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Small cells and satellite – Making rural coverage pay

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Getting the industry thinking

Synopsis

In the densely populated urban areas of many markets, mature and emerging, cellular telephony has reached or is nearing saturation. Competition in these metropolitan markets is fierce and mobile operators are now intent on expanding their reach into remote and rural areas in a bid to drive further growth in subscriptions and revenues.

Historically many of these territories have been under-served by both fixed and mobile communications networks—a discrepancy that has caught the attention of national and international regulators and non-governmental development agencies. These groups are keen to see improvements in rural connectivity for the benefits that it brings to citizens and they are adding momentum to operator activities in outlying regions.

Meanwhile in emerging markets where penetration is low overall, service availability is most scarce in remote and rural areas, restricting communication and economic improvement for the communities most in need.

Mobile operators therefore have two compelling reasons—the drive for further growth and the need to help bridge the digital divide—to expand coverage into rural and remote locations.

Unfortunately this is not a straightforward process. Remote locations can often be difficult to access and costly to service. A macro NodeB with a tower high enough to provide wide coverage requires considerable construction work as well as a continuous power source; both of which are difficult to provision away from built-up areas.

This increases the cost for a deployment where operators may already be facing challenges in terms of the site's profitability.

Compounding this is the problem of backhaul; the cell site must be linked back to the rest of the network. Fibre is not always an option for backhaul in dense urban areas, let alone outlying regions, while microwave is limited by distance and factors such as line of sight.

So a solution is required that can keep deployment costs down, restrict the need for extensive civil works, limit the cell site's power requirement and guarantee high quality backhaul connectivity, all in the most remote of locations.

Small cells in combination with satellite backhaul offer just such a solution—one that can make these deployments profitable and yet one that many operators will perhaps not have considered.

Remote and rural: Demand is high

Deployment of mobile networks has, from the industry's outset, begun in densely populated urban areas. It was true with analogue systems and it has been true with every upgrade and improvement through to today's LTE networks. The reason is simple, these areas are centres of wealth and the density of the population affords the operators scale in their deployments.

Service uptake has accelerated dramatically in a relatively short space of time. It took more than 20 years for the first billion mobile subscriptions to be taken up but only a little over three years to add the second billion. Less than two years were needed to add the third billion and 18 months to add the fourth. Growth has more or less levelled out since then and Informa's WCIS Plus puts the global mobile subscriber base at 6.73 billion at June 2013.

This is close to the current world population but by no means does it reflect the true penetration of cellular service. There are some 25 markets—predominantly in Africa and Asia Pacific—where penetration is still less than 50 per cent, for example; the global penetration figure is heavily skewed by saturation in advanced markets.

Informa is predicting that, by the end of 2016 global mobile subscriptions will be nudging eight billion—and a good portion of this future growth will be achieved by connecting end users in remote and rural locations.

MOBILE MARKETS WITH SUB-50 PER CENT PENETRATION AT 1Q13

Market	Penetration at 1Q13 (%)
Burundi	33.58
Central African Republic	25.80
Comoros Islands	47.74
Cook Islands	44.86
Cuba	14.65
Democratic Republic of Congo	30.91
Djibouti	34.66
Eritrea	5.71
Ethiopia	24.63
Federated States of Micronesia	35.80
Madagascar	26.41
Malawi	31.39
Marshall Islands	29.19
Montserrat	45.24
Mozambique	44.48
Myanmar	6.30
Nauru	26.38
Niger	32.28
North Korea	8.20
Papua New Guinea	46.15
Somalia	48.10
South Sudan	26.03
Tonga	42.26
Turkmenistan	47.13
Tuvalu	45.00

Source: Informa Telecoms & Media World Cellular Information Service Plus

The benefits of connectivity

A 10% increase in mobile penetration can bring about a 4.2% increase in productivity in developing markets

Source: Deloitte/GSMA

Operators have traditionally approached remote and rural deployments with caution, wary of both the economic and technical challenges. Today, advances in technology are enabling solutions that address both sets of concerns. This is fortunate indeed, as governments and regulators are concerned with the end goal of connectivity rather than the means of its delivery, in both mature and emerging markets. And they are driving operators to make that connectivity a reality.

