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Reader Forum: Addressing impediments to outdoor small cell adoption

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This year will see the first real world deployments of outdoor small cells in order to meet burgeoning capacity demands across the globe. That said, there are many advancements in the microcellular network that could potentially delay the need for outdoor small cell deployment. These need to be considered individually to accurately assess the outdoor small cell market as it relates to network spectral efficiency gains, as well as the total cost of ownership of meeting growing capacity demands.

One variable that may impact the growth of small cell deployments is the expected future capacity increases in the macrocellular network layer. It's clear that the capacity (density) of current macrocellular "4G" networks will continue to increase in the foreseeable future, because there's still spectrum available around the world that could be re-used for mobile broadband. As they've done in the past, regulators might reallocate spectrum due to the importance societies have given to having readily available mobile broadband.

On closer inspection, spectrum is by default a finite resource and much of the most suitable spectrum for macro-cells (featuring low propagation losses and good obstacle/building penetration), has already been allocated to mobile broadband. What's more, even if more sub-6 GHz spectrum is eventually allocated for mobile broadband use, it will be a slow and costly process. Capacity gain through new spectrum allocations is not an end-all solution and most short-term (efficiency) gains will probably be made through "re-farming" current 2G and 3G spectrum for 4G use.

Other more experimental ways to further increase spectral efficiency, such as 4×4 or 8×8 multiple-input and multiple-output, adaptive beam forming, higher modulations and coordinated multi-point are also in play. However, some of these promising techniques look less promising when subjected to closer scrutiny.

While using higher modulations is a proven, reliable and well-understood method to increase capacity in a given communication channel, it's clear that doing so has its own limitations. With each and every modulation step, e.g. from 64 quadrature amplitude modulation to 128 QAM or from 1,024 QAM to 2,048 QAM, the available link budget decreases more or less linearly by 2-4 decibels, limiting range, cell size and, ultimately, coverage. The situation is made worse because the higher the modulation, the lower the differential capacity increase from switching to the next-higher modulation, so that relative capacity gain decreases as a function of modulation order.

When considering 4×4 MIMO, it's important to note that is very difficult to implement on mobile devices, where 2×2 MIMO appears to be the practical limit. This is due to the small dimensions of portable mobile equipment that users expect. There is simply insufficient room on the device for proper antenna spacing between the four MIMO antennas in the favourable sub-6 GHz bands used by macro cells. Using higher frequencies, like millimeter waves, might address this "MIMO antenna placement challenge," but it would also increase path loss significantly and be very ineffective in non-line of sight scenarios common in macrocellular settings. High-order MIMO likely could be confined to near-line of sight scenarios, such as small cells, but even this a challenge to maintain in a dynamic environment

Adaptive beam forming/beam steering looks great on paper and works superbly for military radar applications and perhaps in the countryside where near-line of sight between ENodeB and mobile devices are more readily available. However, in an urban environment, where non-line of sight scenarios are the norm, and capacity demand is greater, this method becomes extremely challenging. In effect, you're attempting to hit and consistently track an "invisible" and fast moving target in a totally unpredictable and dynamic electromagnetic environment. This approach makes even less sense when you factor in the sheer cost and complexity of large phased array antennas required for “pencil” beam forming, except perhaps for millimetre-wave line of sight scenarios

In conclusion, while the availability of new spectrum and increases of spectral efficiency may continue to delay the urgency small cell deployments, the cost-efficiency of those measures (their incremental gain) will decrease. For operators, everything boils down to maximizing efficiency gains at the lowest possible capital expense. Hence, moving forward, in terms of total cost of ownership, small cells will outrun advances in macrocellular spectral efficiency, the cost of additional spectrum and/or “re-farming” 2G and 3G spectrum, and distributed antenna systems. However, there are still operator specific obstacles to the immediate deployment of small cells. These include site access, new network deployment philosophies, backhaul, technology availability and operationalization. These factors will vary by operator and will constantly be weighed against the discussed methods of increasing macrocell capacity, ultimately determining outdoor small cell adoption rates.

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