No current small cell backhaul solutions being marketed will meet the requirements of coverage, capacity and cost.

BIG PROMISE FOR SMALL CELL MOBILE BACKHAUL

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A different solution to handle the burgeoning demand for mobile broadband capacity will be needed. More spectrum coupled with more spectral efficiency will not be sufficient. A clear solution is more sites, but deploying more macro-sites in urban and dense urban areas (where most of the traffic will be needed) will not be feasible.

Small cells promise a new "underlay" of outdoor and indoor, low power micro-cells that are deployed on public and private infrastructure within the urban clutter are seen as seen as a likely solution. Sites being considered include:

- Pole tops (e.g., such as street lighting, traffic light systems, electric utility poles, telco poles)
- Bus stops
- Building walls
- Building rooftops

These new sites will need to be compact, simple to install, energy efficient and incorporate an organically scalable and tightly integrated backhaul solution. As a result, there will be many more sites—some projections estimate that up to 10 small cells will be deployed for every macro-site. Small cells hold out the promise of great gains for the end users but massive challenges for the operators.

Small cell deployments so far have mainly been concentrated in Europe (3G) and the USA (LTE). 3G small cells may also be deployed in other regions as a means to avoid the difficulties in obtaining planning approval for larger macro-cell sites.

IT'S STILL EARLY

Today, as far as wireless small cell backhaul (SCBH) solutions are concerned, there is evidence of product immaturity and hyperactivity in equal measure.

There is profusion of aggressively hyped solutions, including many that are a rehashing existing/niche solutions and at the opposite extreme some very new and unproven technologies. In practice, these solutions are jockeying for position while operators grapple to understand the formidable planning and infrastructure challenges being thrown up by their small cell ambitions. It is apparent that few appear that they will fully satisfy the anticipated and emerging requirements in terms of performance (i.e., capacity, latency, availability), size/shape, ease of deployment and most importantly, total cost of ownership.

Today's NLOS solutions in the sub-6 GHz bands will not meet the capacity and latency requirements of LTE small cells. They also lack scalability and introduce significant planning overhead.

TOOLKIT VS. THE SILVER BULLET

A clear gap exists between what we are hearing from most operators and the solutions being proposed by most vendors.

Due to continued uncertainty about how and when small cells will likely be implemented, operators are looking to keep their options open by taking a "toolkit" approach, where they expect that backhaul will need to be a mix of technologies to strike the right balance between coverage, capacity and cost. However, there are questions whether the toolkit can provide a uniform and consistent service, regardless of the tool that is used. Deploying multiple solutions from different vendors will entail multiple planning deployment, maintenance and OSS models, all which need to be maintained and managed in parallel. This will attract significant overhead figures that will need to be factored in the operator business case.

On the other side, we see many vendors promoting specific products that are often presented as a "silver bullet" for operators, with the promise that theirs is the perfect solution. These variously include sub-6GHz point-to-multi-point (PMP)/non-line-of-sight (NLOS), microwave PMP, 60GHz and 80GHz point-to-point (PTP) solutions.

Demand for spectrum will mean that frequencies below 6 GHz will likely be allocated for RAN access in the medium to long term.

OPTIMIZING SMALL CELL SITES FOR BACKHAUL

Given the complications and costs associated with deployment of new small cells at street level, many of these issues could be mitigated through the selection of sites that are favorable for backhaul. Deploying a percentage of sites on rooftops would avoid many of the site issues having to do with power, size, weight and aesthetics, while still providing adequate cell coverage and capacity, particularly for low-level buildings located in urban and suburban environments. Small cell deployments at street level will still be necessary for certain scenarios, such as in dense urban or downtown city locations, where buildings are too tall to allow coverage from rooftop sites.

We must consider small cell deployments as a complete ecosystem (RAN + backhaul) rather than as a one-size-fits-all approach where small cells are situated for coverage without considering the impact on backhaul. In fact, the economics of cost vs. coverage vs. capacity could mean that a better approach would be to allow backhaul to drive the determination of small cell locations. Clearly, more study is needed in this area.

