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Rethinking backhaul

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SYNOPSIS

Any modern communications network is a complex architectural arrangement. By 2013 it's likely that a mobile network operator will have 2G, 3G and LTE operations running in parallel, with support infrastructure such as backhaul that has been updated and augmented over the years.

As networks mature, they also evolve—the trend right now is to alleviate RAN congestion with smaller cells, increasing network density but also putting extra burden on the backhaul infrastructure. In order to keep pace, backhaul implementations also need to evolve.

This white paper will show that legacy Point-to-Point (PtP) architectures alone are no longer sufficient to support the modern RAN. That's not to say, however, that there is no place for such technology in the modern backhaul environment; quite the opposite is true. In order to successfully and efficiently supply the RAN with backhaul, an operator must expect to adopt several technologies, including PtP, and implement them on a case-by-case basis.

While every backhaul technology exhibits distinct advantages, as well as some constraints, none of them can be considered as a 'catch all' solution. However, an optimum solution can be achieved by leveraging synergies between two best-of-breed technologies: P2MP and P2P.

The key message to take away from this paper, is that there is no 'silver bullet' when it comes to backhaul—operators will have to adopt several technologies, deploying each where most appropriate.

INTRODUCTION

Access network planning has always been at the fore in the mobile operator's mind and it was assumed that the transmission network would fall into place and be upgraded as necessary and whenever required. But now with the mobile industry on the cusp of global adoption of fourth generation network technology, backhaul has been pushed into the limelight, as a vital element of any mobile operator's strategic planning.

It has simply become untenable to build next generation networks on top of legacy transport links, and the explosion in mobile broadband means operators need to move away from linear short-term measures and seek a long-term solution for backhauling traffic.

A key consideration is that there is no standard way of doing this and migration paths come in many forms, encompassing E1s, fibre, and wireless. It's well recognised that fibre is the ultimate solution, but is prohibitively expensive for most operators and increasingly inflexible given the speed of deployment of networks today.

Microwave has proved to be the most popular solution to be adopted in recent years, albeit as part of a wider backhaul mix including fixed line. The inherent advantages of multipoint microwave—the ability to share resources and use less radios—means it is the preferred choice for mobile operators at present and will likely remain so going forward. Although in reality, a multitude of technologies are likely to be dominant, since backhaul itself is not likely to rely on a specific technology, topology or frequency.

THE RISE OF SMALL CELL NETWORKS

2012 marked the first year where operators and vendors began discussing their experience with large scale, mass market LTE deployments, as infrastructure providers continued to announce more advanced and cost-efficient LTE offerings, many of which come in the form of small cells.

The case for deploying smaller cell configurations—such as picocells and microcells for outdoor coverage and femtocells for indoors—to supplement traditional macrocell-network architectures, both for LTE and existing 3G networks, is becoming more compelling, because traditional macrocells will soon be unable to cope with traffic demands in urban areas. Small cells are also gaining interest in rural areas, where their typically lower cost is a natural fit for geographies with low population density and lesser revenue opportunities for mobile operators.

Small cell architectures can improve capacity and performance while circumventing the need to deploy cumbersome and expensive new base stations and can give operators commercial advantages, such as a boost in market share. They can also provide a second layer of coverage in 3G and LTE networks, resulting in higher throughput and data rates for the user and improved performance at the cell edge. In fact, compared with alternative approaches such as MIMO, a small cell strategy is the fastest and most effective way for an operator to increase capacity.

The backhaul headache will intensify with the deployment of small cells, and with the associated increase in the number of cell sites deployed in mostly challenging urban locations and requiring a wireless backhaul link. Although small cells move the base station closer to the subscriber, making more sense from a technology perspective, they create new challenges because of their more distributed nature. These new considerations include finding real estate for the small cells on street furniture such as lampposts, phone booths, building and rooftops, and then, most importantly, getting backhaul to those locations.

So how can operators choose from a wide range of backhaul choices, ranging from fibre to microwave and E-band PtP, and to microwave PtMP?

As a starting point it is becoming apparent that PtP microwave will likely become too expensive and cumbersome a solution for a continuously evolving network featuring lots of small cells. Capacity is the principal driver for backhaul connectivity, as a handful of small cells will require a connection with more capacity than each of the cells. But certain other fundamental requirements must also be met. In terms of coverage, the backhaul solution must be able to reach small cells in difficult locations; and the cost per connection needs to be attractive, as small cell backhaul will cater to many more connections than the macrocell network.

