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Small Cell Backhaul – What is the Point?

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Article

September 24, 2012

It seems you can't open a trade magazine or browse a website these days without reading about small cells: How many do we need? When are they going to be deployed in volume? What sort of performance will they actually deliver – and at what cost? With this amount of hype people are prone to jump on the bandwagon, as they say, and claim that what they have or are currently developing is essential for small cells. This is also the case for small cell backhaul. Everything from copper based xDSL solutions, to fiber, to all manners of wireless solutions have some sort of marketing claim to applicability (if not necessity) for small cell backhaul.

The small cell backhaul universe breaks down into a couple of broad cases – for indoor small cells there is typically a wired infrastructure in place and this is generally the solution of choice – fiber if you have it, xDSL over bonded copper if you must. In some instances – such as temporary networks set up to handle sporting events, concerts or even political conventions – it makes more sense to go with an indoor wireless solution rather than string all that cable, but I think we can all agree that almost all permanent indoor networks will use a wired backhaul. Moving to outside deployments, the situation changes completely. The locations where outdoor small cells need to be placed are almost never connected to the wired infrastructure, and the cost and time to do so is prohibitive. As a result, the vast majority of these outdoor small cells will require a wireless backhaul solution. The problem is all wireless backhaul solutions are not the same.

Let's look first at the performance characteristics that these small cell networks require. A good way to model the capacity per site of a small cell is to assume it is equivalent to a single sector of a similar macro site – i.e. 20 to 50 Mbps for a 3G network and 50 to 150 Mbps for an LTE (News - Alert) network. Although a good degree of statistical multiplexing gain can be applied when dimensioning the backhaul links that are aggregating multiple sites, this sort of capacity must be provided by the final link to each site. In order to deliver a significant increase in network capacity we need a fairly large ratio of small cells to macro cells. This drives very small cell site spacing, on the order of 100m to 500m. These cell sites are spread more or less uniformly across the deployment area. Finally, the latency performance must be very low, especially for applications running over an LTE network.

One of the significant challenges of outdoor small cell deployments is the installation and commissioning effort required. To minimize this effort, many people are suggesting point-to-multipoint with non-line-of-sight capability as a simple solution for the backhaul. On the surface this seems attractive – simply deploy a small cell with such a radio in it and let the network connect it to the hub site. Visions of WiFi (News - Alert) network set up are no doubt in the minds of the proponents – no pesky alignment of the wireless link and automated software control of the allocated bandwidth between the hub site and the end nodes.

The problem is, when we examine the performance requirements outlined above, we begin to realize that in order to achieve the required capacity per site we are limited to only a very few end sites per hub. This means that the cost savings of having many cheap end sites per (expensive) hub site are essentially eliminated. Furthermore, in order to get the simplicity value, you have to use very broad beam antennas. This, when coupled with the long propagation distances and non-line-of-sight characteristics of these radios means that it will be very difficult or impossible to avoid interference from adjacent cell sites. Finally, inherent in the design of such radios is a polling protocol that allows the hub site to talk to each of the end sites in turn. This adds latency which is often not acceptable for the more demanding applications. Although this type of radio may perform well in a small pilot network, it is difficult to see how it could be used as the primary backhaul technology in a full scale deployment.

So where does this leave us? We can still achieve almost all of the simplicity objectives and meet the performance objectives if we use point-to-point radio links with small (smaller than 6 inch) antennas that can fit inside the required physical envelope of the small cell site. These have large enough beam widths that, given the short cell to cell distances involved, can be simply pointed at the receiving antenna and do not require a complex, dual ended alignment. Some schemes for automating this beam pointing have also been proposed to simplify matters even further. Although the alignment of the link is simple, the beam widths are still narrow enough that good link to link isolation is achieved. They also enable high modulation rates so that the capacity and spectral efficiency characteristics are good as well. Of course, a combination of area licensed, non-licensed high frequency and low frequency non-line-of-site radios will be required, depending on the network topologies and frequency availability.

The point of all of this is that any solution for outdoor small cell backhaul must meet ALL of the criteria – not just some of them, and it has to work in large scale deployments as well as small pilot runs. There is enough variability in the network requirements that there is undoubtedly room for almost every solution somewhere, but it seems clear to me that the dominant solution will be point-to-point radios.

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