RAP: The Rural Access Point Concept for Remote-Area Australian Communications

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Executive Summary

While broadband communication uptake is increasing rapidly, there is a significant fraction of remote and rural Australia for which terrestrial communications approaches (such as fibre and microwave links) will remain too expensive. Satellite systems can complement broadband terrestrial networks with flexibility and immediate coverage. Their advantages include wide area coverage and broadcast capability. However existing satellite solutions, which usually involve one satellite connection per user, are often not economically viable.

In this outline we present a new concept which provides satellite broadband access to remote areas via **Rural Access Points**. While the concept of supplying communications needs via a single satellite hub is not new, applying the combination of a number of leading edge transmission technologies to enable efficient resource utilisation and sharing between many users provides a significant difference to the affordability of this approach. <u>We estimate that up to a factor of ten reduction in the satellite bandwidth cost is created by the combined use of these technologies</u>.

The following concepts and technology areas are proposed for this system:

- community-based satellite earth stations;
- aggregation of traffic within each community;
- traffic bandwidth shaping and management;
- improved transmission techniques in the satellite links (e.g. turbo coding);
- use of modern last-mile distribution techniques (e.g. wireless LAN)

The RAP idea not only provides financial benefits, but the diverse needs served will act as a community aggregator which gives additional socio-economical benefits.

The Desert Knowledge CRC and the CRC for Sustainable Tourism expressed interest in developing community planning for utilisation of RAP technology in remote communities. The proposed studies will identify user needs for three remote communities, will develop community based, driven and owned utilization plans and methodologies that can be transferable to other communities. Proposed study communities will include Aboriginal and predominantly non-Aboriginal communities.

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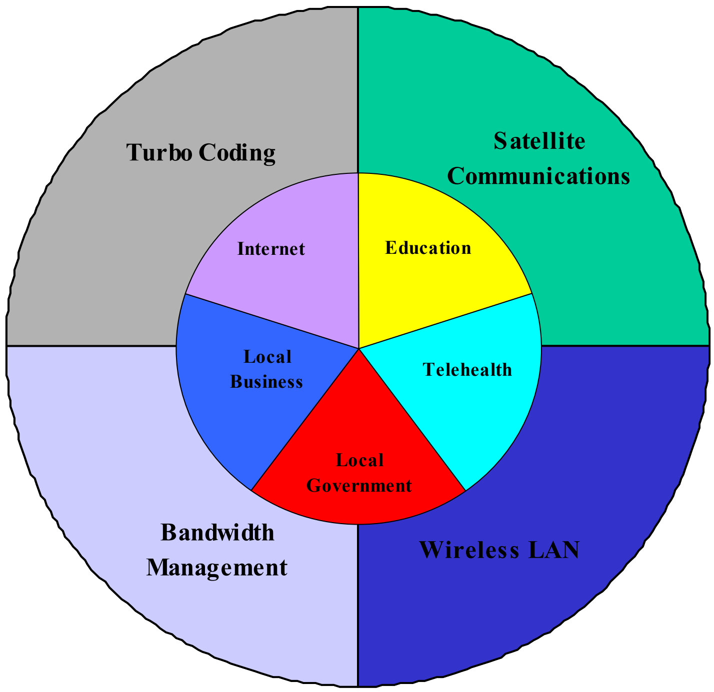
1 Introduction

This paper presents the key aspects of the RAP idea that is proposed as a key concept in the provision of communications services to rural and remote communities.

This new approach can be visualised as a number of technology areas combining to serve the total community telecommunications needs as follows:



Rural Access Point (RAP) Concept

Technology alone is not the answer for providing a sustainable communication infrastructure. Aggregation of communication needs of the whole remote community is the key to achieve a viable economical solution in the long term.

The components of the RAP concept are discussed in the following section, providing insight into how the competing community demands can be efficiently serviced by this combined approach.

2 RAP Concept Components

2.1 Community Earth Stations

The system envisaged in this proposal corresponds to the first solution: we consider a rural community equipped with one earth station communicating with a satellite. We assume the rural community typically comprises:

- **A medical centre** using, or having a desire to use telemedicine services such as image transfer and video conferencing and web browsing.
- **An educational centre** or school with typical internet needs such as web browsing, file transfers and emails.
- **A community centre** open to the public such as internet café with same internet needs as the educational centre.
- **A set of individual users** with typical internet and email needs whose geographical location allows for a last mile connection to the concentration point.