In Germany and the UK, two of Europe's most advanced markets, certain LTE licences came with strict coverage obligations designed to improve rural connectivity. Winners of the German digital dividend spectrum were required to deploy in underserved rural areas before they were allowed to build out LTE in the more profitable urban centres.

In developing and emerging markets the correlation between improvements in telecom service availability and improvements in key economic indicators has been well documented—and employed by the ITU, as well as national regulators and development agencies, to highlight the importance of improving remote and rural connectivity.

In a 2005 paper exploring the impact of mobile telephony in Africa published by Vodafone, the authors asserted that a developing country with a ten per cent mobile penetration advantage over its neighbour between 1996 and 2003 would have enjoyed growth in GDP per capita that was 0.59 per cent higher as a result.

In research conducted with Deloitte, the GSMA sought in 2012 to assess the impact of 3G data services in 14 markets, developing and mature, concluding that a doubling of mobile data use would increase GDP per

PENETRATION OF ICT SERVICES BY REGION, ITU 2012 (PER 100 INHABITANTS)

	Fixed telephony	Mobile telephony	Mobile B'band	Fixed B'band	Households	Individuals using the Internet
Africa	1.4	59.8	7.1	0.3	5.3	14.3
Arab States	9.4	101.6	14.3	2.6	29.6	33.7
APAC	13.2	83.1	15.8	6.9	28.6	28.8
CIS	25.9	158.9	36.0	11.3	42.1	46.4
Europe	40.2	123.3	50.5	25.8	74.0	71.2
Americas	28.6	105.3	39.8	16.0	56.0	57.2
Developing world	13.3	84.3	13.3	5.0	24.0	27.5

Source: ITU

capita growth by 0.5 per cent. The study also concluded that a ten per cent increase in mobile penetration brought about a 4.2 per cent increase in productivity in developing markets.

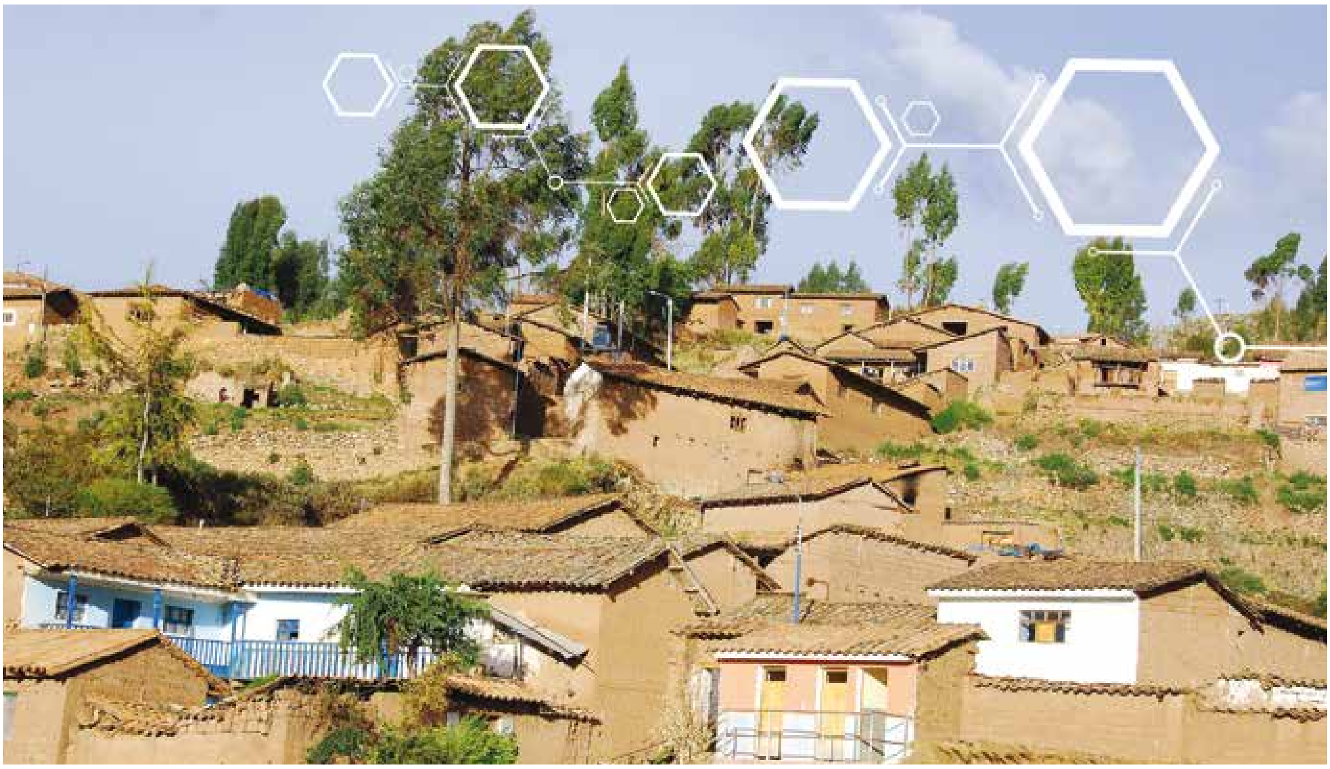
And research is not limited to the mobile industry trying to prove its own worth. The Banco Central de Reserva Del Perú, published a paper in 2012 entitled The Effects of Mobile Phone Infrastructure: Evidence from Rural Peru. The paper's authors charted the effects on Peru's rural population of a dramatic expansion of rural coverage between 2001 and 2007. Summarising their findings, the authors noted:

