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Sweating the Details

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The devil is in the details. A commonly heard expression, but one that is all too often overlooked when making the complex choices that are required when choosing technologies and network architectures. The reality is that you often do need to look at the details in order to fully understand how the bigger picture will work out. A good example of this is in choosing which spectrum/technology combination is best suited for the backhaul of small cells.

The first inclination is simply to choose the cheapest option – both from a spectrum perspective, and also from an equipment perspective. This would likely lead one to assume that the best bet would be found in extensions of 802.11 (Wi-Fi) technologies, as the equipment is low cost due to the high volumes and high levels of integration, and there are no spectrum licensing costs. However, total cost of ownership is something that needs to take into account a number of factors and scenarios.

A closer look at the total cost of ownership reveals that the backhaul radio is only a small component of the total cost per site. In fact, the total CAPEX is one-third of the total cost of ownership (with installation, maintenance and site/spectrum leasing costs making up the balance) and the backhaul radio is one -third of the CAPEX (the rest being spent on power, switching, environmental, etc). So, considering that with the backhaul radio choice only driving 10 percent of the site cost, basing an entire selection on the cost of this one component possibly won't deliver the lowest overall cost.

Secondly, it's also imperative to consider whether the performance of the technology can deliver what is required for the application. The Wi-Fi extensions that are commonly considered for small cell backhaul application do provide benefits by having some limited non line of sight capability. This is certainly advantageous, as achieving a clear line of site on all the links is made difficult by the trees and other obstructions that line our city streets. However, in order to deliver this non line of sight performance, they use a modulation technology called Time Division Duplex Orthogonal Frequency Division Multiplexing (or TDD- OFDM in the acronyms that engineers love to employ). The latency of this type of modulation is significantly higher than that of the Frequency Division Duplex QAM modulation employed in higher frequency microwave radios. This becomes a very serious issue for LTE, effectively limiting these types of radio links to a single hop before the traffic must be delivered to the fiber network for transport to the core network.

What's more, the total capacity is limited due to the smaller channel sizes available in the sub 6 GHz bands (10 or 20 MHz channels that must be shared between upstream and downstream traffic vs. the 50 MHz + channel sizes dedicated to either upstream or downstream traffic that are available with the higher frequency radios). Finally, since the spectrum is not licensed, there is a very real possibility of some other device operating in the same spectrum and interfering with the backhaul radio, either reducing the throughput further, or disrupting the signal altogether.

Moving on, while we have concluded that the sub 6 GHz radios don't deliver the cost per site performance, and do not have the latency/capacity/reliability required for the entire network, the question becomes: Are the higher frequency radios (6 to 80 GHz) any better? As you might expect, they are not without their problems. While they do have lower latency and higher throughput allowing the aggregation of multiple small cells before handing off to the fiber network, they also require a clear line of sight, and many of the frequency bands require larger parabolic antennas that cannot be integrated into the type of packaging required for street lamp deployments. For some of these frequencies the spectrum licensing is done on a link-by-link basis, driving up the cost and increasing the paperwork required to get a link on air. Clearly we must choose a subset of these frequency options that do not require link-by-link licensing, and that can make use of specialized mini antennas.

The good news is that there are a number of viable options, ranging from 24 GHz DEMs, 28 to 32 GHz LMDS, 42 GHz and 60 GHz. In addition, some jurisdictions license channels at other frequencies on an area basis and may be suitable for the small cell backhaul application. The key requirement here is the antenna size, and having no, or minimal incremental, spectrum licenses effort or cost. Notably absent from this list is the 70/80 GHz frequencies commonly referred to as E-band radios. While these types of radios can support very high capacity and often have low latency, they require larger antennas which effectively eliminate them from this application. It is clear that a combination of spectrum choices and radio technologies will be required for any network deployment since no one choice meets all the requirements.

So, the devil IS in the details. There is a simple answer to every complex problem, but it is often wrong. One size does NOT fit all. While there is a seemingly endless selection of quotations supporting such common wisdom, we seemingly always seek the simple, easy answer, rather than doing the hard work of understanding the issues in detail and choosing the correct solution. It's readily apparent that for small cell backhaul what's required is a toolkit approach that utilizes a variety of spectrum/technology options in order to deliver a cost effective, high performance network.

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