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Wireless Broadband Requires Stronger Signals, Less Noise

Gary Breed
Editorial Director

Design efforts for wide bandwidth wireless systems like LTE and WiMAX are concentrated in key areas like: high efficiency/high linearity power amplifiers, better low noise amplifiers and mixers, high resolution/high dynamic range analog-to-digital and digital-to-analog converters, smart antennas and MIMO technology. At the system level, these techniques for higher performance are being applied to handsets and base stations, of course, but the real innovative work is in microcells, picocells, and inter-standard bridge systems (e.g., Wi-Fi to wireless network handoffs).

All of these efforts are aimed at delivering greater bandwidth for all the smartphones, pad computers and other wireles devices that are being welcomed by users with an ever-greater need for internet access, advanced applications, and high quality media like video, movies and online gaming.

Shannon's theorem tells us that the capacity of a communications channel is directly related to its bandwidth and the signal-to-noise ratio (SNR). The available spectrum puts practical and regulatory limits on bandwidth, so the most effective means of delivering more bits per second is to use advanced modulation schemes with sufficient SNR for reliable transmission. And making big improvements in SNR is not easy!

First, we can't just increase transmitter power. The cellular principle is based on shared frequencies, with enough physical separation to keep interference to acceptable levels. Increased power raises the interference (noise) level, so it has no advantage. As you might guess, the signal from the handset would also require more power, which just isn't going to happen given the need to conserve battery power, as well as the need to keep RF exposure at safe levels.

The design efforts for radio circuits will help in two ways. In the receive chain, high dynamic range helps keep strong signals from other channels, or other radio services, from creating distortion products that add to the noise level. On the transmit side, high linearity helps limit the amount of internally-generated distortion in the radiated signal, which can create noise for users on other channels. The "density" of intermod products from high-order modulation is a significant challenge for transmitter designers!

Another place for improving SNR is in the antenna system. Smart antennas steer a focused beam from the base station to the mobile user. This "spotlight" path is reciprocal—it works for both transmit and receive. However, it's not easy to automatically track the path of a mobile user, and effects like multipath can confuse the best systems. Thus, smart antennas can only be one part of an overall solution for more SNR.

The final piece of the puzzle is improving SNR by reducing the distance between the base station and the users. Scaling the size of a wireless network cell to the microcells or picocell level allows much shorter distance from the base station to the mobile user. Since signal strength follows the $1/r^2$ rule, where r is the distance from the antenna, reducing the distance by half will increase signal levels by a factor of four.

The complicating factor for these small cells is the need for backhaul to the central switching system, and the increased complexity of network management. These are the costs of implementing a system with greater data throughput. Central switching is already complex and can usually be scaled up in a straightforward manner. Backhaul using fiber optics or mm-wave point-to-point microwave can be augmented by setting up some picocells as repeaters.

One more avenue to higher capacity at the user's device is to utilize all the wireless routes available—the wireless provider's network, public Wi-Fi access points, and a Wi-Fi (or other technology) link to a high speed wired connection at home or office. A few products are already on the market for the latter of these methods.

Finally, you may be wondering how this month's photo relates to the subject of this column. It was taken at the recent Wireless and Microwave Technology Conference (WAMICON), and I'm standing with Justin Luther, a Ph.D. student at the University of Central Florida. His presentation was the winner of the best student poster, "A Microstrip Patch Electrically Steerable Parasitic Array Radiator (ESPAR) with Reactance-tuned Coupling." This research project is certainly in the realm of high performance wireless systems—a directive antenna with the capability of being tuned to maintain good impedance and radiation performance performance over a wide range of frequencies.

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