"The results suggest that coverage has a strong positive impact on cell phone ownership, hosehold wage income, assets and expenditures. The magnitude of these effects are large, with wage income increasing by 57 per cent and total expenditures by 61 per cent… We find evidence that mobile phone coverage increases the income, assets and expenditures of rural customers."

Operators are either being pulled into rural areas by their need to grow revenues or being pushed by state agencies keen to improve the lives of rural dwelling citizens. The question is no longer one of 'if', it is one of 'how', and operators must find ways to overcome the challenges associated with remote deployments—and they must derive a profit.

Wage income in rural Peru increased by 57% as mobile population coverage increased by 15 percentage points between 2001 and 2007

Source: Banco Central de Reserva Del Perú



Understanding the challenges

A November 2010 survey conducted by Informa Telecoms & Media found that cost was felt to be the biggest barrier to operators' expansion of rural coverage, followed by concern over the business case, the absence of an existing power source and security problems.

Responding to a subsequent survey question, in which the costs of rural coverage provision were broken out, 52 per cent of respondents cited the cost of building backhaul as the greatest challenge involved in providing rural connectivity. Just under a third opted for problems with the business model, while just six per cent cited the cost of the base station itself.

Backhaul is chief among operators' economic concerns in these scenarios and one might well ask why. The problem lies in the distances that must be covered. Fiber is the clear leader among backhaul solutions in terms of technical performance but it is not a realistic option for rural areas. The cost of provision for fiber has meant that it is still to be universally deployed for backhaul even in advanced, relatively compact and densely populated metropolitan markets, let alone in the remote and rural regions of emerging markets.

In coastal areas of African markets, the arrival of submarine cables has brought fiber to the shores, says Steve Good, vice president for network services at satellite operator Intelsat, but inland buildouts have been slow and generally unreliable. Fiber cuts, accidental and intentional, have further slowed progress.

The next most popular solution is microwave—but this is not without its own issues in remote areas. Microwave towers are large, and expensive to deploy and maintain. Over long distances operators will need to use multihop microwave and the installation of towers and sourcing reliable power in the intervening locations magnifies these issues.

