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ARTICLES

Software Radio in Wireless Applications: A Revolution through Software

By Marty Gilbert

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Wireless communications infrastructure manufacturers have traditionally developed single-standard, high-power, high-capacity networks to address the need for cellular coverage over large areas. These networks were intended to support a specific wireless standard and run for ten or more years in order to provide a reasonable return on investment before requiring upgrade. As the need for wireless communications continues to increase, new wireless standards are appearing, the number of licensed frequency bands is multiplying, and the pace of innovation is accelerating faster than ever. Since the cost to implement a dedicated network for each new standard is so high, carriers are looking for ways to increase their capabilities in order to support different wireless standards without duplicating their infrastructure investment. Furthermore, smaller carriers, as well as carriers with remote coverage areas, are looking for ways to cost-effectively introduce new technologies and functionality in order to stay competitive and generate new roaming revenue opportunities.

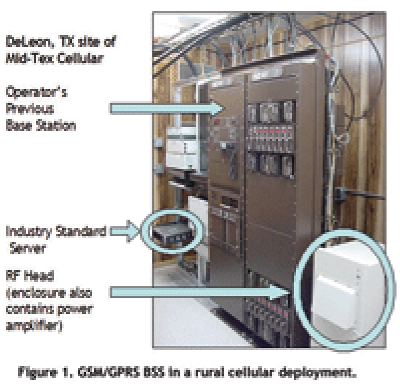

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Figure 1. GSM/GPRS BSS in a rural cellular deployment.

Carriers today need a solution that enables them to operate multiple standards simultaneously on a single platform, while being flexible, scalable and portable enough to be cost-effectively adapted to all types of RF coverage and functionality needs. Fortunately for them, the solution exists, and it's called software radio.

Software Radio — also known as software-defined radio (SDR) — provides wireless operators with the ability to deploy each new technology (GSM, CDMA and beyond) entirely in software, obviating the need to purchase a new set of high cost, proprietary hardware. Software radio solutions can deliver a full range of capital (CAPEX) and operational (OPEX) cost savings, including: no hardware duplication as new technologies are added to the network; the ability to run multiple standards simultaneously on a single platform; use of commercial off-the-shelf computing servers to ensure high performance, low cost hardware; remote software downloads from a central location to increase system capacity or add wireless standards; and significantly less backhaul expense due to its IP-based solution.

Current Cellular Infrastructure Methods versus SDR

Traditional wireless communications work like any other radio — an antenna and a transceiver detect and transmit radio waves. The receiver filters and down-converts these waves into signals that are digitized and further processed by either a digital signal processor (DSP), a field-programmable gate array (FPGA), an application-specific integrated circuit (ASIC) or a combination of the three. The transmitter employs similar components to generate and process digital signals at baseband and up-converts them to analog waveforms. The result is sound or data that is received from or transmitted over the air by the wireless device.

The intent of software radio is to separate the wireless standard from the hardware platform by developing wireless technology standards — GSM, CDMA, 3G and beyond — in software. This approach is possible by taking advantage of the increases in computing power as chip makers succeed in making computers run faster. This enables a software radio solution to ride the Moore's Law price performance curve, where computer processing capabilities double every 18 to 24 months.

However, while the intent of software radio sounds simple, implementation of new standards in software is far from easy. Designing a single antenna with uniform gain across a wide range of frequencies, filtering received signals, efficiently amplifying the power of transmitted signals, and performing wideband analog-to-digital conversion were challenges that needed to be overcome before Software Radio in wireless communication became truly viable.

Software Radio Technology

Software radio technology provides substantial advantages over hardware radios by implementing signal-processing software as application-level programs running on top of a standard Linux or POSIX-compliant operating system. This method delivers a number of key advantages for wireless manufacturers and providers, including:

•Enabling wireless carriers to deploy a network and then cost-effectively add or change the services and standards they support as technology changes, instead of making an up-front financial commitment to a service standard. •Maximizing software portability to minimize the time, effort, and cost of re-implementing software. As faster processors are introduced, they can be integrated into
new software radio products quickly and with minimal expense.
•Partitioning the software to emulate the building blocks familiar to RF design engineers. These building blocks can be re-used across many different RF environments (e.g., indoor, outdoor, urban, rural), minimizing time-to-market for wireless carriers deploying new technologies.

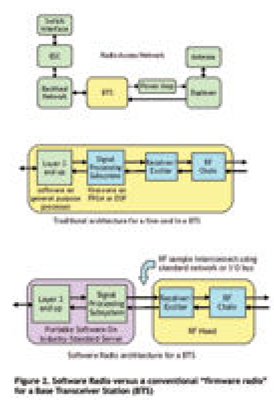

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Figure 2. Software Radio versus a conventional "firmware radio" for a Base Transceiver Station (BTS).

