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Software Radio For Cost-Effective Growth Opportunities for Rural Carriers

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Introduction

For cellular carriers in rural areas of the developed world, the increasing pace at which new wireless network standards and additional spectrum are being introduced presents both challenges and opportunities. To meet escalating market demands for new and compelling services, carriers must decide whether to upgrade to new digital and broadband standards or risk becoming less competitive and losing market share and roaming revenue opportunities in the process. Typically, these deployments require expensive and time-consuming network build-outs. Investing in a discrete hardware infrastructure for each wireless standard is simply not affordable for many carriers, especially those serving rural areas and operators in emerging markets overseas. Yet if carriers can't implement new and future standards, they put their current and future business in jeopardy.

The solution? Software Defined Radio (SDR), and more specifically, the type of SDR known as Software Radio, where a radio access network (RAN) is implemented using off-the-shelf hardware and portable software.

Traditional Infrastructure Doesn't Meet the Needs of Rural Carriers

Traditionally, wireless infrastructure manufacturers have developed single-standard networks to address cellular coverage needs. These dedicated networks require extraordinary financial investments and a long lead time to generate positive financial returns. Each time a new technology and standard has emerged, carriers have had to make another large investment to build a new network. Each wireless standard has required its own dedicated radio access network (RAN), mobile switching center (MSC) and team of field service installers. For a rural carrier, dependent on a relatively small subscriber base and roaming agreements with nationwide carriers, this presents a tremendous challenge. Most rural carriers can't economically justify the implementation of a dedicated network for each standard they wish to deploy.

Rural carriers need a way to cost-effectively adopt—and profitably operate—multiple standards using their existing spectrum, towers, antennas, shelters, and other infrastructure. Furthermore, traditional outdoor macro network designs do not provide financially viable solutions for effective in-building enterprise and home coverage, the fastest growing wireless environments today.

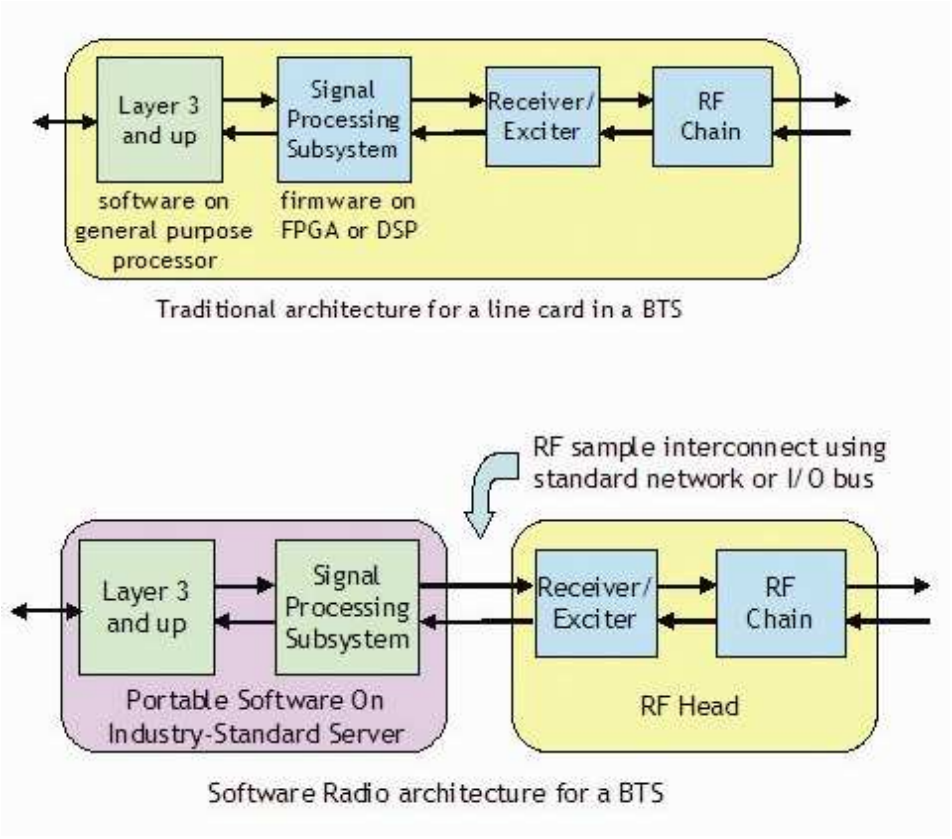
With Software Defined Radio, upfront equipment costs can be substantially lower than traditional equipment suppliers. Moreover, SDR enables multiple standards to operate simultaneously within a single base station platform. Additionally, new standards or additional system capacity can be downloaded remotely via the Internet to each base station so costly site visits are significantly reduced. Finally, if the SDR is implemented using Software Radio technology, the rural carrier can select from a wide range of hardware configurations to meet a full array of RF coverage requirements including: outdoor macro, enterprise, residential and disaster recovery.