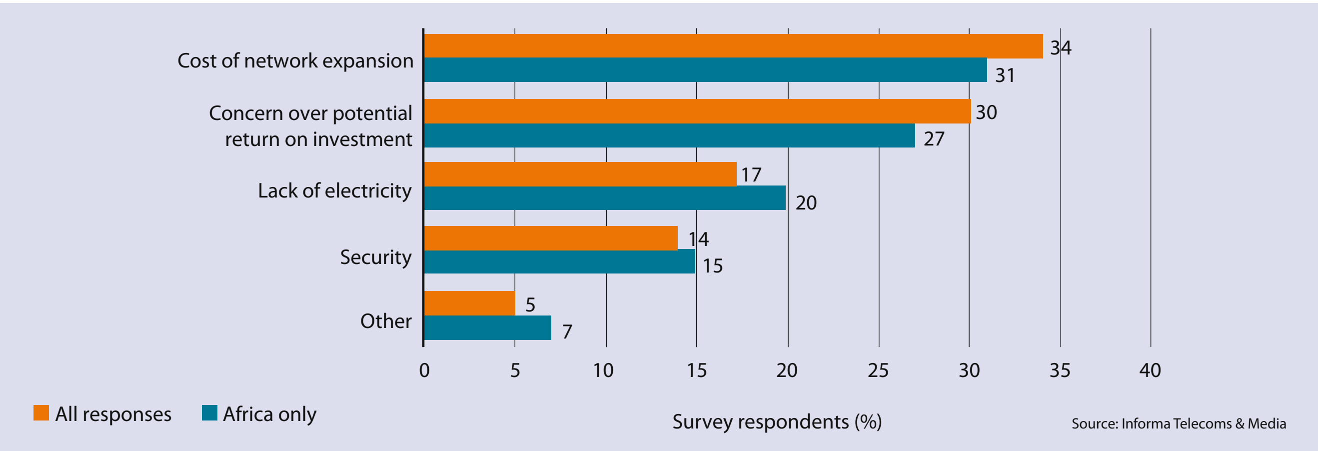
Intelsat's Good reports that mobile operators will generally opt to use microwave in situations where up to three hops are required. Only where four or more hops would be needed have operators tended to find it more economically beneficial to use traditional satellite backhaul; itself a costly option.

Base station costs might not have scored highly in Informa's survey of challenges to rural deployment but the capex outlay involved in deploying a macro cell site is non-trivial. When leading infrastructure vendor Ericsson deployed a cell site in the small riverside town of Belterra in Brazil's Amazon rainforest in 2009 it did so at a cost of $300,000, because the nation's operators did not want to take the risk.

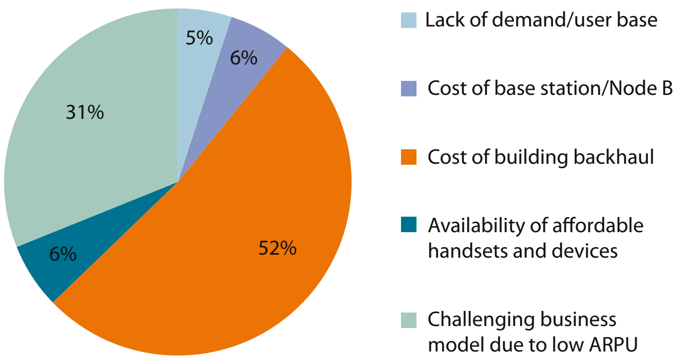
Traffic levels when the site had been connected to the Vivo network and activated led Ericsson to calculate that ROI would have come inside six months had Vivo made the investment itself.

To illustrate the size of the rural connectivity problem in a market like Brazil, Sergio Quiroga da Cunha, who leads Ericsson's operations in Latin America, told Telecoms.com that the country would need to double its existing number of cell sites—which was in the region of 60,000 at the end of 2012—in order to provide coverage to all of its remote and rural citizens.

Q What is the biggest barrier to infrastructure expansion into rural areas?



Q Which of the following do you think represents the greatest challenge in providing rural connectivity?



