WHITE PAPER

Cellular Backhaul over Satellite

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Executive Summary

Even in challenging economic times, mobile operators face intense pressure to expand networks and win new subscribers. With most urban areas having high penetration rates and fierce competition many operators are beginning to build their networks outward and expand service in rural and remote areas to capture new opportunities.

While expanding into new areas has many positives for the operator it presents challenges as these regions are less accessible, have smaller populations and generate less revenue with higher operating costs.

For years this has limited the profitable expansion of mobile networks in these regions. The costs of terrestrial infrastructure like fibre and microwave were prohibitive and traditional satellite connectivity was the only option even if it was expensive and inefficient. Today, with the boom in Internet Protocol (IP) technology combined with new developments in satellite backhaul and mobile network infrastructure there has been a positive change in the economics for expanding networks into rural and remote regions.

For satellite backhaul, IP-TDMA has proven to be particularly useful in situations where traditional satellite technologies were neither cost nor bandwidth efficient. TDMA backhaul is giving mobile operators a tool to cost effectively reach new subscribers, expand coverage and maintain organic growth beyond urban areas.

This paper looks at the strategies of operators in rural and remote areas, available backhaul technologies and how these technologies are enabling profitable networks to be deployed in underserved areas. The appendix presents four case studies from mobile operators that have utilised satellite backhaul to connect remote areas and generate new revenue opportunities. Findings from our research indicate that TDMA is increasingly being considered for cost savings compared with SCPC, at a time when operators are evolving their core networks to all-IP.

Section A: Operator strategies

The expansion of mobile connectivity

It took nearly 15 years for 25 percent of the human race to subscribe to mobile services; the second 25 percent subscribed in four years. While over four billion mobile connections are currently in service, six billion users are forecast by 2013. The race to connect these new subscribers is driving a wave of mobile expansion around the world.

The first phases of mobile expansion were seen across affluent regions of the globe, including North America and Europe. Today, the majority of new mobile subscribers come predominantly from emerging markets where demand for connectivity is the greatest based on lack of access to legacy fixed infrastructure. For many users across much of Asia and Africa mobile telephony is their first access to communications.

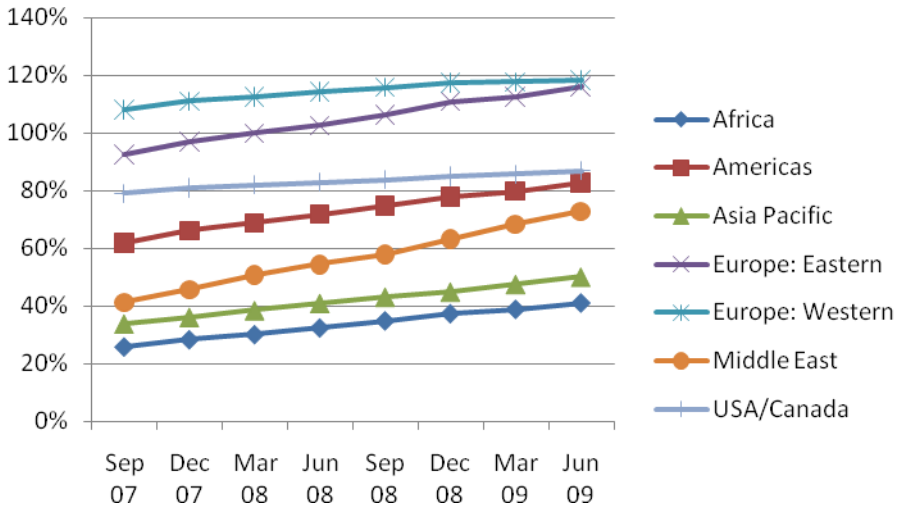
So vibrant are these markets that operators from saturated North America and Europe have started taking an interest. Vodafone Group, Telenor, France Telecom-Orange and NTT Docomo have all taken significant stakes in African and Asian operators and MTS, VimpelCom and TeliaSonera have moved into Central Asia.

Regions of network expansion

Emerging markets have therefore become the new battle ground for operators in pursuit of ambitious and continued growth. Asia, Africa and Latin America are providing the most promising opportunities for expansion.

India added 114 million cellular subscribers during 2008 while China Mobile, the world's largest operator, added 30.8 million subscribers in the first five months of 2009 alone. China's three telecom operators – China Mobile, China Telecom and China Unicom – have already reported the largest network investments in the world this year. Similarly, mobile phones provide the majority - around 90% - of all telecommunications in Africa and today, despite several countries reaching 100% penetration and rapid network expansion, Informa estimates mobile penetration in Africa to be as low as 40%.

Figure 1: Global mobile subscriber penetration



Source: Informa Telecoms & Media

Remote and Rural network expansion

Traditionally, most networks rolled out in emerging markets concentrated around moneyed minorities in urban areas. Today, networks extend way beyond cities and reach further into less populated areas to capture new subscribers. Networks are now extending to two markedly different regions: remote and rural areas.

Remote areas may have higher or fairly high population densities but are difficult to access because of the terrain. Many remote areas can only be reached across deserts, mountains, seas or wetlands, where deploying terrestrial-based technologies can be extremely difficult. There are many examples of such remote areas, from island archipelagos and mountain communities to refugee camps with tens of thousands of inhabitants.

