TELEDYNE PARADISE DATACOM, Ltd.
A Teledyne Technologies Company

PARADISE DATACOM APPLICATION NOTE

OPTIMIZING CELLULAR SATELLITE BACKHAUL

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INTRODUCTION

It is well known that cellular operators are experiencing an unprecedented surge in demand for mobile data, driven by the rising popularity of smart phones. A key question for everyone involved in satellite-based cellular backhaul is: what does the latest satellite technology have to offer by way of a cost-effective solution?

It is a fact that, like terrestrial communications, satellite communications technology has been changing extremely rapidly in recent years, providing a new era of bandwidth-efficient products and features with sophisticated data management capabilities. This new technology has required knowledge and expertise not just in satellite, but in IP and GSM as well. The challenge for satellite equipment manufacturers has been to incorporate this technology into their products and make it simple to use and understand. The challenge for cellular operators is to cost-effectively introduce this technology. This may involve the migration from existing older, inefficient and uncompetitive satellite technology that is ill-equipped to deal with the opportunity and problems created by the extraordinary ongoing increases in consumer demand for data.

Now Paradise Datacom has produced a concise overview of its new GSM-centric satellite technology, answering two fundamental questions: what is it and why do I need it?

EXECUTIVE SUMMARY

Satellite has traditionally been chosen for cellular backhaul to overcome a lack of terrestrial communications infrastructure, to overcome difficult terrain and to roll out bandwidth quickly. However, new developments in satellite technology are changing the economics of deployment and making it a more attractive option for dealing with the unprecedented surge in demand from smart phone users.

This paper, which focuses on IP satellite modem technology, explains:

How you can maximize satellite bandwidth efficiency to reduce opex by up to 80%.

- Satellite bandwidth efficiency can be maximized by using techniques that can collectively reduce bandwidth requirements by over 80% when compared to Paradise satellite modems installed as recently as three years ago. The reduction in operational expenditure means that a return on investment is typically achieved in less than three months.

Provision quality of service end-to-end, including over the satellite portion of the network, to provide differentiated services commanding premium prices.

- Optimizing data management creates a harmonised, fully provisioned end-to-end quality of service covering both terrestrial and satellite portions of the network (as opposed to the satellite portion being just ‘best effort’ as in the past). Guaranteeing the quality of satellite services underwrites end-user service level agreements. Carefully provisioned quality of service also creates a potential strong competitive differentiator, allowing premium services to command premium rates.

  IP has become successful because it is relatively cheap, ubiquitous and scalable but, in itself, this confers no advantage if every other GSM operator is offering the same technology - Paradise recognises that *quality of service* is our customer’s battleground and has made it the primary focus for our development efforts.

How to deal with legacy in order to migrate to IP in a flexible way that recognises the need for services to evolve over time without throwing away past investment.

- Paradise technology ensures seamless and painless migration from traditional TDM (E1/T1) technology to IP. Our Quad E1 technology (with low overhead of 0.39%) allows up to four E1s to be used with Drop and Insert of timeslots. It also allows E1s to be mixed with IP and both transmitted at the same time. It therefore provides a flexible upgrade path from E1 to IP, with no further investment required in hardware or software.

Reduce capex significantly by reducing system box count.

- Paradise has integrated the features of around a dozen standalone pieces of equipment into its satellite modems (such as an oscilloscope, spectrum analyser, data test set, data accelerator, encapsulator, interference detector, etc.). These features are either free or offered at a nominal price and, combined, save up to $300k when compared to buying the equivalent features as standalone equipment.

  Accessing the built-in modem tools by remote control reduces the number (and cost) of maintenance trips engineers need to make to remote locations. Even more importantly, the rapid diagnosis that the tools make possible, serves to minimise link degradation and outages, stemming the loss of revenue that would otherwise occur.

MAXIMIZING SATELLITE BANDWIDTH EFFICIENCY

Satellite bandwidth efficiency can be maximized by using techniques that can collectively reduce bandwidth requirements by over 80% when compared to a satellite link installed as recently as three years ago. The reduction in operational expenditure means that a return on investment is typically achieved in less than three months.

Among the techniques that can be used on Paradise modems are the following.

Adaptive Coding and Modulation (ACM)

ACM converts otherwise unused link margin into additional IP throughput. It works by dynamically varying the modulation and FEC rate to provide only the level of error protection that is required for the prevailing atmospheric conditions at the receiver.

The throughput benefit is achieved in two ways: 1) converting some of the overhead introduced by the error correction into user data (i.e. using a more efficient FEC rate such as ¾, which is 50% more spectrally efficient than using rate ½); 2) using a higher order modulation where each symbol represents more bits of information (e.g. moving from QPSK at two bits per symbol to 8PSK at three bits per symbol, which is 50% more spectrally efficient).

Systems deploying ACM have reported throughput increases of up to 100%.

IP Payload Compression

It is possible to compress the payload of IP packets to typically 50% of their size, resulting in a doubling of data throughput.

IP Header Compression

IP packets have considerable amounts of overhead in their packet headers.

As an example, a G.729 VOIP packet (containing Ethernet, IP, UDP and RTP headers) with a 20ms voice sample in the payload, can be compressed by over 60%, more than doubling throughput.

Paired Carrier

Using ViaSat's patented PCMA technology, *Paired Carrier* can reduce the overall required satellite bandwidth by up to 50% by overlaying Tx and Rx carriers in the same space segment, doubling throughput for a given bandwidth.