Source: Informa Telecoms & Media

Expanding coverage on a geographical basis like this requires a full size Node B and a very tall tower that maximises the reach of the site. This in turn requires significant earthworks, concrete and construction activity. Additional facilities are required to house the generator, which in turn needs feeding with fuel on a constant basis. Fuel is a valuable resource in remote and rural areas and generators are often targeted by diesel thieves. So security staff have to be employed and their effectiveness is often unpredictable at best.

If the costs for the Belterra deployment are typical then the investment associated with the kind of expansion that Quiroga da Cunha was talking about would run into many billions of dollars—if Brazilian operators were to use macrocells to provide coverage.

But macrocells are not the only option available to operators looking to provide coverage to remote and rural areas. And fiber, microwave and traditional satellite are not the limit of choice for backhaul.

Small cells backhauled over new, High Throughput Satellite connections that can be dimensioned in real time to meet demand, represent a cost-effective and fresh approach to a well-established and hitherto expensive problem.

OPERATOR'S VIEW

"The main technical challenge we face in terms of rural connectivity is to establish the connection between two very distant localities that cannot be covered by a transmission link. Sometimes we are required to install a relay site in a deserted area, just to interconnect these two communities, unnecessarily increasing network Opex.

Then there is a problem in the supply of building materials; roads are a real obstacle here. There are also difficulties regarding site power supply, because African communities do not all have reliable sources of energy.

Commercially, the rural sites are generally considered sites where costs are offset by urban sites with high potential. Sometimes it can be almost impossible to monetize these rural sites, where often people are unable to read or write. The purchasing power is very low in rural areas, so the ARPU in these areas is very low."

Sub-Saharan African operator

HIGH THROUGHPUT SATELLITES

High Throughput Satellite solutions exploit frequency reuse technologies similar to those used in cellular networks, along with tightly focused spot beams, to derive greatly improved spectral efficiency. Whereas traditional satellite systems use a very wide single beam to cover vast terrestrial areas, HTS systems continuously recycle frequency on the remote side, connecting to a feeder link through a hub infrastructure.

The most advanced satellites that are currently in deployment promise to be able to offer the key benefit of higher data speeds at lower cost. According to Northern Sky Research, High Throughput Satellites will supply at least 2.3Tbps of capacity by 2022, while COMSYS has forecast that Ka- and Ku-band High Throughput Satellites will account for 90 per cent of all available bandwidth by 2015.

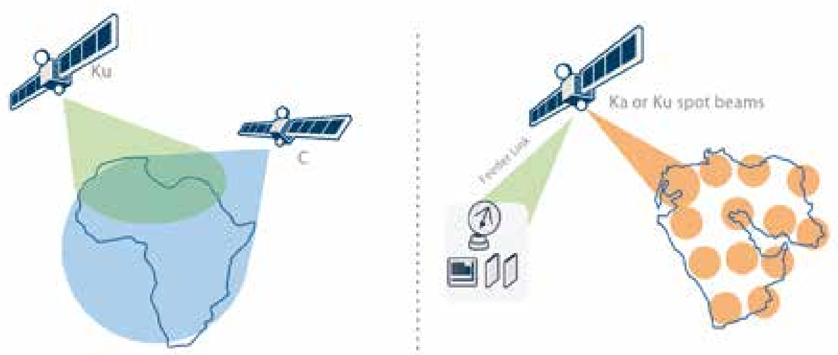
Small cells and satellite: alternative solutions

Much of the focus on small cells in recent years has been on the domestic femtocell market. But public access small cells offer a convenient alternative to the significant structural and installation work required to deploy a macrocell in remote or rural positions, the problems associated with powering the cell site and the concerns around the business model that operators must face.

The use of small cells in remote and rural deployments could enable operators to look at their coverage requirements and obligations from a different angle; focusing on on the provision of connectivity to people rather than geographies.

