Smart Antennas: The Freedom to Choose

Smart antennas are a practical, economical solution to many challenges faced by wireless operators.

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Today's economic climate in telecom tests wireless service providers with monumental challenges, including mounting pressure for profitability, shrinking spending, a spectrum drought, constrained network capacity, customer churn, and rising competition. Meanwhile, demand for wireless services continues to grow: while net subscriber additions have leveled off, monthly minutes of use are still rising. Wireless service providers have ample incentive to innovate by identifying new ways to use their spectrum and network resources more efficiently.

As demonstrated by deployments in many of the top wireless markets, smart antennas are a practical, economical solution to many of the toughest challenges faced by wireless operators. As market conditions have changed, through new product offerings smart antennas have expanded outside of their traditional realm into totally new applications, such as antenna sharing and optimization efficiency.

SpotLight CDMA Add-on for Capacity and Quality

The SpotLight&reg smart antenna add-on for CDMA networks is an appliqué to existing or new base stations. It replaces the antennas and RF front end of the base station with an array antenna and signal processing electronics. SpotLight can be quickly and easily deployed with standard RF connections to commercially available base stations to solve capacity and quality problems.

Using a technology called Sector Synthesis&#153, SpotLight generates performance gains by increasing the sectorization efficiency of the cell site through load balancing, managing handoff and controlling interference (Figure 1). These benefits are achieved by the unprecedented ability of phased arrays to customize sector pointing angles, beamwidths, and shapes. All adjustments are made using a remote software interface through which the smart antenna can be configured to automatically adapt to changing traffic conditions. In three-sector deployments, SpotLight capacity gains are as much as 50 percent.

Figure 1. SmartCell is a targeted, sector-by-sector smart antenna solution that enables operators to "sculpt" or customize the shape of a cell site's coverage pattern to deliver greater quality, capacity and coverage than off-the-shelf sector antennas.

Historically, CDMA six-sector deployments have been unsuccessful in large part

because of optimization and implementation difficulties. Due to their unparalleled ability to control interference and handoff, smart antennas are ideally suited to solve problems associated with increased sectorization. The SpotLight product supports 4-, 5-, and 6-sector configurations where it yields capacity increases of over 90 percent compared to traditional three-sector.

SmartCell for Optimization Efficiency

SmartCell&#153 is a passive antenna-only product that connects to existing or new base stations. Unlike SpotLight, it contains no active electronics or real-time software. SmartCell uses Cell Sculpting&#153 technology to efficiently optimize cell site capacity and quality by fine-tuning the sector footprints (Figure 2).

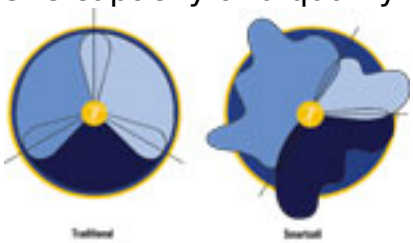

Figure 2. Multiple operators can share a single set of phase-array antennas while independently optimizing antenna patterns for their individual networks. Service providers gain fast and economical access to the sites they need and the capacity, performance and flexibility not available with standard antennas.

SmartCell is a phased-array antenna with a configurable beamformer referred to as a Personality Module&#153. The Personality Module is a plug-in card that feeds each element in the array with the appropriate phase and amplitude to create a desired antenna pattern. Changing and customizing sector antenna patterns is quickly and easily accomplished by replacing the Personality Module with a different one.

Cell Sculpting technology uses an off-line software program to determine an ideal antenna pattern for each sector. Based on network information and drive test data, the program optimizes the antenna pattern to minimize transmit power. In CDMA networks this optimization criteria has the desirable effect of designing antenna patterns that minimize pilot pollution, especially in those regions of the network heavily populated with users. The optimum antenna pattern determined by the Cell Sculpting software is then realized into a custom Personality Module that is inserted into the antenna. When deployed in a cluster of cells, SmartCell can provide capacity gains of greater than 30 percent.

Like the SpotLight appliqué, the SmartCell passive antenna supports six-sector deployments. This is accomplished by plugging in a special Personality Module that supports six sectors. SmartCell is designed to be air interface independent, so it is compatible with all major air interface standards (CDMA2000, GSM/GPRS/EDGE, WCDMA).

SmartShare for Antenna Sharing

A limited quantity of desirable cell site locations combined with severe zoning

restrictions make antenna siting one of the most difficult problems in growing wireless networks. Prime tower space for antennas, or vertical real estate as it is often called, has become an extremely valuable and scarce commodity. There's simply not enough of it to go around in today's wireless marketplace with a half a dozen or more service providers competing in each city.

Antenna sharing, the idea of allowing more than a single service provider to share the same antennas, is an obvious proposal to alleviate the congestion. However, in the past, the sharing concept was thwarted by the fundamental drawback of all service providers being locked into the exact same sector antenna patterns. The problem is that different networks (e.g., operators with different air interfaces, frequency plans, network topologies, etc.) require vastly different sector configurations for optimum performance. This severe restriction of sharing the same antenna patterns ties the hands of the RF performance engineer, who no longer has the flexibility to optimize through traditional means. The resultant compromises in performance are far too great to outweigh the benefits of sharing.

The SmartShare&#153 antenna sharing solution solves this problem by enabling multiple operators to share a common set of antennas, while independently optimizing antenna patterns for their individual networks (Figure 3). Like SmartCell, SmartShare&#153 uses the same Cell Sculpting technology and Personality Module concept, except now each service provider has his own Personality Module to control.