This model can be further enhanced by:

- **A tourism centre** that could include hotel, B&B, local atractions, etc.
- **Local businesses** with a wide range of communication needs.

It is important to recall that from a network point of view, the satellite system can be applied in two modes: **user access** and **network transit.**

- In the user access mode, the satellite network provides access links to a large number of users and the earth station provides a concentration point for multiplexing and demultiplexing functions.
- In the network transit mode, the satellite systems provide high data rate links to interconnect broadband network nodes or network islands.

2.2 RAP Traffic Management

It is important to consider that not only are a diverse range of applications required, but the times those services are required and the priorities they carry are all important considerations in dimensioning a solution. For instance, some interactive telehealth services require large transmission rates, are very sensitive to time delays and are not used very often. Another application such as file transfer normally requires a relatively high transmission bandwidth, but is typically not time sensitive. Web browsing, which is perhaps the most popular internet service, can tolerate some transmission delays and is also somewhat variable in its required transmission bandwidth.

With the combination of factors to consider when sending information, including bit rate, transmission delay and priority, a significant improvement can be gained by appropriate transmission and bandwidth scheduling from a single satellite hub.

This "traffic shaping" part of the RAP concept will work efficiently if located at the traffic concentration point in the earth station. This device will control and monitor the RAP traffic in order to maximise its throughput and to ensure that priorities among different services and traffic types are kept. More specifically, each data transmission will depend on:

- **its service type** (i.e. medical centre, school centre, community centre, individual user)
- **its traffic class** which is characterised by the time sensitivity factor (video conferencing, web browsing, email etc).

This "network police" approach has been developed for wired networks (WANs and LANs) eg [1]. The extension of existing approaches to a RAP network would only require modest adjustments.

2.3 Transmission Technology

Most of the current satellite communication systems employ half rate error control coding and QPSK modulation. Modern modulation and coding systems can give great improvements in spectral efficiency (ie the amount of transponder bandwidth required for a given bit rate) and the power efficiency (ie the transmit power or antenna size required to give the required bit error rate performance).

A good example of state of the art transmission performance for a satellite link is shown in [2]. This system uses advanced error correction coding called turbo coding with high order QAM modulation and operates to tens of megabits per second. It offers a factor a two improvement in either power efficiency or bandwidth efficiency compared to current standards. This improvement translates directly into cost saving.

2.4 Space Segment Options

So far in this paper we've assumed the use of conventional space segment hardware (ie "bent-pipe" satellite technology). To further optimise the transmission system a regenerative satellite transponder should be employed. Not only does this allow further improvements in the uplink and downlink performance, it may provide other network advantages. However a much greater investment is required to achieve this space-segment infrastructure and this option is not pursued here.

2.5 Last-Mile Distribution

To realise the full benefits of the RAP approach, an efficient distribution technique is required to connect end users to the RAP. We assume that most subscribers will be located within several kilometers of the community earth station, and few might be up to 25 km away, and that all traffic would be IP-based. While several alternatives exist (such as ADSL, 3G wireless, LMDS) we believe that modern wireless local area networks (WLANs) will provide an excellent solution for last-mile distribution. For example see

[3], which covers the distances required (assuming fixed links with simple antennas), operates up to tens of Mbit/s, is very flexible and easy to install.

2.6 Adaptive Bandwidth Allocations to RAPs.

Even with simple bent-pipe transponders, assuming a large enough numbers of RAPs it will be possible to improve overall performance by dynamic allocation of link capacity depending on the specific requirements of each RAP during the day. For example given the time differences across Australia there will be some significant variations in the traffic requirements. Various methods of adaptive bandwidth allocation may be envisaged – from highly flexible schemes to lower-cost quasi-static channel assignments updated on a regular basis. In the cost comparison mentioned below we haven't taken these additional system benefits into account, but it would clearly provide further benefit at the expense of requiring a control strategy at the master ground station.

In addition, in an optimised RAP system approach it would be necessary to consider the most appropriate way to provide broadcast functions to local users, as well as the specific traffic requirements of each RAP. More specifically, various components of the earth station could also be used for video and audio broadcast applications in a very cost effective manner. The local redistribution of the broadcast material could then be done from the RAP site, say via UHF transmission.

3 RAP Concept Benefits

Clearly the benefits are both cost and social, and a brief discussion of these is provided in this section.