"If you look at most rural communities they're usually pretty compact," says Richard Deasington, director of market development at iDirect. "A small village might be one kilometre square, with a couple of hundred houses and there will be a big gap between that village and the next one. A big macrocell will consume a lot of energy in providing coverage for livestock and not much else. The alternative is to place a small public access cell at the heart of each of these villages and backhaul using satellite from each location."

Obviously small cells are a great deal cheaper than their macro counterparts. They can be bolted to walls or poles and innovation around power consumption means that a solar panel is all that is required to keep them running. They also allow operators to judge deployment business cases on very specific locations and revenue opportunities.



Traditional satellite coverage provided a large beam to cover an entire region, but limited capacity made it an expensive resource.

Spot beam technology takes advantage of frequency reuse, using more concentrated beams to increase satellite capacity and lower costs.

Small cell specialist ip.access has made efficiency gains in its products such that a small cell with a 1 – 2 Watt transmitter can be powered by a solar cell, according to Dr. Nick Johnson, founder and chief technical officer. Such a cell could have a radius of one kilometer. A 32-user 3G cell deployed along these lines could support between two and three hundred subscribers, Johnson says.

"With that you have something that is free standing, has relatively low capex and near zero opex," he says. "It's very easy to deploy and also not vulnerable to the infrastructure issues that are inherent in these kind of rural deployments, where anything that has possible resale value can get stolen. If you can make it secure and reduce its vulnerability to the interruption of supply so that it is self sufficient in power, then that's a really powerful proposition."

It is not an entirely new idea. Japanese operator Softbank, one of the most committed small cell operators in the world, was recognised by the (then) Femto Forum in 2009 for its Niimi project which saw the operator deploy 3,000 small cells in rural locations throughout Japan.

Meanwhile, satellite has long been in use as a backhaul solution for remote cell sites, and economies of scale have brought capex costs well under control. Satellite coverage cannot be matched by other technologies and capacity can be provisioned extremely quickly. Historically the problem with satellite has been opex; the monthly cost of access has been off-putting for operators.

But the advent of High Throughput Satellite technology and innovation in the terrestrial infrastructure that controls the satellites themselves are changing the economics of satellite backhaul. Steve Good says that these new technologies have brought the point at which satellite becomes attractive relative to multihop microwave down towards two hops.

Combined benefits

Small cells are an attrative alternative to macrocells for remote and rural deployments, and High Throughput Satellites offers great improvement on legacy satellite technologies in terms of efficiency and cost. But it is only when the two solutions are deployed in combination that their potential can be truly exploited.

Previously satellite backhaul for macro cells relied on Single Channel Per Carrier (SCPC), an architecture that keeps a satellite link open, consuming bandwidth, regardless of the volume of traffic being backhauled. This suited large cellsites where traffic volumes were high and traffic profiles comparatively uniform because backhaul was allocated to accommodate peak traffic.

But SCPC is inefficient where an operator is looking to backhaul a higher number of smaller sites with varying traffic, as it would be with a small cell deployment.

A large portfolio of small cells, deployed to cover the specific locations of the addressable population, would generate very different traffic patterns than would a smaller number of macrocells. With far fewer users, each site is likely to be peakier, because a single call would represent a larger relative shift in traffic. For a deployment of small cells, a dynamic control system that offers immediate response to demand can drive efficiencies and cost savings.