It's also critical that the backhaul network achieves aims of cost, coverage and capacity, and does all of this without compromising quality of service.

As a result, PtMP microwave is seen as occupying the ideal middle-ground, having enough capacity to backhaul lots of small cells, whilst remaining affordable. Multipoint microwave will be an essential component in an operator's toolbox of small cell backhaul solutions.

BACKHAUL: THE TECHNOLOGIES & SOLUTIONS

In terms of capacity requirements and expectations, most operators are looking at providing several hundred megabytes per second capacity to a fully loaded site in 2013, compared to around 25Mbps of bandwidth for a HSPA cell in 2009. Today, virtually all tier-one operators use microwave to backhaul their traffic to a greater or lesser extent and many already have spectrum that they can use as backhaul with microwave, while unlicensed spectrum is also commonplace.

According to analyst house Informa Telecoms & Media, microwave can typically connect more than ten times as many sites for the same investment as a greenfield fibre installation. Moreover, the average cost of rolling out fibre is somewhere between $32 and $64 per metre, while microwave backhaul costs as little as five per cent of that amount, Informa estimates.

The high availability of microwave equipment and the lower maintenance and repair costs also have an immediate impact on operating expenditure, while small cell deployments also use less energy than macrocells and have a far smaller physical footprint. For example, a 70kg base station using 5kW of power can be replaced by a cell a few inches square, that can be just about hidden from view.

There are a wide variety of technologies and solutions available as carriers for backhaul traffic, and then several topology configurations that can be applied to each. As a general rule, the bandwidth available for backhaul needs to match that available on the access network at any particular node, with some experts erring on the side of caution and advising a little extra headroom.

There are, of course, a couple of fixed line options available, offering various connectivity and performance capabilities at increased costs and reduced flexibility. For more rapid deployment, wireless options offer a range of cost and functionality alternatives.

FIBRE

Fibre provides a very high-capacity, low-latency connection, but at great expense. If it is already available it may well be the best suited option, but to install it is slow and very costly, making it unsuitable for a continuously evolving network architecture.

DSL

An alternative to fibre which is more widely available but lacks the performance, making it less suitable for bursty traffic, putting quality of experience in jeopardy. If a fixed connection is not already installed it would make more sense to go with fibre than DSL, however, wireless may again be the better option.

WIRELESS BACKHAUL

Radio spectrum for backhaul purposes is licensed in much the same way as the access network. There are link licensed options for Line-of-Sight and Point-to-Point installations with local restrictions on radiation patterns to manage interference; as well as area licenses for large geographical regions where power transmission constraints are applied.

Line-of-Sight coverage in urban environments requires propagation down streets but provides high capacity connectivity where available. Area licensed spectrum facilitates massive backhauling service provisioning as there is no need to licence each individual link.

A wireless backhaul solution with NLoS or near-Line-of-Sight (nLoS) capability means that the Point of Presence (PoP) does not need to be visible from the cell, since radio signals can penetrate or diffract around obstacles. But NLoS is generally only practical with frequencies below 6GHz as penetration losses are significantly larger at higher frequencies. Moreover, NLoS connections are not reliable, spectrum resources are scarce and very expensive at sub-6GHz, making NLoS the least favourable technology for the backhauling of small cells.

Naturally, the most attractive low carrier frequencies are already licensed and used for the access network, with small cells and Wi-Fi installations using much of the rest.

LICENCE EXEMPT

There are also swathes of licence exempt or 'free' spectrum available, such as that used for Wi-Fi in the 2.4GHz and 5GHz bands. While the usefulness of such spectrum should not be underestimated, it is also likely that such bands will be heavily populated and their availability unpredictable, especially in traffic hot spots and areas of high demand.

There is also a considerable amount of spectrum in the 60GHz area, between 57 to 66GHz, a large part of which, depending on the market, is unlicensed and allowed for fixed PtP connectivity applications. This cost-free spectrum, which supports high-capacity links and the potential to use small form factor radios, is considered a prime facilitator for small cell backhaul systems.