Rural Areas tend to have much lower population densities. They typically consist of hundreds rather than thousands of people, living in villages or hamlets that can also be tens or hundreds of kilometres apart.

The benefits and opportunities of rural and remote expansion

Both remote and rural areas present a huge opportunity for mobile operators. First, an enormous number of people – about 40 to 50 percent of the world's population - live in rural and remote areas and many have limited access to basic communications according to the International Telecommunications Union (ITU). In many countries people living in remote and rural areas outnumber those living in urban settings. In India, where only 30% of the population lives in cities, rural teledensity (number of telephones per hundred people) was just 12.59 by the end of 2008.

Operators are seeing several other key benefits and opportunities for expanding into rural and remote areas including:

Winning/maintaining customer loyalty: Expanding networks to rural areas is not just about winning new customers. Many existing customers live in urban areas, but have dependants, relatives and ancestral homes in rural areas. Not only do new customers in rural areas want to be able to contact migrant workers in cities, but the regular stream of subscribers returning home for extended periods of time require connectivity. That's why many operators are increasingly deploying services in rural or remote areas; they need to prevent existing customers from churning to competitors that might have rolled out networks in home villages.

Social and economic benefits: Today, the customers targeted in emerging markets are predominantly lower income per-capita customers, especially when compared to the wealthy nations that have made up the bulk of the world's first 3 billion mobile subscribers. Emerging economies have grown as a direct result of mobile telephony as the use of the technology has increased access to information, expanded education and improved social connections.

New products and services: Innovative mobile operators are attempting to increase the ARPU and stickiness of existing subscribers by providing more services that are absent in remote or rural areas such as access to market information, health and some financial services. The untapped wealth of these areas is often underestimated too. Surprisingly India's rural population contributes 56% to the country's income, 64% of its expenditure and 33% of its savings. That's why mobile payment and banking services are also revolutionising Africa's banking sector where only a tiny minority of the population has previously had bank accounts.

Section B: Backhaul network infrastructure

Introduction

A mobile transmission network consists of three main infrastructure components that connect a wireless device to the core wireless network which in turn interconnects with, and provides access to other mobile networks, fixed voice/PSTN networks and the internet:

At the edge of the network you have base transceiver stations (BTS) that contain the antenna and transceivers (TRXs) that transmit and receive radio signals from phones and other devices on the ground.

The BTS are controlled by base station controllers (BSC) which are high-capacity switches that determine call handover, cell configuration data, and radio frequency (RF) power levels for the BTS.

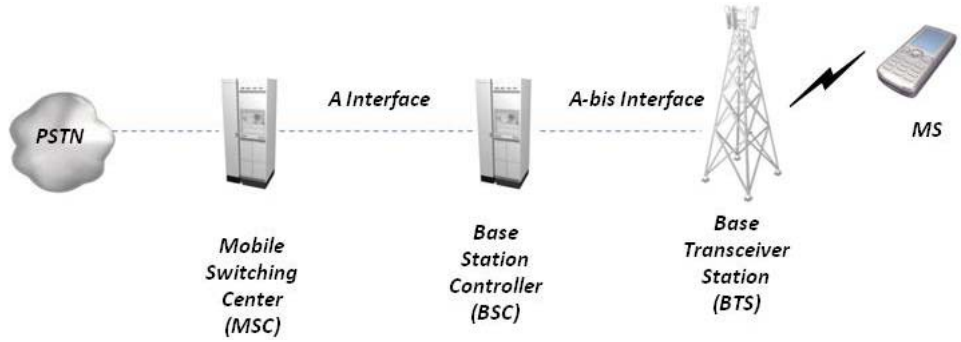
The mobile switching centre (MSC) is at the core of the network and runs the back office subsystems and connects the wireless network with the other networks or the PSTN.

In a typical network there are usually a few MSCs, multiple BSCs and many BTSs. Satellite can be used to support the interfaces between any of these network elements, but in general when the term satellite backhaul is used it refers to the link between the BTS and the BSC, known as the Abis Interface. The number of BTS locations and the volume of traffic carried over this interface make it the most common one implemented over satellite.

Traditional Backhaul Technologies

For years mobile operators have used a range of backhaul technologies. Mobile backhaul networks supporting mobile base station equipment have been deployed using TDM, a basic static transmission protocol; and for higher bandwidth 2.5G and early 3G networks with ATM-based core networks. Connections still deliver TDM connectivity as E1s or T1s (the US equivalent of E1s) at the remote base stations and base station controller nodes. E1 circuits are deployed in blocks of 2.048Mbps and T1 in units of 1.544Mbps.

Figure 2: A traditional backhaul network



Source: iDirect

Traditional TDM circuits, including T1 and E1 are the predominant backhaul access technologies used today. They can be delivered via fixed-line and wireless technologies.

Fixed-line backhaul technologies

Copper: Traditionally, E1/T1 lines were deployed in copper cabling throughout towns and cities in Europe and the United States. Lines are leased and therefore have the advantage of no upfront installation costs – apart from a set-up fee. The leasing costs are usually distance-dependent. A downside of such a technology is that as capacity on the network increases, operators are forced to use multiple leased lines to connect base station sites. That increases the backhaul cost linearly and means the cost of backhaul can rise considerably. Still, around 90% of cell sites in the US are fixed-line because mobile operators have traditionally received favourable rates to rent backhaul from their fixed-line sister companies.