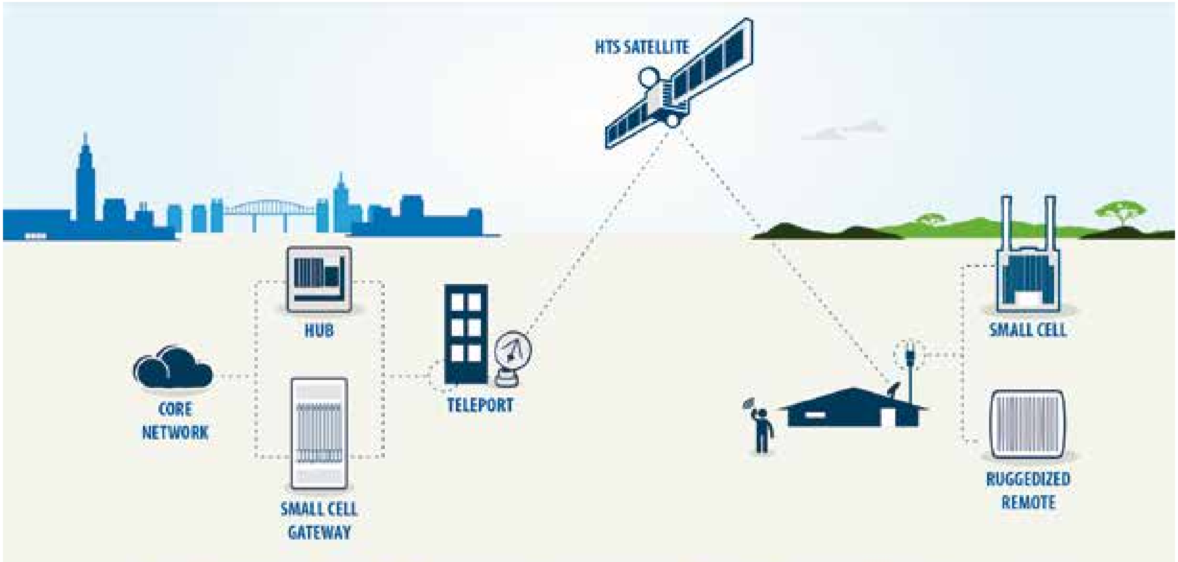
Much as the current trend in advanced markets is towards data sharing plans that allow subscribers to apportion their data allocation to a range of devices, dynamic satellite control systems can deliver the bandwidth only where it is needed, making more efficient usage of a high value, high cost resource.

The iDirect satellite platform is one such system, explains Richard Deasington. "Our system sends a burst time plan to all satellite remotes, which tells them when to send their traffic so that they don't overlap," he says.

"The system communicates this burst plan to each remote site eight to ten times each second and that's the essence of this kind of network; it works on a bandwidth on demand basis."

But architectural elegance and bandwidth efficiency are not the only benefits to such an approach. Public access small cells are extremely affordable, with a single unit likely to cost as little as $3,000—in some cases less. As we have seen, a single macro NodeB deployment can run to hundreds of thousands of dollars and will generate substantial costs associated with installation and maintenance.

In remote and rural areas such a cell will be providing coverage over large, unpopulated expanses. A small cell can be installed and functioning inside a day, powered by sunlight and requiring no ongoing maintenance. And it provides coverage exactly and only where it is needed.



Cost effectively backhauls traffic from remote sites equipped with small cells over satellite to the core network

In combination with the reduction in satellite backhaul costs that will result from the increased availability of High Throughput Satellite systems, small cells could offer a significant cost advantage, as Richard Deasington explains: "With bandwidth being allocated ten times a second you can make a saving of between a factor of three and five on your bandwidth requirement. It makes a huge difference to be able to pool that bandwidth and you're then looking at a situation where the cost is a third of traditional satellite backhaul costs."

In such a scenario, mobile operators are only paying for the satellite bandwidth that they are using, and only providing the backhaul where it is needed, in real time, using infrastructure that is likely to pay for itself in days or weeks rather than months or years.

OPERATOR'S VIEW

The use of small cells in remote location, in combination with satellite backhaul, could help to reduce deployment costs associated with macro cell deployment.

The expansion of small cells is very low capex because of lower hardware costs and lower power requirements. Also, the opex for satellite backhaul could be shared between the small cells and macro cells because rural sites can easily operate with a capacity of 1Mbps, sometimes up to 2Mbps. Sometimes we launch sites with a capacity of 512Kbps, when the population and targeted traffic is low.

The use of satellite in rural backhaul has advantages because, for a point-to-point connection, the installation is very fast and the site can quickly be functional without adding unnecessary sites along the route.