TODAY'S NLOS MICROWAVE SYSTEMS CANNOT MEET SMALL CELL CAPACITY NEEDS

NLOS solutions are designed to operate in unlicensed or licensed frequency bands below 6 GHz, and can be PTP or PMP in nature. NLOS systems have the distinct advantage of not requiring a clear line of site between the aggregation node or hub site and the small cell, enabling much more flexible deployment strategies. When combined with a PMP architecture, where a single hub can connect to multiple remote cells, NLOS systems can appear to be the perfect solution for SCBH.

However, in a small cell deployment scenario, it is unlikely that NLOS systems can deliver the capacity needed (50 Mbit/s and greater). Capacity figures provided for NLOS systems are best case, and assume clear line of sight conditions. NLOS systems also typically use unlicensed, uncoordinated spectrum, where the likelihood of interference is high. Even in a PTP configuration, the capacity that can be delivered to a single site is far below the requirement. In a PMP configuration, where the aggregate capacity is shared between multiple end sites, the individual link capacity will be even less.

Some of the interference issues can be removed by using licensed spectrum, but its availability below 6 GHz is extremely limited (Figure 1) and in many cases has already been auctioned off for fixed broadband access (WiMAX) applications, so it won't be available to most mobile operators.

Finally, since NLOS systems are typically TDD (Time Division Duplex), where a single frequency is shared in time between the uplink and downlink, the latency performance will not meet the stringent requirements of LTE.

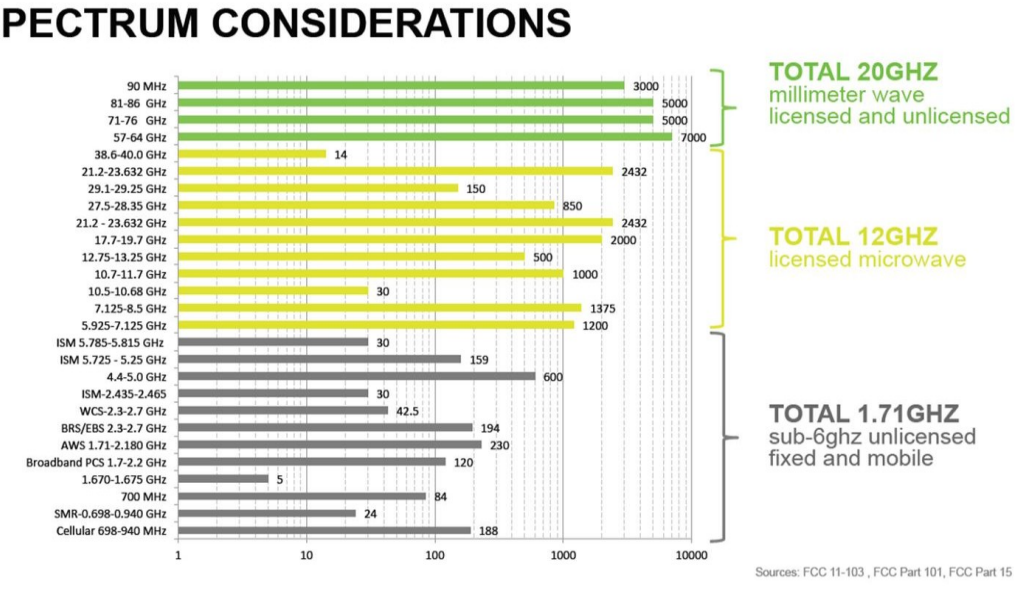

Figure 1. Spectrum above 6 GHz is much more available for small cell backhaul than spectrum below 6 GHz.

PTP systems, in both the microwave and millimeter wave bands (i.e., 6 to 90 GHz) show the most promise for small cell backhaul.

Licensed spectrum allocations below 6 GHz are fragmented and relatively shallow (not many channels available).

SPECTRUM AVAILABILITY WILL BE KEY FOR SMALL CELL BACKHAUL

Spectrum will be a critical factor for SCBH, and there is more than 40 times the spectrum available above 6 GHz that could be utilized (Figure 1). For example, in the USA, spectrum available by frequency includes:

- Sub-6 GHz—1.71 GHz
- Licensed microwave; 6 to 42 GHz—12 GHz
- Millimeter wave licensed and unlicensed; 60, 80, 90 GHz—20 GHz

Many of these bands are already being used for backhaul, while others—in particular millimeter wave—are now being made available, which have very complementary characteristics for small cell applications (i.e., suitable for short distances, delivering high capacity in a small, compact form factor).