So far, mobile operators have never really embraced licence exempt backhaul, with the only notable exceptions limited to small deployments in low traffic or rural areas, because of the potential interference in these bands.

However, given that the interference potential in the 60GHz band is significantly reduced, today mobile operators are eager to exploit the use of radios operating in this band for small cell backhaul especially in urban areas.

In a Small Cell survey of operators carried out in 2012 by Informa Telecoms & Media, 38.7 per cent of 212 respondents said that they preferred to operate small cells in managed spectrum, because the unlicensed nature of spectrum used for Wi-Fi and its 'best-effort' operation is the complete opposite of cellular networks, and mobile operators are very sceptical of operating their own hot spots in interference-prone, busy areas.

MICROWAVE

There is plenty of spectrum available in the 6GHz to 60GHz range for use in microwave applications, incorporating mmWave (millimetre wave) spectrum in the 42GHz and above band.

It is a mature technology often used for fixed links and LoS installations, offering high availability and high capacity.

Short wavelengths mean that compact high gain directional antennas can be used for long range links as long as they are properly aligned to accommodate the narrow beam widths, taking into account physical obstacles such as buildings and trees. On the flip side, however, this helps reduce interference from nearby links and makes the solution ideal for both PtP and PtMP installations.

MILLIMETRE WAVES

V-band spectrum is available at 60GHz and E-band spectrum is available within the 70GHz to 80GHz range, benefitting from high atmospheric absorption, which reduces interference but limits range. Short wavelengths mean very compact high-gain and narrow beam antennas can be used for high capacity PtP links, although these will also require careful alignment. However, many regulators have made this spectrum available with less restrictive licensing requirements in order to encourage innovation and uptake, meaning a quick process for assigning frequencies and costs as low as $100-200 for individual links.

ARCHITECTURES & TOPOLOGIES

Each wireless technology used as the carrier can be deployed in a variety of topologies, with some better suited to evolving situations. Today's networks are dense, heterogeneous, and require strong networking, besides the flat requirement for a radio transmission of yesterday's cellular networks, constructed either following a Point-to-Point (PtP); Point-to-Multi-Point (PtMP); Mesh; or Multi-hop model.

POINT-TO-POINT

The simplest form of topology uses one or more links to connect cells to a PoP. Each link requires an antenna and radio at each end, so the PoP site can quickly become crowded with antennas.

The solution is a tree structure making use of intermediate nodes, defined as either a Chain, Tree, Ring, Mesh, Star, or Bus topology. There are some clear benefits, for example, Rings include redundant links which improve resilience; while Mesh nodes form multiple redundant links and can make use of algorithms to find the lowest 'cost' path through the mesh. However, Multi-Hop connections that pass over multiple links will see an impact on latency where nodes are many hops away from the PoP. Capacity can also be reduced as certain links may aggregate traffic from multiple cells and may become a bottleneck.

The main issue with PtP is that, since frequency allocations are often managed on a per link basis, building out such networks can be time consuming and may well become a hindrance with the evolution of higher density, smaller cell network rollouts.

POINT-TO-MULTIPOINT

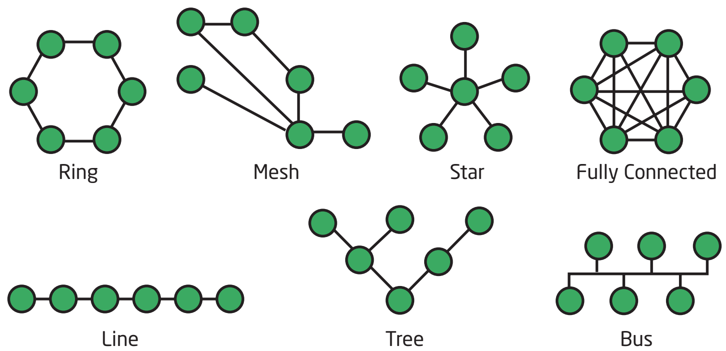
Multipoint topology is already used in the access network itself. A central 'hub' forms multiple links to a number of cells with total hub capacity shared across. Since traffic demands are bursty, resources are pooled across a large number of cells, rather than having a fixed resource allocated to each cell. The result is a much higher and more efficient utilisation of spectral resources.