Fibre: With the potential for supporting high-capacity links fibre is a great backhaul technology, especially to cope with growing mobile data usage. However, it is prohibitively expensive to install because such extensive civil works are required to lay networks; roads must be dug up and

rights of way purchased. For example, an OC-3-leased fibre of 155Mbps, can cost up to US$7500 per month, and almost the same to provision.

Wireless backhaul technologies

In many areas of the world, particularly emerging markets, fixed infrastructure is limited to urban areas and is often of poor quality, so wireless technologies predominate.

Microwave: This technology operates in frequency bands from 2 to 40 GHz. Several microwave systems operate in 2, 4 and 5 GHz bands while higher frequency systems are also used (6, 11, 15, 18, 23 GHz and above) but only where there is a clear line of sight between the two connecting points.

A typical microwave backhaul link can be used for distances up to 60 km and operators can add more radios to increase the capacity at any one site. Therefore, operators can scale according to capacity requirements, making microwave a very flexible and cost efficient backhaul technology.

Microwave connects up to 60% of the world's mobile base stations as greenfield operators roll out new networks in areas without any previous infrastructure. Even in areas where extensive copper exists, such as Europe, backhaul is usually a mixture of microwave where possible and leased lines as a reserve technology. That is because the favourable rates for leased lines seen in the US are not as common elsewhere.

Satellite: In many areas where terrestrial infrastructure is limited satellite becomes the primary option for transporting voice and data services. Connectivity relies on communications satellites that receive radio waves from one location and transmits them to another location using a transponder. On average, a transponder can carry around 5,000 simultaneous voice or data channels and typical satellites used for cellular backhaul have between 24 and 32 transponders.

A host of satellite companies manage and maintain satellite capacity over Africa, Asia and South America. They usually sell capacity to satellite service providers, which resell a packaged service to mobile operators. The satellite segment is usually sold to the satellite service provider in transponder units, where a full transponder is equivalent to 36 MHz and a 2.048 Mbit/s E1 using legacy SCPC equipment uses about 3.7MHz.

On the ground, there is infrastructure that links the satellite with the mobile network. It consists of a Very Small Aperture Terminal (VSAT) comprising of a remote router or SCPC modem, with a small (1.2m to 3.8m diameter typically) dish that links the base station with the satellite. On the other side of the satellite connection at the BSC site there will either be a stack of corresponding SCPC modems (one for each remote) or in the case of TDMA, a shared central earth station, called a hub, that manages and switches satellite resources, and directs signals from the BTS, via satellite to the BSC.

VSATs and hubs are not only used for backhaul. They can provide trunk links that connect international voice switching centres and ISPs to the Internet backbone.

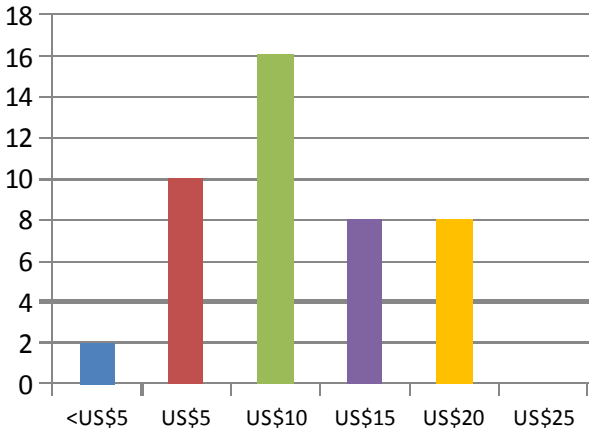
The use of VSAT technology has mushroomed in recent years to support a number of different markets and applications. Between 2002 and 2006, the VSAT market, particularly in the Middle East and Africa, experienced exponential growth. While corporate and development agencies increasingly operate remote networks based on VSATs, the key reason for the blistering growth in the use of this technology has been mobile backhaul.

Section C: Building the business case for cellular backhaul over satellite

Building a business case for cellular-based backhaul has traditionally been quite difficult as the high cost of satellite capacity has prevented a more widespread adoption of satellite backhaul solutions. With fibre in short supply and demand for internet access expanding satellite capacity has continued to increase in cost, especially in regions with limited supply. Today, capacity can be as much as $5,000 per megahertz – or well over US$15,000 for an E1-equivalent. However, the value of satellite backhaul is tremendous in several cases where terrestrial backhaul cannot be used. In these cases, price is not a deterrent as revenues can quickly outbalance costs. Moreover, advances in satellite infrastructure and services by leading vendors are providing more cost efficient solutions for mobile operators.

The limited revenue potential and lower Average Revenue per User (ARPU) for subscribers in remote areas have made operators believe that they cannot support a satellite backhaul solution. The result is that many operators believe that satellite can only support premium users and areas where high spending customers reside, such as popular tourist destinations for roaming. Informa's satellite backhaul survey revealed that 36% of operators believe satellite backhaul is so expensive that users must have an average monthly ARPU of US$10 or more to support connections.

Figure 3: What average monthly ARPU would you consider to be the minimum to make satellite backhaul cost efficient in remote/rural areas?