It is also highly likely that the available licensed sub-6GHz spectrum will come under increasing pressure to be utilized for RAN access. For example, AT&T recently decided to reallocate its 2.3 GHz spectrum, which was previously available for backhaul, to be now exclusively used for RAN access. A lack of spectrum is a worldwide issue for operators planning to roll out mobile broadband technologies, so it is expected that this will not be an uncommon development.

SUB-6GHZ NLOS A 'NICHE' SOLUTION FOR SMALL CELL BACKHAUL

The inherent limitations of sub-6 GHz NLOS systems—insufficient capacity, high latency, interference and limited spectrum, even in PTP configurations—vastly outweigh the advantages. There may be circumstances where an NLOS PTP/PMP solution could be useful in deployments along with other technologies, but it will remain a niche solution that will not provide a panacea for SCBH.

TRADITIONAL MICROWAVE BANDS WILL HAVE A ROLE TO PLAY

Most of the attention for SCBH has been recently given either to frequencies under 6 GHz or over 60 GHz, where many new products and concepts are being proposed. Most vendors and industry pundits have largely ignored any possible contribution of the traditional microwave bands between 6 and 42 GHz that have supported macrocell mobile backhaul for the past few decades. PTP microwave has also proven itself capable of delivering a uniform and high quality transport medium that is a good complement to fiber in a hybrid backhaul network.

However, current microwave solutions are unsuitable for SCBH, due to size, cost and power requirements, since they were designed for longer distance basestation links. On the other hand, a new generation of microwave solutions is possible, specifically designed for the needs of SCBH. This would include reduced power needs (since links are so much shorter), miniaturization of designs and new flat panel integrated antennas, all enabling much more compact and lower cost solutions. Combined with new spectrum being made available or reallocated to PTP, such as 26, 28 and 42 GHz, microwave will most likely play an important role for SCBH in the future.

MILLIMETER WAVE RADIOS ARE SUITABLE FOR POLE MOUNTING

Traditional towers may not be available in applications for mounting microwave equipment for small cell backhaul, so carriers are looking at utility and light poles as potential mounting sites. However, operators are concerned that these smaller poles will sway too much in the wind to support effective microwave and millimeter wave band communications.

New innovations and approaches will be needed to solve the small cell backhaul challenge.

In particular, radios operating in the 80 GHz band have an inherently narrow antenna beamwidth, which will make alignment extremely difficult. Therefore, operators believe that will preclude mounting these radios on light poles and other "flexible" street furniture. However, in a recent study Aviat Networks undertook to examine light poles and other potential street-level mounting infrastructure designed to commercial standards found vibrations that create sway are generally within a range tolerable for backhaul link deployment. See http://www.aviatnetworks.com/media/files/Small_Cell_Sway.pdf for more information.

Planning, deployment and construction issues are likely to dwarf the technology issues.

IT'S NOT ALL ABOUT TECHNOLOGY

Aviat's experience in supplying microwave backhaul solutions for some of the world's largest LTE networks demonstrates that construction is key challenge for deploying LTE today, and with a new generation of small cells, this will be much more difficult. The practical aspects involved in deploying and maintaining a network of small cell links in a dense urban environment will be significant, with the potential for dramatically escalating costs. Questions to consider will include:

- Who owns the infrastructure that the small cell will be located on?
- What are the restrictions and cost of getting power on these poles?
- What size enclosure is allowed to be on the poles?
- What are the aesthetic requirements for such an enclosure?
- What attachment height is needed for the best network performance?
- Who can climb which poles and to what heights?
- When can installs be performed? Do streets need to be closed?
- How much will it cost to lease the space and gain access for installation and maintenance?

OVERCOMING DEPOLYMENT CHALLENGES

To help overcome these deployment challenges operators will need partners who have the breadth of experience to provide support for all stages of deploying a network of small cells—from planning and design, deployment and, possibly, maintenance and operation. Not all these issues will be solved with standard business-as-usual approaches, so some out-of-the-box thinking will be required!

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