FastLink Low-latency LDPC

FastLink is an efficient LDPC forward error correction (FEC) technology that improves on the BER performance of TPC by around 1dB on average. This benefit can be taken as either a power reduction or an increase in throughput by using a spectrally more efficient FEC rate and/or modulation.

TCP Acceleration

Under some circumstances it is possible for GSM satellite links to benefit from TCP acceleration, which overcomes the problems of TCP data slow ramp-up and congestion avoidance, which together can limit throughput to a very small fraction of what the link is capable of. For a 2Mbps link, throughput can be increased by a factor of up to 16, with the link running to over 90% of theoretical capacity.

OPTIMIZING DATA MANAGEMENT

Data management can be used to create end-to-end quality of service covering both terrestrial and satellite portions of the network.

Among the techniques that can be used on Paradise modems are the following.

Traffic Shaping

Traffic shaping assigns each packet to a distinct stream and then provides a guaranteed throughput level for each. It also provides a maximum throughput level for each stream for when excess bandwidth becomes available. A priority setting determines the order in which competing streams get any excess bandwidth. It also determines which packets in the queue for transmission get sent first (thereby reducing jitter for priority traffic). Packets can be identified as belonging to particular streams using many different techniques, including *diffserv* and IEEE 802.1p priority tags.

VLAN Tagging

VLAN tagging is a powerful method for identifying different data streams allowing each to be processed according to its needs. It is particularly useful for filtering out unwanted data at remotes.

Routing

Routing makes a forwarding decision for each packet, thereby restricting access to satellite to only those packets that need to go over satellite, thereby conserving valuable bandwidth.

DEALING WITH LEGACY

Migration from E1 technology to IP is possible using Paradise Quad E1 technology (with low overhead of 0.39%). This allows up to four fractional E1s to be mixed with IP and both transmitted at the same time. It therefore provides a flexible upgrade path from E1 to IP, with no further investment required in hardware or software.

REDUCING CAPEX

Using the built-in tools within Paradise satellite modems saves on the cost of standalone equipment such as spectrum analysers. Paradise was first in the industry to introduce these tools and still has a commanding lead in the market.

Paradise's latest tool is LinkGuard™, our patent-pending technology for detecting in-band interference underneath satellite carriers.

LinkGuard™ allows the rapid diagnosis of 'signal under carrier' type of interference while remaining on traffic. A visual indication of any unwanted interference is provided through a signal-under-carrier spectrum web graph (see Figure 1) showing the wanted carrier along with any unwanted interference. The graph includes a 'persistence' mode to show even intermittent interference such as that caused by Wi-MAX.

LinkGuard™ takes detection one stage further by providing a user-set power spectral density threshold, above which the modem will automatically alarm to indicate that a significant source of interference has been detected. The alarm information is accessible remotely thereby providing automated 24x7 interference detection without the need for an operator to be present.

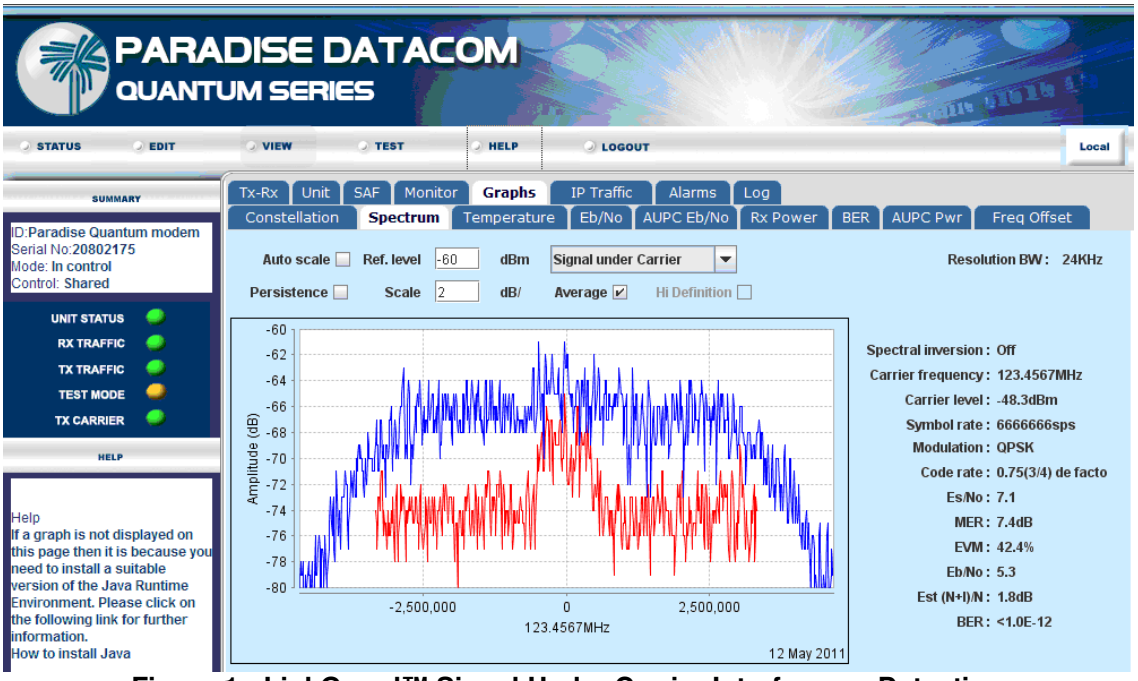

Figure 1 - LinkGuard™ Signal Under Carrier Interference Detection

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