Like access networks, hub sites use sector antennas which provide coverage over a large area. This topology also has the added benefit of halving installation costs, since only the cell end of the link needs to be visited to connect up the backhaul to the hub.

PtMP communication is used in systems designed both as single and bi-directional structures. A central antenna or antenna array broadcasts to several receiving antennae and the system uses a form of time division multiplexing to allow for the back-channel traffic. PtMP is increasingly viewed as a cost-effective way to serve areas of higher base station density in urban and suburban environments.

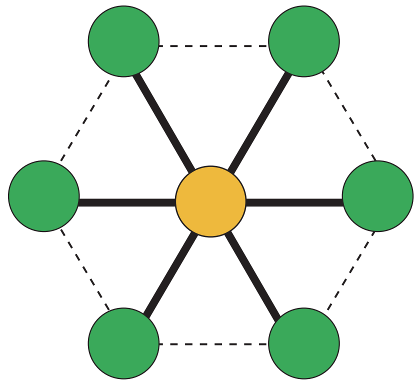
One of the benefits of PtMP allows the operator to share resources across radios and, as capacity and density rise, the spectrum requirement grows the total sum of the mean bandwidths of each sector in a busy hour for all sites as each sector within the network becomes an aggregation point. The ability to apply statistical multiplexing within a sector, whereby the total available bandwidth is shared between all the NodeBs in that sector, can reduce the total backhaul capacity required.

Point-to-Point



As identified by research carried out by NGMN, the total hub capacity is shared across the small cells, so statistical multiplexing gains are realised where traffic characteristics allow. And furthermore, where latency and capacity can be impacted in multi hop scenarios, the NGMN also found that this is mitigated by multiplexing gains.

Among the wireless technologies explored in this paper, microwave PtMP is the cheapest option followed by E-band as the second-cheapest. This is as a result of two factors: a smaller number of radios required for PtMP as multiple terminals can feed traffic to one access point and lower spectrum costs, due to the fact that cost savings grow as the number of terminals that feed to an AP increases.


Point-to-Mutipoint

According to research from Senza Fili Consulting, PtMP's lighter demand for radios saves around 48 per cent on site rental, compared to microwave and E-band PtP, with further savings of around 42 per cent on maintenance and power. The other factor making microwave PtMP cheaper than PtP is spectrum costs, which account for only one per cent of its opex, compared with 12 per cent of microwave PtP's opex, according to Senza Fili.

PtMP is also able to leverage traffic aggregation gains to estimate backhaul requirements more efficiently, leading to a more efficient use of spectrum. While both PtP and PtMP technologies benefit from aggregation gains, the impact on PtMP is larger because lower throughput requirements result in fewer radios.

And according to estimates from Informa, provisioning for mean traffic demand, as opposed to peak, can reduce the backhaul bandwidth requirement by up to 80 per cent.

MATRIX: COMPARISON OF SMALL-CELL-BACKHAUL TECHNOLOGIES

Technology	Range	Link speed	Cost	Decision factor
NLOS microwave	✓	✓	✓✓✓✓	No line of sight available
PtP microwave	✓✓✓✓	✓✓✓	✓✓✓✓✓	Mature technology
PtMP microwave	✓✓✓	✓✓	✓✓✓✓	Flexibility for urban areas
PtP mm-wave	✓✓✓	✓✓✓✓	✓✓✓✓	Higher bandwidth possible
PtMP mm-wave	✓✓	✓✓✓	✓✓✓	Cost savings compared with PTP
PON (fibre)	✓✓✓✓	✓✓✓✓	✓✓	Fibre availability
Active fibre	✓✓✓✓✓	✓✓✓✓✓	✓	Only option for cloud RAN

Source: Informa Telecoms & Media

PRODUCTS

OmniBAS

OmniBAS is a native Packet Point-to-Point MW solution (from 6 GHz to 38 GHz) that ideally fits today and tomorrow's bandwidth-intensive backhaul applications. It offers cost-effective high-capacity (over 1Gbps per link) backhaul for mobile (2G / 3G, HSPA+ / LTE) and WiMAX networks, while at the same time enables an evolved and smooth migration to an all-IP architecture. Legacy (circuit based) services are seamlessly transported with carrier-class reliability and the highest availability. OmniBAS allows highly-flexible link configurations, from all-outdoor and split-mount at tail sites up to high nodal implementations for traffic aggregation sites, all from the same platform.