3.1 Cost reduction

This section provides a rough but realistic idea of the cost improvement brought out by the RAP concept as compared to existing commercially available satellite service providers. Our analysis can be summarised as follows:

- We assume current systems use QPSK modulation and half rate channel coding.
- Our enhanced system uses the turbo coding technology described in section 2.3 and the traffic shaping approaches outlined in section 2.2.
- We assume a fixed annual cost per MHz of transponder space.
- Spectral efficiency is improved by a factor of two, which leads to a reduction in transponder costs to approximately 50% of the current ongoing costs.
- Aggregation of the traffic from all users in one RAP provides an improvement in the efficiency of the system resources resulting in a further significant saving compared to individual user access.

If the RAP traffic is uniformly distributed over the day, our analysis shows a factor of ten saving of the proposed system compared to conventional systems. Note that this analysis does not include the extra benefits described in sections 2.4, 2.5 and 2.6.

3.2 Socio Economical benefits

We believe that **community consensus and organisation is necessary** to fully realise the benefits of the RAP concept. Indeed, determining the service and traffic class priorities should be discussed within the community in order to ensure a fair share of the bandwidth and to further improve the performance of the network. For instance, it could be understood that certain “bandwidth-hungry” applications are given very low priority until off peak periods, or that e-learning and professional related applications have priorities over recreational applications during business hours. If managed with appropriate flexibility and fairness, this interaction and consensus will act as a community aggregator that could lead to local initiatives. Such meetings could lead to a better communication within the local community and should also stimulate local initiatives such as rural tourism promotions via web design. It is important to view the RAP concept not only as a way of improving communications between rural communities and the outside world, but also as a way of improving communication within the community itself. Local initiatives which could involve community groups, educational centres and individuals, would also help in promoting indigenous culture, regional communication and improved community awareness.

4 Conclusion

In this outline, we have presented a new concept for providing rural communities with broadband communications. This concept is based on Rural Access Points (RAPs) which consist of a number of communal institutions, businesses and residential users that, with a combination of local coordination combined with advanced technologies, efficiently share a single satellite link. It has to be pointed out that most of the technology described in this document is currently available and we believe that a proof of concept Rural Access Point could be implemented quite readily.

We have shown that this is made possible by an appropriate traffic aggregation and management policy, plus link and interface optimisation. We have also highlighted the fact that in order to function efficiently, this concept requires a community consensus and organisation that could be the driver to greater communication and initiatives within the rural community. Finally, our analysis has shown that this scheme significantly reduces the cost to transmit information as compared to the existing commercial systems.

5 References

[1] Traffic shaping example: http://www.foursticks.com/

[2] Turbo modem example: http://www.itr.unisa.edu.au/tech_res/products/specs1.pdf

[3] WLAN product example: http://www-au.cisco.com/warp/public/cc/pd/witc/ao1200ap

RAP: the Rural Access Point for Remote-Area Communications

Institute for Telecommunications Research
University of South Australia

Foursticks Pty. Limited

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RAP

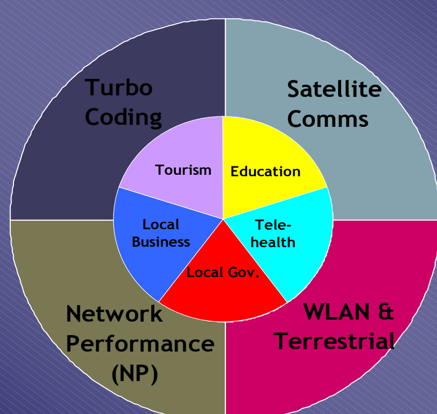
Rural Access Point for Remote-Area Communications

- RAP is a unique combination of technologies that satisfies the integrated communications needs of a remote/rural community
- Aggregation of the community traffic via a single access point
- Network performance management
- Most power/bandwidth efficient transmission technique available over satellite links

What is RAP (cont.)