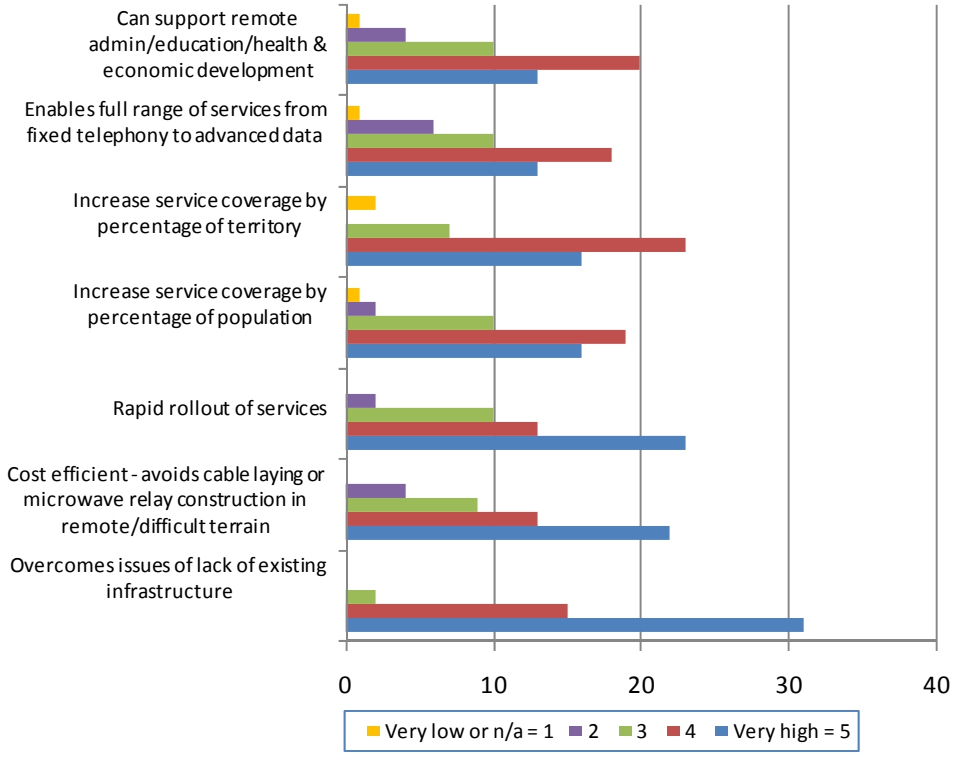
Source: Informa Telecoms & Media – Mobile satellite backhaul survey 2009

Some operators have even decided to run some sites at a loss, believing that the benefits of a ubiquitous brand throughout the country far outweigh the cost of satellite backhaul. Operators questioned by Informa also report that in some cases, satellite-based technologies can be more difficult to deploy compared to terrestrial technologies, as engineering personnel are more familiar with the latter.

Benefits of cellular backhaul over satellite

In contrast, other mobile operators who have deployed cellular backhaul over satellite have done so because they have built up a business case for the technology. Figure 4 highlights results from our recent mobile backhaul survey that asked operators to prioritize the reasons they would use satellite backhaul.

Figure 4: What specific benefits can satellite backhaul offer for remote/rural regions?



Source: Informa Telecoms & Media – Mobile satellite backhaul survey 2009

The survey reveals that the primary reason operators use satellite backhaul is to overcome a lack of existing infrastructure. Not only communications networks such as fibre or microwave, but often power and transport networks are limited as well. Over and above the technological reasons why terrestrial infrastructure like microwave is challenging to deploy, it is thoroughly impractical from a business standpoint. Microwave signals travel in straight lines so are blocked by hills and limited in range by the horizon. This means several hops may be necessary to link

very remote communities. That means operators must deploy multiple microwave towers as well as supply fuel to power the radios on each hop.

Without power, mobile operators need to arrange alternative power for these locations, and then ensure there is enough security so electricity generators and the fuel are not stolen. RF equipment also requires regular maintenance because if one hop fails, all those beyond it fail too. These considerations add to an already hefty operational expenditure (See case study of the Nigerian operator at the end of this white paper) and have deterred several operators from deploying microwave.

The second most important reason that mobile operators embraced cellular backhaul over satellite is to overcome difficult terrain. Terrestrial networks are impossible to deploy when the users are located on Islands or beyond mountains, lakes, marshes and deserts. In contrast, satellite enables mobile operators to deploy a VSAT at the location of the BTS in a village or city, and then bypass the challenging geography using satellite, which links to a hub that is closer to the main network, as seen in the case study from the operator in Chile.

The third most important priority for mobile operators in our survey was the ability to roll out networks rapidly. Many operators are rolling out networks to capture new subscribers before their competitors. Satellite has the ability to be quickly deployed and does not require a major investment in the construction of infrastructure to begin operations.

The ability to roll out networks quickly using satellite can become a strategic tool for an operator as a way to gauge exactly how profitable a particular area might be. It is often hard to predict the precise traffic levels that a new site may produce and predictions are regularly incorrect. Satellite backhaul is being used to test where the network should grow. It is used to build a business case to expand networks into areas that might become unexpected cash cows for operators. Sometimes the effects are so great it can even be worth building a road, supplying fuel and providing security to carry greater traffic throughput.