Bandwidth prices are still high in Africa which can be a challenge. They can be around US$3000 bidirectional, depending on availability and the band which is a real drag in the expansion of VSAT in Africa. Halving the price would really benefit MNOs in Africa, in particular, that are using VSAT in their backhauling.

Sub-Saharan African operator

Conclusion

The provision of communications services to people in remote and rural areas—data as well as voice—has become a political imperative across the globe. And saturation in dense urban environments is driving operators to look further afield for growth opportunities.

But operators face significant challenges to their business cases in remote and rural areas, particularly in emerging markets, where purchasing power is low.

Traditional macro cell site installations are difficult to justify in sparsely populated regions and difficult to achieve in areas that are beyond the reach of key road and power infrastructure.

Backhauling sites in these areas is another difficult challenge. Physical links are impractical and even microwave over long distance becomes expensive and awkward to deploy. Historically satellite connectivity has been viewed as too high-cost by operators for many deployments.

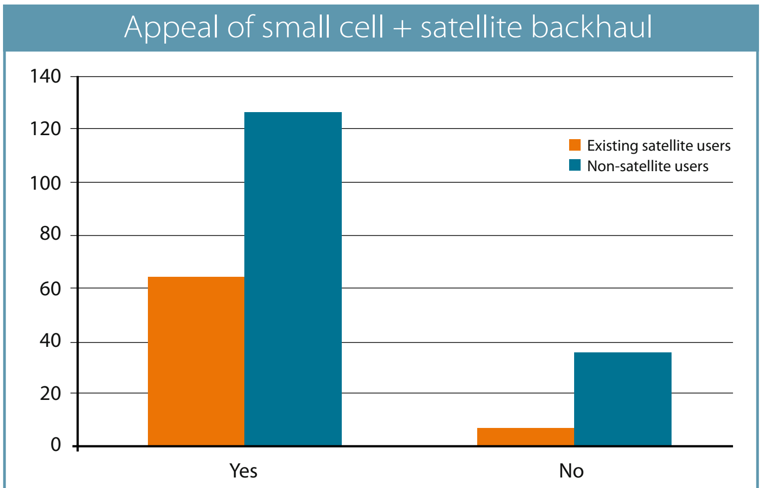
The use of small cells in combination with advanced satellite technology that allows for the dynamic allocation of bandwidth enables operators to provide coverage only when and where it is needed. In a survey carried out in 2012, Informa uncovered significant support for just such a model, despite it being a new concept to many of those surveyed.

Such solutions offer marked improvements in:

- Efficient use of satellite bandwidth;
- Cost of deployment for rural/remote cell sites;
- Power management and security for rural/remote cell sites;
- Cost of backhaul provision; and
- Speed of deployment

Satellite backhaul should no longer be dismissed out of hand as too expensive; in combination with small cells it represents an important tool for operators driven to provide coverage in sparsely populated remote and rural locations.

Q Would you consider evaluating a solution that utilized outdoor femtocell/ small cell technology and all IP based satellite backhaul for remote and rural coverage?



Source: Satellite backhaul for rural coverage survey, 2012, Informa Telecoms & Media

Breaking down the 230 respondents that answered the question 69 respondents used satellite in their network while 161 did not. For those using satellite 90% of respondents stated they would be interested in evaluating a satellite and small cells solution, along with 78% of non-satellite users.

Small cells and satellite – Making rural coverage pay

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Getting the industry thinking

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iDIRECT

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iDirect is a market leader in IP-based satellite communications providing technology, hardware and software that enable VSAT connectivity around the globe. Our Intelligent Platform™ is a single, unified IP-based architecture engineered to handle a wide range of applications. iDirect technology integrates with traditional macro cells and the latest in small cells from leading infrastructure manufacturers to create an easily deployable, low cost solution for remote and rural connectivity. Our platform has unique features that maximize bandwidth efficiency while enabling superior voice quality and high-speed data throughput. Combining satellite and small cell technology creates an economical way to backhaul voice and data traffic where it hasn't been possible before. www.idirect.net