technology and utilise existing copper cables as a reliable broadband communications infrastructure. Quite apart from the additional bandwidth derived from the underutilised copper, immediate commercial advantages to these companies would be offering of 'Fast Internet Services' to its internal and external customers. To be viable in these niche markets, the specialised equipment need to offer additional flexibility that would not be available from a standard Telco system. The new product's features must better reflect individual customers requirements and be adaptable for a wide range of applications.

First Working "P4" Prototype April, 1999

A very effective example of a dedicated xDSL system is the so called "P4" System, designed specifically for the Australian Department of Defence. "P4" used primarily to make LAN extension over steel-reinforced copper cables. This application required a portable multi-channel system capable of operating in a "stand-alone" mode (i.e. without the need of any external supporting equipment or power sources).

In summary, although 60 to 80% of world's xDSL market remains the Telco's domain, there is an unexplored market of profitable applications for xDSL based systems. And although these applications require specific equipment design and adaptation, the resultant product will better reflect customer requirements and in some instances will prove to be an invaluable field deployable communications tool.

The Australian Department of Defence had envisaged important benefits from a portable field deployable LAN Product that could use copper cables as its main communications medium and wanting to trial this idea, contributed towards the product design and its evolution.

The seeds for the new product were sown.

Subsequently to the Australian Army trials of several functioning "P4" prototypes, this technology and its applications had proven resolutely a strong market for the new product. A market that could not be accommodated by standard 'COTS' xDSL products.

IV. PORTABLE (RADSL) SYSTEMS FOR MILITARY APPLICATIONS

A. The Concept

Field deployed data applications demand rapidly established communications links of high bandwidth. This is particularly prominent in areas of defence and industrial applications *(such as mining, telemetry, etc)*.

xDSL is one of the best technologies to cope with this demand. A niche market has been identified by the Australian Department of Defence in field deployed LAN link extensions. The concept of portable RADSL *(Rate Adaptive DSL)* systems was born and had evolved with the cooperation of the Australian Army and had subsequently been proven in several strategic operations.

Portable RADSL Systems provide LAN (10BT Ethernet) extensions over copper wires. Their main advantages over standard Telco xDSL systems are:

a) flexibility in bandwidth configuration
b) overcoming of distance limitation (3..4KM) of standard 'DSL' equipment *(by configuring device as a "repeater")*
c) stand alone operation; no external computers are needed to operate or configure devices
d) battery operation

Additional and specific advantage for military applications is that copper offers a significantly cheaper and simpler medium, compared to fibre-optic based infrastructure. Fibre-optic cable damages easily in an operational environment and that is exactly where the old humble copper cable shines – as a viable broadband communications medium.

The main appeal of xDSL in defence and industrial applications is that the technology effectively provides viable high-speed communications links over a sturdy physical infrastructure *(copper cable; plain or reinforced)*. In fact copper remains the preferred infrastructure in many military and industrial applications. Whereas fiber-optics clearly offer more bandwidth, the cable often breaks under strain and its repair is often unpractical in the filed environment. Wireless technology offer easy solutions but only where the radio waves can propagate. Copper, on the other hand can be installed rapidly and inexpensively and in together with xDSL offer cheap and high speed communications links.

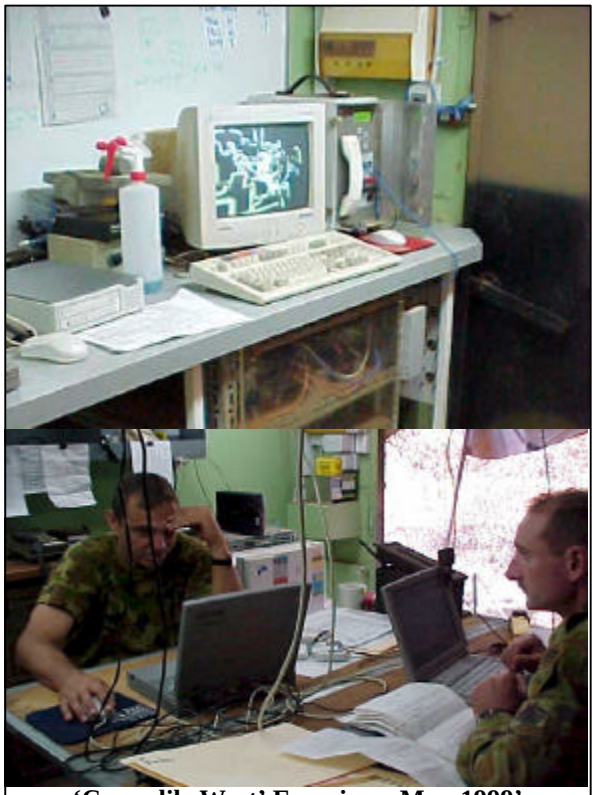
The new portable xDSL system, designed by the paper's author was called "P4" *(**P** for portable and **4** is for four channels)*. These systems can be used in a number of industrial applications; be easily configured via the on-board micro-controller *(no external computers are required)* and operate on internal battery. A variety of power sources *(DC or AC generators or solar panels could be used)* to operate the device.