Section D: Building the case for TDMA-based cellular backhaul over satellite

Satellite technology has been available for many years, but deploying and managing a satellite solution for many operators has been cost prohibitive. Bandwidth is expensive and earning a return on investment is difficult as most operators are looking to deploy satellite technology in remote areas where the volume of subscribers can't compare to densely populated urban areas. However, satellite technology that is based on IP is changing the economics of deploying such connections.

As we take a more in depth look at satellite technology there are two main types of networks that are used. SCPC and TDMA offer different types of connectivity options for mobile carriers and both of them have their strengths and can help in the backhauling of mobile traffic.

SCPC: Traditional VSAT equipment is based on Single Channel Per Carrier (SCPC), using dedicated links that offer individual operators a set amount of bandwidth at all times. By its nature, SCPC supports only one transmission (BTS) per satellite channel, requiring links to be engineered to support the peak-time bandwidth usage, essentially being an E1 replacement. SCPC is easily sold to transmission engineers since it provides a simple migration to satellite from TDM circuits, but is often several times more expensive than competing technologies, making it a more difficult sale to finance departments or executives making strategic decisions.

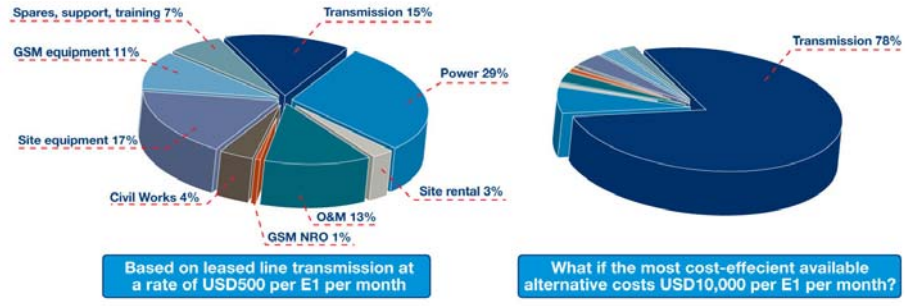
TDMA: A new class of equipment has come out of the enterprise world: IP-based Time Division Multiple Access (TDMA) based equipment. In contrast to SCPC this type of network allows a number of base stations to share capacity from a pool of bandwidth. Each base station is allocated a number of time slots from the pool in accordance with its real-time bandwidth demands, which dramatically reduces bandwidth usage, thereby lowering costs.

Balancing the TCO

Both SCPC and TDMA have advantages and disadvantages. However, while dedicated link capacity makes SCPC a compelling technology for trunking and higher capacity links, it has inherent disadvantages in specific situations: large numbers of disparate base stations with lower capacity and base stations with variable traffic patterns. In other words, SCPC becomes less economical as the number of base stations deployed increase and smaller amounts of traffic from each location are carried.

Dedicated links can be inefficient when base stations have variable usage patterns because mobile operators will pay for a peak bandwidth usage, regardless of whether base stations are using that capacity most of the time. In a worst-case scenario, satellite transmission can absorb almost 78% of TCO compared to 15% in urban E1 deployments. TDMA backhaul, in contrast, will enable a link to be shared amongst a number of base stations so that efficiency in capacity utilisation is maximised. Satellite capacity is dynamically allocated, meaning that backhaul links that are subject to high traffic are allocated more capacity on demand.

Figure 5: Typical TCO for a GSM RAN based on data from Middle East & Africa



Source: Ericsson

Table 1: TDMA and SCPC comparison

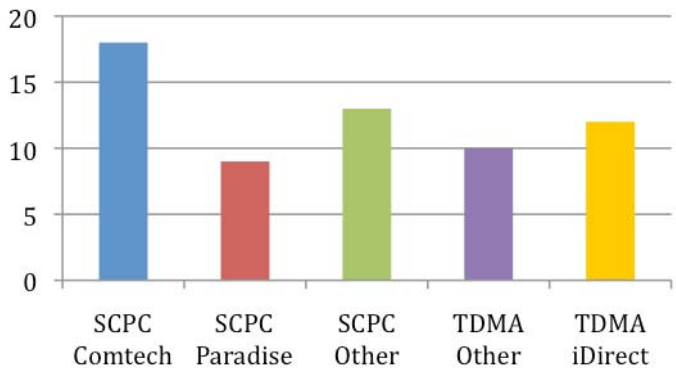
	TDMA	SCPC
Pros	• Very efficient and can reduce the cost of satellite capacity for base stations with low traffic • Significant space segment savings over an SCPC solution without sacrificing quality. • Quick payback on equipment • Simple and economical network expansion • More channels can be added without any remote hardware change • Remote sites easy to install	• Dedicated links are hassle-free but require re-planning every few weeks to optimise bandwidth usage. • Great for large base stations in remote areas with large populations, such as refugee camps.
Cons	• TDMA is complex but networks through IP which can be easily integrated with existing and off-the-shelf infrastructure • Remote sites are easy to install, but hubs may be more complex to set up	• Very inefficient and expensive way to allocate capacity for much smaller sites • Has prohibited a wider rollout of satellite technologies • To ensure more efficiency, CAPEX on antennae and modems is higher than TDMA.

