Migrating to the Wireless Internet with Software-Defined Radio

SDR technology is a viable solution for the expansion challenges faced by wireless providers.

By Terry Williams, AirNet Communications
Wireless data services are poised to become the next hot revenue-generating opportunity for service providers worldwide. Analysts project that by 2003, the number of wireless data users around the globe may approach 200 million &#151 a lucrative market driven by an exploding demand for information anytime, anywhere, and the proliferation of new tools designed to provide access.

While existing wireless networks may perform reasonably well for voice traffic, there is little question that major network overhauls will be required to also handle high-speed data applications using packet radio technologies like General Packet Radio Service (GPRS), Enhanced Data rates for GSM Evolution (EDGE), and third generation (3G) technologies.
By far the largest capital investment that wireless providers are making is in acquiring spectrum. For example, in Germany alone, 3G spectrum auction generated $78.6 billion from operators seeking to enlarge their capacity for wireless voice traffic and also enhance their positions in the emerging wireless Internet and enhanced data services markets.
To make the most of these costly spectrum investments &#151 and to achieve a competitive edge in an increasingly crowded marketplace &#151 providers today are turning their attention to maximizing the capacity of their cellular networks. Until recently, any capacity-enhancing effort would have meant a traditional build-out: acquiring more land for additional cell sites, applying for zoning and permits

from local governments, and building new towers. Today, however &#151 while such an approach is still an option &#151 the costs and time delays inherent are increasingly prohibitive, and the ultimate catch is that even with reallocation, available spectrum is still limited. Any spectrum that is available will be quickly devoured by bandwidth-hungry data services competing directly with voice traffic.
One solution to maximizing network capacity that is drawing serious attention from suppliers, service providers, and the FCC is the software-defined radio (SDR). The potential benefits of SDR technology have been extensively discussed at various FCC round-tables and other forums related to new technologies and spectrum use &#151 and by providers preparing for a new era of wireless services.
These discussions highlight that SDR technology provides a viable solution to the wireless industry as operators cope with the challenge of accommodating multiple protocols, migrating to new protocols, and responding quickly to changing capacity and service needs while minimizing capital-intensive network expansion. FCC Commissioner Susan Ness last year stated, &quot...SDR holds the potential to enhance our participation in the global economy, to access new services, and to utilize the spectrum more efficiently.&quot
Just what is it about SDR technology that makes it an ideal solution for many of the expansion challenges faced by wireless providers?

Enhanced Functionality and Flexibility

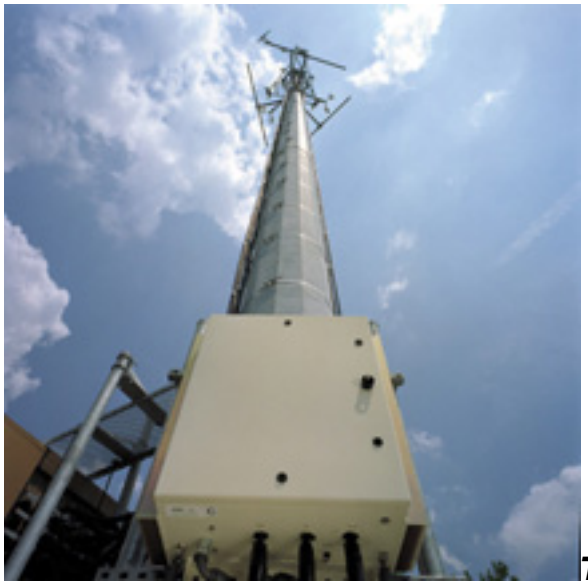
Traditional base station technology is based on narrowband, hard-wired logic that dates back some 60 years and has not substantially changed during the past two decades &#151 resulting in mounting feature and performance compromises as subscriber levels increase. Today's 2G base station architecture would require nearly complete replacement in order to upgrade to much higher data rates and feature sets. SDRs represent a quantum leap in base station technology that allows operators to dynamically distribute radio channel resources where and when they are most needed.
For example, in contrast to a hardware-based radio, which is capable of processing just one protocol, a software-defined radio supports multiple protocols, ensuring interoperability as digital transmission technologies move to GPRS/EDGE and then to 3G.
It is also likely that 3G standards will change due to market forces and technical advances. The ability to provide flexibility in the face of changing standards and conformity assessment schemes is one of the compelling value propositions of SDR.
In addition, varying regulatory requirements and market characteristics will force significant differences in spectrum usage for 2G systems around the world. It is likely that spectrum allocations will have to be flexible to accommodate many different legacy systems. Since SDRs are frequency agile, they can also ease any potential interface problems between such legacy networks.
Another requirement is the need to provide higher capacity and higher data rates for GPRS, EDGE and 3G networks. Operators must be able to provide a cost-effective solution to meet these needs. Since many of these new services will be deployed in conjunction with voice services, providers who opt for a hardware-based approach will face the costly task of installing a different base station to support each new service at each cell site, with no means of moving capacity between the base stations. This illustrates yet another strength of SDRs. In addition to the previously mentioned benefits, they can also incorporate advanced techniques, such as adaptive array antennas (AAA), to provide the radio frequency

(RF) quality necessary to support the enhanced bit error requirements of higher-speed data services. Adaptive arrays are able to process multiple signals simultaneously by simply downloading different software into different elements for spectrum processing.

SDR-based systems allow for software reconfiguration of frequency band, RF plan, and pilot structure. Changes and upgrades to new standards can be accomplished dynamically, often from a remote location, eliminating the need for providers to dispatch personnel and reducing the amount of hardware changes and provisioning required.

SDRs also have fewer components and offer higher capacity than traditional radio products, resulting in smaller size, and reduced deployment costs and operating expenses.