The "P4" concept extend possibilities over the typical xDSL system. They can operate; from a simple point to point transparent LAN (Ethernet) link to a complex web of 'P4's and importantly, as a data repeater configuration *(effectively extending the reach of 'P4' from 5 to 10Kms and beyond)*. The same device can operate as a line qualification, testing and measurement instrument. Data throughput, achieved over 1 to 3Km lengths of copper cable is typically in the order of 8Mbit/sec in one direction and 1Mbit/sec in the other direction. As the distance of the link increases the effective throughput stars to decrease *(e.g. 4Km of steel reinforced copper cable, operating in adverse conditions, produced consistent data rates of 4.6Mbit/sec and 1Mbit/sec in respective directions)*.

Other applications for Portable ADSL systems include general LAN network extensions and fiber-optic based LANs back-ups in any of the following general areas;

Telemetry applications
Defence
Fire Brigades
Police
Mining
etc.

P4's unique design, incorporating both "master" and "slave" transceiver modules, provides for an effective range extender (repeater) configuration. This effectively extends the physical reach of ADSL in hops of 3..5 Km. This is an important feature as it allows very effective LAN extensions over long distances (E.g. Rail Lines, Oil Pipelines, Airport Security perimeters and similar).



'Crocodile West' Exercises, May-1999'
- Proving the 'P4' Concept for Tactical LANs -

B. The Proof Of Concept

In April 1999 the first functional prototype of the new portable ***RADSL*** system was manufactured. The product came with batteries making it possible for operation in isolated locations without power, as well as, operation from a variety of AC and DC power sources.

Another important feature of P4 is to offer voice communications over the same copper cable, independent of the data transmission *(the so called "engineering wire" that can be interfaced into any telecommunications network)*.

The bandwidth, maximum possible transmission between any two P4s, is automatically set depending on the line condition *(the so-called Rate Adaptive DSL – RADSL protocol, similar to the way a common telephone modem negotiates. The best speed possible is selected; typically 8Mbit/sec in one and 1Mbit/sec in the other direction)*. P4 displays actual line operating parameters on its status display during its operation.

In total 10 x P4 were made, of which 9 were delivered to Australian army for trials.

C. Australian Army P4 Field Trials – The Report

Australian Army tested P4s in several operations, most prominently, during its East Timor mission.

Below is a report extract by WO2 Peter Thornton and Major Ian Thomas of the Australian DoD (Signals and Army HQ); who effectively instigated and promoted xDSL technology within the Australian Department of Defence;

"New Technology - WDD A/TT (Don-10) Network"

Army uses fibre-optic cable to provide a communications infrastructure for logistic support. The fibre optic cable, kevlar-armoured especially for Defence, is an expensive medium and suffers breakages from being caught up in the track link of tanks or broken by forklifts. These accidents, actual events during Exercise Phoenix, normally occur during night under blackout conditions. Although the fibre can be

repaired, such repair requires return to base and expensive facilities.

Army traditionally uses Don-10 copper wire strands reinforced with strands of stainless steel wire to carry voice in the field. This cable, capable of withstanding heavy stress, still gets broken but is easily repaired by users. Wire cable deployment is also considerably easier to achieve than laying fibre optic cable. P4 xDSL was employed during Operation Phoenix and Crocodile West to prove an ability to replace fibre optic cable segments with Don-10 on selected long runs.

The following are some first hand impressions and feedback from Army users of the Don-10 technology on Operation Phoenix; "Soldiers understand this and they can fix it" (meaning wire and breaks that occur as opposed to fibre optic cable); "Can I get some more; "This is great"; and "Hey, it works". Portable xDSL systems provide data rates over copper or steel cables that are acceptable with significantly reduced capital costs. P4 primary application during Operation Phoenix was to enable a transparent LAN extension within a large logistic area, located in the bush near Tindall.

P3 in a Ruggedised Case including Field Telephone

A number of specific future requirements have been discussed. One such special development is a simple back to back xDSL modem, providing the Army with rapid deployment multimedia infrastructure over copper cable. It greatly reduces the cost-per-line factor due to the elimination of the more cumbersome subrack assembly of a standard system. This technology successfully provided the logistic LAN backbone on Operation Crocodile West, 150 km SW of Tennant Creek, when fibre optic breakages and distance limitations proved difficult to overcome.