Source: Informa Telecoms & Media

The market for TDMA versus SCPC

IP-based VSAT is growing rapidly for backhaul. Informa's survey shows that today mobile operators are choosing a mixture of technologies, with TDMA-based infrastructure accounting for the majority of growth in the coming years. Moreover, TDMA is increasingly being used in developing markets where SCPC is not a viable solution for distributed cell sites. The following figure illustrates Informa's survey results for satellite backhaul technologies being used globally.

Figure 6: Which type of satellite technology do you use?



Source: Informa Telecoms & Media – Mobile satellite backhaul survey 2009

Although SCPC is mostly deployed in developing areas, many of these legacy deployments have been using satellite for several years. TDMA is a newer technology which has gained traction in the market over recent years and is growing rapidly, outpacing SCPC growth. This is also accentuated by the move towards all-IP networks for cost efficiency and better integration, since IP-TDMA integrates seamlessly with IP hardware, offering a more cost efficient integration that can be scaled according to requirements. On the other hand, traditional TDM and SCPC infrastructure has to be customised before integrating effectively with IP based network infrastructure, potentially becoming a cost driver and increasing time to market.

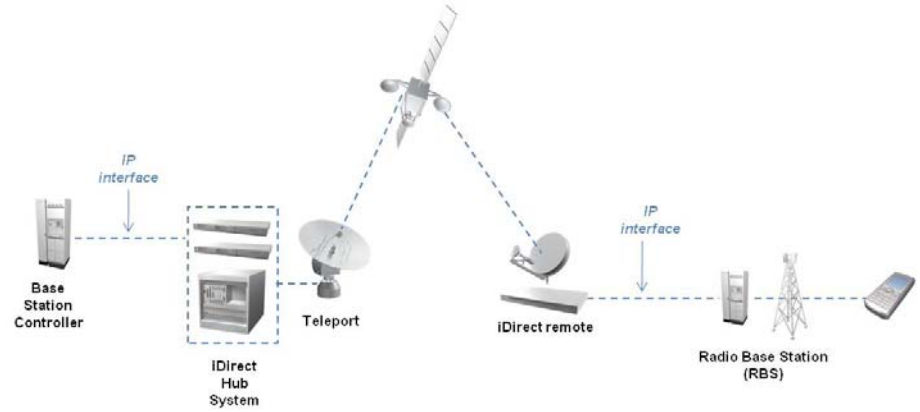
Section E: Innovations in IP-based cellular infrastructure

Backhaul is migrating to IP as older ATM and TDM-based technologies are becoming increasingly uneconomical as mobile broadband increases worldwide. Ethernet, which is optimized for packet data traffic and can be transported over a multitude of transport media – from fibre to microwave – is expected to accelerate as next generation mobile equipment and networks migrate to all-IP packet based technologies. The IP/Ethernet portion of worldwide mobile backhaul equipment revenue is set to skyrocket. Ethernet microwave connections accounted for 27% of all new connections in 2007, 43% in 2008, and ramping quickly over the next few years.

Satellite-based infrastructure is no exception. IP-based satellite backhaul for remote and rural areas is being considered by operators in emerging markets as a way to reduce costs while offering new opportunities for organic growth past the already penetrated urban areas. It is especially attractive to operators that are considering or have already deployed IP-based core infrastructure because it can integrate directly with existing infrastructure.

The benefit of IP can be extended to the radio network as well as TDMA backhaul. A majority of the mobile infrastructure vendors including Ericsson, Huawei and ZTE have devised innovative IP-based infrastructure that seamlessly connect to an IP based satellite solution helping to reduce costs through many of the optimization techniques available on IP based networks. Mobile operators are deploying IP-based interfaces between base stations, base station controllers, and MSCs - the Abis and A-interface connections. Deploying IP reduces bandwidth costs by up to 40% and avoids converting IP-based traffic back into TDM using mediation devices. Optimizing the Abis over IP interface in particular, helps eliminate the traffic sent during idle or silent moments during phone calls.

Figure 7: IP-TDMA satellite backhaul network



Source: iDirect

In addition to all-IP and TDMA, there are several technologies and trends that are affecting rural cellular rollouts.

BTSs designed for rural and remote areas: Not only do they include native IP but satellite modems are built right into the BTS. Many also contain fewer TRXs than those traditionally deployed in cities. Smaller TRX counts reduce the power consumption making alternative power sources such as solar more viable. Some vendors are even innovating ways to "rest" TRXs at certain times, to reduce power consumption further.

Local switching: Traditionally all calls, no matter how close callers and recipients are to each other, have been routed through the satellite. In some areas almost 70% of calls are of this nature. Local switching technologies enable calls between subscribers in relatively close proximity to bypass the satellite and reduce the demand for satellite capacity. Ericsson estimates that a combination of IP interfaces and local switching will increase the number of base stations that can be supported by a single transponder by over five times.

Radio techniques: A range of wireless techniques can improve both SCPC and TDMA satellite links. Higher order modulation and carrier cancellation techniques can be applied to both TDMA and SCPC and can reduce the MHz of capacity required from satellite operators.

Conclusion

Mobile operators that are expanding into rural and remote areas have a multitude of backhaul technologies at their disposal. But choosing the proper technology and location is essential to developing a profitable service that will support the number of subscribers in these areas.