The AirNet&reg AdaptaCell&#153 Base Transceiver Station (BTS) is designed around the philosophy of software-defined radio and provides maximum flexibility in configuration and incorporation of future enhancements.



The AirSite&reg Backhaul Free&#153 Base Station, used in conjunction with AirNet's high-capacity, software-defined AdaptaCell&#153 BTS, provides backhaul-free operation for applications where low-cost coverage is the primary objective. In these applications, where there is typically an under-utilization of the available spectrum allocated to a GSM service provider, the AirSite eliminates the T1 or E1

interconnection to the cell site while also reducing infrastructure and deployment costs.

First SDR Solution

The first broadband, SDR solution was deployed by AirNet Communications in May, 1997. The company's broadband, software-defined AdaptaCell&#153 Base Transceiver Station (BTS) is based on patented radio architecture, and utilizes digital signal processing (DSP), analog-digital and digital-analog conversion (A/D and D/A), and multiprocessing technologies that make it possible to simultaneously process multiple radio carriers using a single broadband transceiver.

Narrowband architecture utilizes fixed hardware components for each RF carrier. Numerous narrowband transceivers are required, supported by an intricate interconnection scheme for multiple carriers. This often-unwieldy mix of equipment requires a complicated array of components and a large amount of cabling that seriously degrades the RF signal when more and more RF carriers are added. This complexity limits the maximum capacity of a cell site, requiring more elaborate means such as cell splitting and complex cell layering structures to achieve higher capacities.

By contrast, the SDR solution, exemplified by the AirNet&reg AdaptaCell BTS, allows providers to maintain the number of cell sites within a network and simply upgrade their SDR base station software, reconfigure their antennas, and immediately have twice the capacity and data rates of conventional base stations.

AirNet's patented technology utilizes a broadband receiver to downconvert a block of RF spectrum to an intermediate frequency (IF). This block of spectrum is then digitized, resulting in a very high data-rate digital bit stream representing the block of RF spectrum. The digitized IF signal is "channelized" using advanced DSP algorithms to isolate individual narrowband signals from the digital IF data stream. The narrowband signals are further processed by generic DSP microprocessors performing demodulation, equalization, and channel decoding functions.

A similar inverse DSP algorithm performs a digital &quotcombining&quot function. DSP microprocessors perform channel coding and modulation of a narrowband signal. Multiple narrowband signals are frequency multiplexed into a single wideband IF signal for transmission. The composite IF signal is converted to analog and upconverted by broadband transmitted to the appropriate RF frequency. This output signal is transmitted using a single ultra-linear multi-carrier power amplifier.

SDR and Adaptive Array Antennas

Another area where SDR holds a decided advantage is its ability to support the use of AAA, which has also emerged as a key technology for meeting the coverage, capacity and enhanced signal quality challenges faced by providers. Adaptive array technology reduces interference, improves voice quality, increases data throughput, and conserves signal power by focusing energy directly toward the end user.

Cellular systems are prone to interference and poor voice quality due to the fixed-directional transmission of RF signals. In traditional base station systems, the wide area dispersement is necessary because the user's location is unknown. This dispersed transmission pollutes the electromagnetic environment by radiating most of the transmitted power in unnecessary directions. In contrast, adaptive array systems determine a user's location and attempt to focus and receive energy only in desired directions.

By adjusting to an RF environment as it changes, AAA technology can dynamically alter the signal patterns to optimize performance of the wireless system. The

adaptive approach uses sophisticated signal processing algorithms to continuously distinguish between desired signals, multipath, and interfering signals, and calculate their arrival direction. It continuously updates its beam pattern based on changes in both the desired and interfering signal locations. A software-defined radio is able to quickly incorporate these algorithms.

The adaptive system can continue to distinguish between the signal and the interferer and allow them to get substantially closer while maintaining superior C/I levels. The adaptive array system will hand-off any two co-channel users, whether they are intercell or intracell, before they get too close and begin to interfere with each other.

Until recently, cost barriers have prevented the application of AAA technology in most commercial applications. The advent of low-cost digital signal and general-purpose processors, broadband radios, and innovative algorithms have made adaptive antenna systems practical at a time where spectrally efficient solutions are an imperative.

AirNet Communications Corporation has incorporated the advances in adaptive array signal processing technologies into its new broadband, software-defined AdaptaCell&#153 Super-Capacity&#153 Base Station. Using this adaptive array platform will improve the quality, capacity and throughput of the network &#151 maximizing the use of the operator's radio spectrum. The improved throughput enables the new super capacity base station to handle more traffic through any given cell. This capacity improvement will allow operators to significantly increase the number of users within their coverage area, and provide additional high-speed data services &#151 such as the wireless Internet &#151 without adding new base stations or towers.

The Best Choice for a Changing Wireless Future

Technical issues related to 3G remain, but it is certain that providers of the wireless Internet will face the challenges of dealing with multiple frequencies and standards, and a wide variety of legacy architecture. By allowing the same hardware to support different protocols and by dynamically and easily adapting to new standards as they emerge, SDR represents a viable &#151 and proven &#151 infrastructure expansion solution for service providers seeking cost-effective migration to enhanced data services and the wireless Internet.

SDR can help providers move to the next generation of wireless technology seamlessly, without making costly hardware investments obsolete, and also adapt to changing market conditions by easily and quickly re-allocating resources. SDR that seamlessly integrates adaptive array technology will be the key enabler for the integration of new standards and services that will propel providers into the lucrative wireless Internet market.

Terry Williams is the director of systems engineering for AirNet Communications, located in Melbourne, FL. Terry can be reached at (321) 984-1990.

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