WiBAS

WiBAS addresses today's requirements for Fixed Mobile Convergence (FMC) and smooth Next Generation Network (NGN) migration. WiBAS becomes a clear differentiator for the demanding operator, as it enables a broad range of profitable solutions for a growing number of different business models.

WiBAS is a carrier-grade Point-to-MultiPoint microwave product line that perfectly addresses demanding operator backhaul needs. With a powerful packet based core engine and field proven reliability, it provides significant CapEx & OpEx savings to operators regarding the backhaul of their mobile (2G / 3G / LTE) & WiMAX networks. The product family is enriched with the SMC Backhaul node, a new and exciting radio unit that is specifically developed for the small-cell backhaul application. The aesthetically appealing form-factor of the SMC Backhaul node facilitates seamless integration in the urban landscape while technical advances allow for automated connectivity establishment reducing the time required to deploy the network. Finally, the SMC Backhaul node is an s/w defined radio that can operate either in PtP of PtMP mode and it can be used to establish in clutter links and reach small cells that do not have direct LOS with the central aggregation hub.

Ultralink

The Ultalink platform leverages the high capacity and low to no-spectrum fees of the 60GHz or the 71-76 & 81-86GHz millimetre wave area, to offer excellent urban backhaul solutions. Its advanced and highly integrated SiGe radio transceiver technology and its comprehensive Carrier Ethernet networking functionality are combined in the most compact all-outdoor units in the market to provide the lowest PtP backhaul link TCO.

Convergent backhaul

The nodal Convergent Backhaul Node (CBAN) in particular, part of OmniBAS portfolio (OmniBAS-8W), is a market unique multi-technology solution allowing aggregation of PtP, E-Band and PtMP links and supporting a wide range of connectivity options (E1, SDH, GbE).

CONCLUSION

Right now, operators are using PtP architecture in the last mile, but there's nothing dynamic about this model. A PtP-only setup is very inefficient and given that every other part of the network is dynamic with the radio access and core networks able to redistribute capacity as needed having that last connection over a dedicated link makes little sense in many cases.

But what needs to be understood is that there is no silver bullet when it comes to backhaul. In reality, operators are likely to face many different small-cell-deployment environments, and those that support a variety of solutions and topologies will be the most successful.

In many cases, PtMP is seen as the most cost effective solution because it requires fewer radios to meet the backhaul requirements than either microwave or E-band PtP does, and this translates into lower equipment and installation costs, as well as lower opex with fewer links to operate. But as with the PtP microwave landscape for macro cells, a catch-all wireless technology is not likely for small cell backhaul, because each country has its own guidelines for regulating microwave and millimetre wave spectrum.

An exception is the millimetric 60GHz band, which is unlicensed but exhibits extremely high oxygen absorption, making this band suitable for localised small cell backhaul. Yet its unlicensed nature might limit wide operator acceptance in favour of licensed bands.

Moreover, area wide spectrum licences, instead of those covering individual links also make PtMP faster to deploy, especially in challenging urban environments. And unlike voice, data traffic is extremely bursty. But the nature of PtMP means that traffic from multiple RAN site can be combined just as backhaul from multiple PoPs can be combined, ensuring that spectrum resources are always most effectively used, even when RAN traffic levels—and backhaul traffic levels as a result are set to grow.

So not only do we have to conclude that nodal PtP, E-band PtP and most importantly the PtMP, as a nodal radio with excellent spectrum management and statistical multiplexing, are the best options. But it must also be understood that the vendors that offer a multitude of technologies are those most likely to be dominant—and therefore future-proof—since small cell backhaul is not likely to rely on a specific technology, topology or frequency.

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The company has strategically focused and is investing heavily in the continuous evolution of its broadband wireless product line. Intracom Telecom is incorporating the latest standards and state-of-the-art technologies in order to deliver cost-effective wireless solutions that address the rapidly growing market for broadband IP services. Dedication to R&D and commitment to technology innovation is at the foundation of the company's business strategy. Intracom Telecom maintains in-house state of the art research laboratories that facilitate the rapid development of high-quality, advanced telecommunication systems.

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