Satellite-based backhaul has traditionally been viewed as a complex and expensive option for operators and the prohibitively expensive cost of space segment has prevented many from developing networks and trying to expand into ultra-remote or rural areas. But the combination

of intense competition and the advent of IP-based technologies are dramatically changing the business case for developing sites in such areas. A combination of factors including smaller base stations with lower power consumption, alternative energy sources, local switching, IP-based network infrastructure and TDMA based satellite technology for the flexible provisioning of shared bandwidth is dramatically reducing the cost of expanding services in remote and rural areas.

Operators that are able to balance the cost of disparate, low-capacity base stations against the lower ARPUs that are likely from many users in these remote and rural regions should be able to successfully expand their networks and get a return on investment.

But more importantly, there are many opportunities to improve profitability once those base stations have been successfully deployed and service expands. Certainly, connectivity at some sites can generate much more traffic than operators expect as more subscribers sign up and begin to use their mobile phones to improve social networks and income. Operators can also capitalise on the lack of service infrastructure that exists here - such as financial services and healthcare – and even internet access, by developing the types of services that will appeal to users in remote or rural areas. Such potential has been underestimated until now.

Mobile operators can therefore use shared bandwidth and the flexibility of TDMA-based infrastructure to analyse in detail each of the BTS sites and test the viability of developing high-capacity networks in particular, areas without a huge terrestrial CAPEX infrastructure outlay. They can also move sites easily or respond to seasonal changes as traffic increases at a specific site. With the proper deployment and monitoring of a satellite network, mobile operators now have a viable solution that will enable cellular backhaul over satellite to be a profitable solution for reaching remote and rural areas and truly connecting the rest of the world.

Appendix: Mobile operator case studies

This appendix presents a series of case studies for operators that have utilised satellite backhaul to enable profitable business models for remote/rural areas. Although the majority of mobile operators had installed SCPC as the traditional satellite backhaul technology, several of them are transitioning to TDMA for cost savings and many new installations to connect remote areas are utilising TDMA instead of SCPC.

Chile

With over 4500km of mountains and coastline, Chile is the longest and most narrow country in the world. Deploying mobile networks in a varying landscape that consists of volcanic peaks, arid deserts, ancient forests and islands is a challenge for Chilean operators.

Challenge

One operator wants to deploy its network to remote communities in the southern most cities of the country which are so cut-off by mountains they are regarded as islands because the only way to reach them is by sea. There are also thousands of islands off the country. All three major Chilean operators are competing for subscribers in remote regions which are grounds for intense competition. The Tier-1 mobile operator profiled here has reported that it is planning to extend coverage throughout the country.

Solution and results

As a result the operator has begun to deploy satellite-based backhaul connections. Interestingly, it has discovered that users tend to use more bandwidth per person then average usage patterns seen in the rest of the country and has been trialling 2G and 3G services over the technology.

But crucially, cellular backhaul over satellite is now becoming a key revenue stream for the operator. Chile's challenging landscape attracts tourists that want to visit areas off the beaten track, and are willing to spend money on roaming. This operator is now capitalising on remote connectivity in these areas by having the ability to flexibly deploy satellite based technology in the right areas at the right time.

That means deploying satellite connections at Chilean ski resorts in the winter and moving them to beaches during the summer. The operator has even set up a dedicated satellite link on Easter Island, a remote outpost that attracts many foreign tourists.

Indonesia

Indonesia is a country with a vibrant mobile market with 13 wireless operators, a population of over 234 million and mobile penetration of 61%. The country is now a competitive environment for mobile operators and has experienced rapid expansion in mobile networks. The largest network covers over 95% of Indonesia's population and covers all of the country's provinces, regencies and counties - so-called kecamatan - in Sumatra, Java, and Bali/Nusra.

Challenge

Many of the thousands of islands that make up the Indonesian Archipelago – including around 38,500 villages or half the country's villages - have still not been reached by any form of communication system. Instead, mobile communications have been concentrated around metropolitan cities and have become increasingly saturated (half the population is located on Java island).

Unsurprisingly, connectivity is a challenge in a country with 70% of its territory made up of sea. Operators have avoided such areas because the distances are large, terrain difficult and the return on investment potentially quite small.

Solution

There are government initiatives to drive fixed coverage to deploy one phone per village, but one mobile operator is embarking on a project that will bring mobile connectivity to individuals. The project launched in July last year and the operator aims to deploy as many as 13,000 sites in total. The system is a specially designed project to cover hard-to-reach areas cost effectively and is nicknamed, the "Remote Solution System". Although SCPC has been used within the rest of this operator's group before, this project is based on IP-VSAT technology.

The operator has quoted that: "Conventional SCPC links fall short of offering the flexibility to dynamically adjust to changing calling patterns. Cellular providers need a more cost-effective backhaul solution. Today, VSAT TDMA connectivity is literally transforming the landscape of the cellular backhaul market. We expect by implementing this technology it will gain more for us."

The operator plans to use its own infrastructure including a C-Band frequency satellite and a hub that will act as a control centre for the management of remote VSATs. This will be integrated with its existing mission-critical IP MPLS backbone. The operator has introduced several other elements to cut down on costs. It is deploying Pico BTS base stations with just one TRX that can be solar-powered with a battery backup.