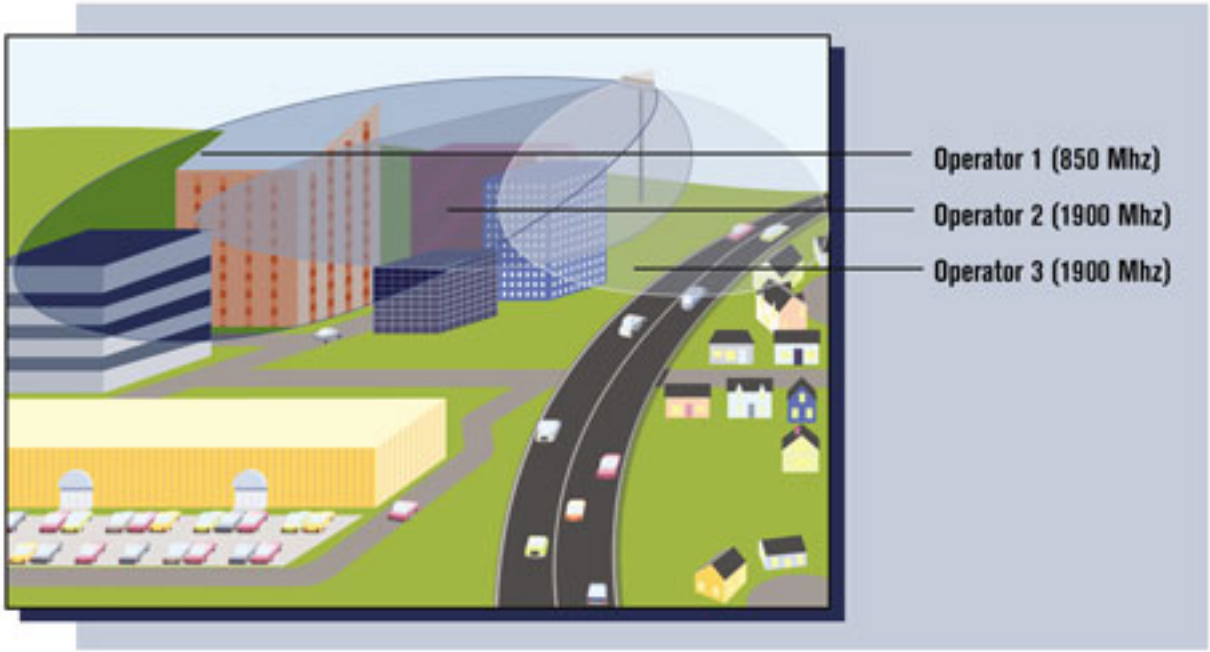

Figure 3. Adaptive smart antenna technology uses sophisticated algorithms to calculate custom, narrow beams that track each individual mobile as it moves about the network. Narrow beams significantly reduce interference and maximize capacity.

With SmartShare, multiple antenna arrays, each with an independent variable downtilt mechanism, are built into a single antenna enclosure giving each operator access to a separate array. The arrays are configured so that each service provider sharing the antenna has a distinct antenna pattern that is defined in a separate Personality Module. This provides each sharing operator with the flexibility of

designing his own unique antenna pattern, in effect, providing even more flexibility than the operator had in a traditional deployment without sharing. Wireless operators gain fast and economical access to the cell site locations they need, and the capacity, performance and flexibility not available with standard antennas.

Adaptive Smart Antennas for 3G

Of all the approaches, adaptive smart antenna technology yields the greatest capacity improvement by embedding the smart antenna processing directly into the base station electronics. Adaptive array processing implements the smart antenna functions at the digital baseband level in the transceiver as an integral part of the base station. Unlike the previous solutions presented, adaptive smart antennas are not add-ons to existing base stations, but rather new base stations that come off the factory assembly line with smart antenna capabilities built-in.

Adaptive smart antennas use algorithms to track a mobile's location and then to direct a custom, narrow beam to each subscriber. The narrow beams track the users in real-time as they move around the cell site. The advantage of a narrow beam is to radiate energy only in the direction of the desired mobile and thereby to minimize interference elsewhere (Figure 4).

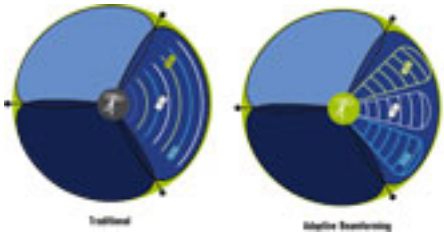

Figure 4. Unbalanced traffic is often a problem with traditional cell sites. SpotLight enables CDMA operators to balance traffic loads across the sectors of a cell site to increase capacity and quality. SpotLight also enables the implementation of six-sector configurations by minimizing handoff and interference.

Adaptive smart antenna systems in field trials today for CDMA2000 yield capacity increases in the range of 2.5 to 3 times greater than traditional deployments. For high rate data applications, the performance of adaptive arrays is unsurpassed. By combining the spatial processing of adaptive arrays with RF packet scheduling algorithms, data throughput increases of up to 3X can be achieved, greatly enhancing the viability of data-hungry services.

Which Smart Antenna to Choose?

The answer depends. A wireless operator could conceivably employ each of the different smart antenna technologies described at different stages in their network evolution, depending upon the immediate challenge at hand. Innovative smart antenna solutions have been proven to solve the most difficult problems of today's CDMA networks and will play an integral part of an operator's migration strategy to 3G technologies, such as CDMA2000 and WCDMA. Regardless of the implementation, one thing is certain: smart antennas are an economical means for operators to tackle tough problems, whether they are addressing capacity, quality,

coverage, optimization efficiency or antenna sharing.

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