The WDD A/TT (Don-10) LAN extensions are robust, cost-effective and well-accepted by soldiers. Tempest-rated within the restricted environment, the solution is now a Defence Infrastructure standard within the strategic environment however it is not yet formally accepted in the tactical arena.

end of report

This field exercise clearly indicated viability of portable xDSL systems. There have been several other successful strategic deployments of the technology by the Australian DoD over the last two years including; HMAS Cerberus, Holsworthy Barracks, Fort Queenscliff and other bases.

Royal Australian Air Force (RAAF) Airborne Telecommunications Unit (ATTU) has deployed a number of RADSL systems for its remote communications requirements.

In recent "real" operations a number of mobile units have successfully used portable RADSL products for rapid filed LAN extensions. The original 'P4' prototypes are to this day deployed by the Australian Army in East Timor for INTERFET peace-keeping operations.

In summary, the Australian DoD views the deployment of xDSL as "copper cable resurrection" and the recent operational deployments have clearly proven it.

D. Future Of Portable (RADSL) Systems - the 'P3'

Following the product's initial deployments, the product has been redesigned to incorporate the latest RADSL technology, as well as, higher tolerance electronic components. The number of fully configurable RADSL channels has been optimised to three and the overall package was integrated in a fully ruggedised (Mil.Spec.) carry case.

The new 'P3' *(**P**ortable **3** channels)* is a portable stand-alone device, requiring no external devices to configure or operate it. This is an important feature in industrial and defence applications. All unit's management is established via the internal microprocessor – no external computers are needed. P3 has internal batteries providing stand-by operation for up to 8 hours under the full load conditions and longer when only one or two of the RADSL channels are active.

The product is particularly suitable for telemetry applications where a rapid deployment of data networks is essential. One of the configuration options of the device could be a new generation (high bandwidth) data logger.

'P3' will also function as an effective line qualification and testing tool, offering automatic loop-back facility and measuring line/s performance. Its design, incorporating both "master" and "slave" programmable transceiver modules, provides for effective flexible configurations for its many applications. P3's unique feature is to be configured as a range extender (repeater), effectively overcoming the physical reach of RADSL (of about 5Km). A number of P3s can be cascaded together establishing flexible data link over long distances.

An important feature is introduction of PCM/CIA plug-in cards that significantly extend the product's applications *(e.g. instrumentation and sensors reading, video surveillance, tele-medicine and many others).*

Integrated handset provides telephone function between any P3s and can be interfaced into the telephone network.

The phone operates even if the data link fails.

Other new features considered for future product releases are VDSL transmission (up to 52Mbit/sec), as well as, radio and fibre-optic modules.

V. CONCLUSIONS

The pivotal factor in successful xDSL technology introduction is the product's suitability for any given application. Considering, essentially industrial applications for portable RADSL systems, it transpires that, in a similar way that any business or domestic customer can benefit from the additional bandwidth derived by the xDSL technology, an industrial customer can too, substantially benefit from the extra bandwidth.

The Author with the first 'P4' Prototype, April-1999

However, whereas a standard xDSL system requires a telephone exchange infrastructure to operate it, portable, stand-alone systems offer advantages of stand alone operation and configuration flexibility.

Even though single line xDSL modems are already available on the market and finding their applications, they too require additional equipment to configure and operate them.

Portable, stand-alone RADSL systems are likely to find substantial popularity in industrial and defence applications, wherever usage of copper cable is considered to be the preferred infrastructure for communications.

VI. BIOGRAPHY

Alec Umansky began his career in the telecommunications industry, with Telecom Australia *(currently known as Telstra)* in 1981 in the area of Trunk Switching, being the first generation of computer controlled telephone exchanges. Following his graduation from RMIT (Royal Melbourne Institute of Technology) where he took a degree in Electronics and Digital Communications, he joined Philips (Public Telecommunications Systems).

His work focused on introduction of new fiber-optic transmission technologies (SDH) in Australia.

During his career with Philips, Alec worked in Germany and England in progressively, business development orientated positions.

Since March 2000 Alec formed an independent company, Defence Communications Industry specialising in design, development and marketing of communications products for defence and industrial markets.

In addition to his main studies, Alec attained two post-graduate degrees in Advanced Microprocessor Design and Development from RMIT.

Alec plays guitar, enjoys travelling and is an active AFCEA member (Armed Forces Communications Engineering Association).