Results

According to the operator, since the programme was launched, the growth in traffic has been promising. Around 100 sites were deployed during 2008 and another 5,000 nodes are scheduled for the rest of 2009. The satellite project is proceeding despite the major fibre projects ongoing in the islands. Indeed there is such a demand for satellite in the region that the operator's parent company plans to launch a new satellite in 2011. This satellite will carry 32 C-band transponders and 10 Ku-transponders and has a 15-year-lifetime.

Nigeria

Africa's most populous country is also the largest market on the continent. With its multitude of GSM, CDMA, WiMAX and other operators, competition is intense as operators struggle to roll-out networks fast enough to meet demand.

Challenge

Competition has reached rural northern Nigeria, where communities can be hundreds of kilometres from major city centres or neighbouring communities. Most of these areas are characterised by populations with relatively low incomes, and who primarily use mobile phones for voice services; residents need to be able to ring family members who are working in the cities. There are also a number of remote communities living beyond mountainous regions, that generally live on higher incomes and want to use both voice and data services.

Satellite is an important element of Nigerian telecommunications infrastructure. It is not only used for cellular backhaul, but for backhauling international voice since there is so little terrestrial and submarine fibre. This mobile operator has been operating in northern Nigeria for about eight years. Its company policy has been to provide 100% population coverage and it, therefore, plans to deploy extensively in rural areas.

Solution

First, satellite is used to deploy services to new areas quickly and in advance of the operator's competitors. After a satellite connection has been established, the operator can gradually in-fill those areas with microwave. Once the connection has been completed with microwave, the satellite link is moved to a new area.

Second, permanent satellite connections are deployed in particularly remote areas. Here microwave is prohibitively expensive because it would require infrastructure for up to 50 hops – each of between seven and 30km, depending on the microwave frequency. The decision to deploy such a connection is based on the cost of satellite bandwidth compared with up-front microwave installation costs, and how much microwave or satellite capacity a site may need.

Results

The Nigerian mobile operator was quoted: "Because of the time it will take to put in microwave, it's worth putting up a satellite link to get coverage quickly."

This operator has been able to grow its network quickly, achieving a return on investment of one to two years by using satellite for cellular backhaul in two distinct ways.

Caribbean

Satellite backhaul is a well-used technology in the Caribbean and South America. Here there are remote towns, rural villages, island tourists and residential communities. Some users are so remote that there are few roads, so base stations and other network infrastructure must be delivered by helicopter or small plane on make-shift runways.

Challenge

Microwave is often regarded as unfeasible for many sites in these areas, particularly when they require more than one hop. That's because the cost of installing intermediate sites in areas with no roads, providing power and maintaining the infrastructure can be prohibitive and the potential returns on traffic flows are often unknown.

Solution

One operator with operations across the region has embarked on a major implementation of satellite backhaul to rural and remote sites across four countries. This operator has been deploying satellite backhaul to remote sites over a four year time period, and initially based its installation on SCPC-based VSAT infrastructure. However, in the last year the operator has begun to deploy new sites based on TDMA and is replacing older SCPC sites with this technology. In Honduras and Panama the operator is deploying a multi-node VSAT network based on IP-based VSAT equipment from iDirect.

TDMA has also enabled the operator to migrate to a more IP-based infrastructure to cut costs further. Ericsson base stations are based entirely on IP and reduce the amount of the satellite bandwidth needed. In addition Ericsson's local-switching platforms ensure that local traffic is not tromboned through the satellite and reduces space segment costs further.

The decision to deploy TDMA or SCPC is based on detailed analysis of the traffic at the site to determine the best system, says Globecomm Systems, the specialist systems integrator that has been tasked to install and manage the system. TDMA-based backhaul is usually deployed in areas with variable or low traffic density. And inevitably as the number of users making consecutive calls increases, so does the business case for a dedicated link.

The rule of thumb is that TDMA must be considered for traffic below 50 Erlangs and is the only option below 10 Erlangs. The operator must consider the merits of both because while SCPC may work out cheaper in operational expenditure (OPEX) terms, it might require a greater capital expenditure (CAPEX) in the modems and antenna to achieve a greater efficiency.

To respond quickly to such changes, the operator has recruited Globecomm to closely monitor each of its sites, to ensure there is maximum efficiency and that the right technology is chosen for each location. If a site reports increasing traffic flows, for instance, there are several options that the operator can follow. It can remotely switch from using the bandwidth pool with other TDMA base stations, to a dedicated connection enabled by the same TDMA platform. Alternatively, it may opt to replace the VSAT equipment altogether with dedicated infrastructure. And eventually, if a site becomes highly profitable, the operator may decide that the capital expenditure of a microwave network, and associated infrastructure, is a good investment long-term.

Results

The gradual approach to upgrading from TDMA-based VSAT to microwave can be a benefit for operators, because without such detailed traffic information, it can be difficult to decide where to site intermediate microwave hops. The TDMA network can therefore help establish the data that will ultimately help the operator to make informed long-term network decisions.

And, if the site that has already been deployed with SCPC-based infrastructure, and traffic flows are unsustainable to justify a dedicated link, the operator can opt to swap it for TDMA. The SCPC infrastructure can then be reused elsewhere so infrastructure is not wasted.

The Caribbean deployment is ongoing and will constantly require modification as traffic patterns change. This is the best way to achieve the most cost-effective deployments, but it is complex and requires expertise to manage, says Globecomm.