Software Architecture Across all Systems

Wireless standards are made up of two parts, with significantly different portability challenges. The control part configures and controls the system, and implements higher-level functions such as protocol state machines and network routing. The signal processing part implements the high-speed transforms between user data and a sampled representation of a RF wireless standard.

The signal processing component consists of a middleware layer that performs data transfer and module integration, and a library of signal processing modules for functions such as FM modulation, Viterbi encoding and FIR filtering.

The control component is a portable, modularized software application written in C or C++. Where possible, software executables are automatically generated from higher-level descriptions, such as state charts, reducing design time and increasing assurance.

Software costs are a significant and growing component of software radio engineering costs. In all but the highest volume applications, the development cost of the software is a major part of software radio device unit cost.

Bringing modern software engineering techniques to bear on high-speed signal processing is a significant challenge. Traditional approaches to building signal processing software result in high overheads for abstraction, modularity, and similar software engineering techniques.

Software portability is the key lever available to dramatically reduce software costs and development time.

With portability, there is no need to develop each wireless standard from scratch for each new platform. Every module that is ported reduces testing cost and time in addition to development.

Software radio devices designed for wireless standard portability lead to a quantum leap in benefits for users. Portability is what will make it affordable to deploy many standards to many platforms and to upgrade platforms over time with improved capacity. In short, a high level of software portability is essential for software radio to deliver the promised transformational impacts on user applications and operations.

Software Radio in the Real World

The future for software radio will include devices that seamlessly handle a range of frequencies and multiple wireless standards. In the end, software radio has the potential to replace many existing mobile devices.

Currently, software radio is finding specific wireless infrastructure advantages in cases where wireless operators incur high CAPEX and OPEX costs for upgrading their existing network. An example is rural area cell phone coverage. A case in point is Mid-Tex Cellular, a rural carrier with 14,000 customers in central Texas, with a territory 100 miles long by 75 miles wide. Mid-Tex chose to deploy SDR in order to offer GSM/GPRS services to its existing TDMA customers, and to gain the flexibility to add additional cellular standards in order to strike new roaming agreements with national carriers. Mid-Tex previously operated a TDMA analog network that required two large racks at each base station site.

Mid-Tex selected the Anywave® base station from Vanu, Inc. as the technology platform for this upgrade. Today, equivalent functionality for GSM/GPRS executes on a single rack-mount IT-grade server. The BTS server and RF head are co-located at the antenna sites, while the BSC and other functions are centralized. Backhaul in a typical rural deployment such as Mid-Tex occurs over leased T1 lines and microwave links and requires dedicated backhaul for each wireless standard. With Vanu's software radio solution, however, multiple standards are served by a single BTS, thereby significantly reducing backhaul costs. Industry-standard routers provide IP connectivity between the remote sites and the central BSC. The BSC itself is implemented on IT-grade servers, connected by Gigabit Ethernet links. The Mid-Tex GSM/GPRS network entered into commercial service early in 2005 and continues to scale month by month to support more users with 27 BTS sites up and running, servicing 4,000 subscribers on the GSM/GPRS network, and billing more than 2.3 million minutes of use (MOUs) per month. Mid-Tex is now certified and carrying GSM roaming traffic for both Cingular® and T-Mobile®, securing incremental and ongoing sources of revenue.

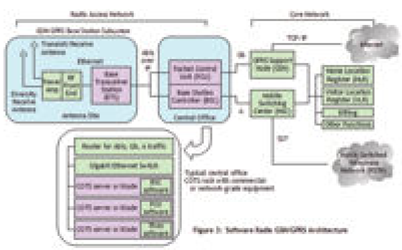

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Figure 3. Software Radio GSM/GPRS Network.

Another ideal application for software radio is in remote sites, where network access to the cellular switch or PSTN is expensive and/or intermittent. Examples of this could be a remote village, an offshore oil rig, a cruise ship or an airplane. A remote site of particular interest to network operators is the home base station, where a low-cost femtocell (utilizing broadband Internet backhaul) in a customer's home provides dramatically improved residential coverage and enables the elimination costs associated with landline telephone service.

Other software radio applications are picocells. Picocells provide "fill in" coverage for areas with dense traffic patterns or in enterprise environments where a smaller footprint is needed in order to increase capacity and spectrum efficiency. Due to its small, easily deployable form factor, software radio is also useful for temporary coverage during emergencies and special events. In addition, a software radio base station can be mounted into a vehicle and driven to the site of a natural disaster to bring in communications where they may have been damaged and to support multiple standards.

Because a software radio base station is written in portable software, it is not locked to a specific processor and can take advantage of Moore's Law. Software radio base stations benefit from new processors as they increase in performance and capacity every 18 to 24 months. These technological advances in the processing power of CPUs enable software radio companies like Vanu, Inc. to transform the promise of software radio into a reality.

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