- Main satellite link is "data pipe"
  - Shared by whole community according to traffic priorities and performance requirements
- Community network comprises:
  - Schools, medical centres, local government
  - Local businesses, Internet cafés, tourism
  - Individual homes
- Last mile by:
  - Wired network
  - 3G type network (e.g., Mnet example in Whyalla)
  - WLAN (e.g., 802.11b)

Rural Access Point (RAP)



Competitive Advantages

- Addresses needs of a whole community
  - Versus VSAT-based services which solve individual needs
- Integrates the latest technologies at physical and network layers
- Optimisation of traffic over the satellite link through turbo coding and traffic multiplexing
  - Exploit inherent burstiness of IP traffic
- Prioritisation of traffic through network performance management
  - Dynamic management of delay-sensitive traffic (e.g., emergency services) vs. delay-independent traffic (e.g. database updates, tourist info, etc.)
- Reduced provisioning costs and per-user costs

Institute for Telecommunications Research (ITR) Overview

- One of Australia's foremost research organisations specialising in technology for digital wireless communications
- Part of the University of South Australia
  - Located at the Mawson Lakes Campus, 14km north of Adelaide (www.itr.unisa.edu.au)
- Core partner of the CRC for satellite systems
- 80 personnel
  - Split between research/academic staff and postgrad students

- Customers:
  - Intelsat (US), Inmarsat (UK), Telstra, Optus, Nortel, Ericsson, DSTO, …

ITR Research & Development

Institute for Telecommunications Research

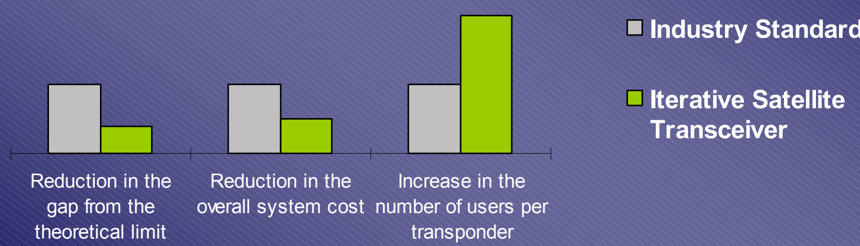
- Systems & Multiple Access
- Source and Channel Coding, and Information Theory
- Telecommunications Networks and Services
- Digital Modems
- Digital Implementation (DSP, FPGA VHDL, ASIC) & Software Engineering
- Radio Frequency Systems & Measurements
- Project and Quality Management

IST: Iterative Satellite Transceiver

- Satellite communications modem/codec achieving close to theoretical performance
  - Up to 45 Mbps
  - QPSK, 8PSK, 16QAM
  - BER < 10-10
  - IP/voice/data
  - Close to channel capacity
  - Available in early 2003
- www.itr.unisa.edu.au/~adrian/tc.html

IST vs. Competition

- Significant performance improvements over current satellite standards



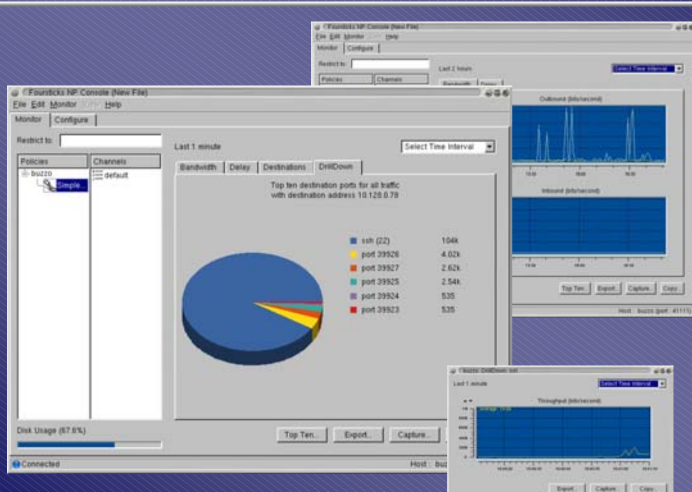
Foursticks Overview

- Network Performance (NP) software company
  - Vision: To build NP technologies that will enable IP-based networks to live up to the promise of becoming ubiquitous
- Fastest growing technology company in SA
  - Founded in 2000, growing to 50 employees in 2002
  - Office in Singapore
  - Well funded by US & Australian investors, including UniSA subsidiary ITEK
- Five patents pending
- Channel business model
  - OEM, integrators
  - Network service providers, managed services
  - Network device makers
- Customers
  - BRL Hardy, Bridgestone, Santos, SA DECS, …

Foursticks NP

- Policy-based network performance enhancement
- Optimize network performance to match business/community needs
- NP Console: Simple and effective management
  - Real-time network monitoring
  - Real-time policy enforcement and control
  - Compiled policies
  - Extremely low-overhead monitoring
  - Management reporting
- NP Engine: High performance QoS engine
  - Dynamic bandwidth management
  - Guaranteed maximum packet latencies, including UDP
  - Doesn’t touch TCP window sizes
  - Extensible and scalable

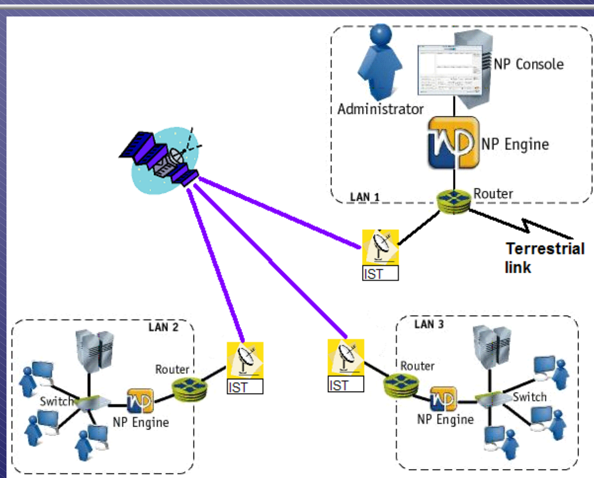
Foursticks NP Console



Foursticks NP vs. Competition

	Foursticks NP	Router	Bandwidth Manager
Bandwidth management	✓	✓	✓
Latency management	✓	✓?	X
Simple to install & use	✓	X	X
Policy verification	✓	X	X
Real-time monitoring	✓	X	X
Open systems platform	✓	X	X
3rd-party extensible	✓	X	X

Putting it Together: IST + NP

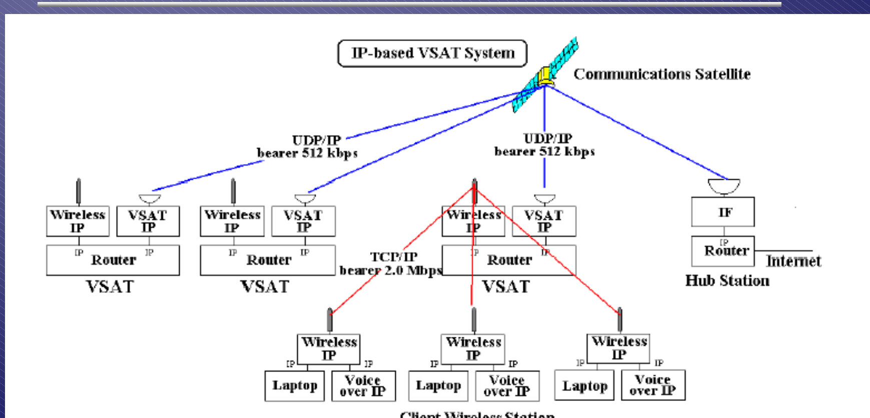


Case Study 1: Oodnadatta, SA

- Population: 200
- Not connected by fiber
- 20 private VSATs for residential users each equipped with their own satellite connection
- 1 VSAT for the School
- 1 VSAT for the Medical Centre
- 1 VSAT for the Community Centre
- ➡ Could all be provisioned by one RAP installation at a fraction of the cost

RAP: the Rural Access Point for Remote-Area Communications

Case Study 2: Telemedicine WLAN



Reference: www.itu.int/ITU-D/fg7/pdf/hagajima.pdf

RAP Current Status

IST

- All core technologies have been tested
- Commercially available in late 2003

Foursticks NP

- Version 1.0 shipping since September 2002
- Over 30 installations to date

RAP Commercialisation

Technical

- Investigate complementary technologies to reduce link traffic
  - Content management, caching, network attached storage, etc.
- Integrate sub-systems
- Demonstrate fully functional integrated platform by Q4 2003

Business

- IST will be marketed through Foursticks under a technology license from ITR
- Develop strategic partnership with OEM for mass production
- Sell through Foursticks channel partner

RAP Commercialisation (cont.)

Financial

- Requires initial funding for market research and traffic modelling of specific cases
- Fully functional integrated prototype is internally funded
- Secure full-scale commercialisation funding in Q4 2003

Rural Access Point (RAP)

Cost-effective communications for remote areas

- Aggregation of community traffic via a single access point
- Targeted markets: Australia, China, S-E Asia
- Most advanced network performance management available by *Foursticks NP*
- Most power/bandwidth efficient transmission available over satellite links by *IST*