Different Types of Software Defined Radios

The terms Software-Defined Radio and Software Radio are often used interchangeably. It is valuable to distinguish the two. SDR describes an overall technology within which there are two design approaches, Firmware Radio and Software Radio. Most wireless infrastructure manufacturers today use a Firmware Radio approach. Their systems depend heavily on dedicated digital signal processors (DSP), field-programmable gate arrays (FPGA) or other low-level reconfigurable processing engines such as a system-on-a chip (SOC) with an array of hundreds of DSPs. The "software" built to implement various communications standards in these SDRs is actually firmware: low-level embedded code tied to the particular processor and board for which it was written. Software Radio differs significantly from Firmware Radio in that almost all signal processing functions are implemented in portable high-level code. In today's Software Radio systems, general-purpose processors running standard operating systems support the signal processing functions. The resulting systems are far more flexible and economical than Firmware Radio systems, because they eliminate hardware lock-in.

Hardware lock-in is characteristic of Firmware Radio. The manufacturer's investment is tied to a particular hardware platform. With each passing year, the platform falls farther behind the performance available with state-of-the-art components. The manufacturer cannot quickly deliver hardware improvements to customers because it is so expensive to re-implement the communications standard for a new processor or board.

Software Radio eliminates hardware lock-in. The manufacturer can move the software implementing wireless communications standards to a range of platforms and can introduce new platforms inexpensively. This provides direct and significant benefits to carriers. Because the manufacturer can quickly and cost-effectively adopt improved components or entire platforms as these appear in the commercial marketplace, the carrier always gets the best available price-performance when an order is placed. Furthermore, because the manufacturer can amortize its software investment across markets that require different hardware platforms (e.g., urban, rural and in-building), the initial cost to the carrier is reduced.



The Benefits of Software Radio

The Software Radio approach to SDR, using portable software on standard hardware, provides powerful benefits to rural carriers looking to upgrade to new digital and broadband networks. A few of these advantages include:

Software Radio easily supports simultaneous operation of multiple wireless standards – In the same way that an IT server runs multiple and different applications, a Software Radio solution can support all current standards (GSM, CDMA, iDEN, etc) and has the ability to remotely download new standards as they are introduced. Multiple standards can operate at the same time within a single base station (BTS). While this capability is theoretically feasible for Firmware Radio designs, in practice the firmware design approach has made it extremely difficult for manufacturers to implement simultaneous multi-standard operation. With Software Radio, in contrast, it is straightforward. Simultaneous operation of multiple standards, in turn, provides ongoing benefits to the carrier. It reduces site rental and electrical utility costs due to a smaller BTS footprint with fewer hardware requirements. It reduces backhaul costs through sharing of IP-based backhaul links across multiple standards. It reduces administration and maintenance costs through managing only a single system for the multiple standards. Finally, the carrier can dynamically reallocate resources (e.g. spectrum, transmit power) among standards as the customer load changes.

Software Radio uses an open standards approach to hardware – Unlike Firmware Radio which is limited to the specific hardware that it's designed for, Software Radio can use any off-the-shelf platform, ranging from cost-effective high volume servers to high-reliability environmentally tolerant systems. This avoids locking the carrier in to a single source of supply, a situation that is typical when acquiring base stations from traditional wireless infrastructure manufacturers.
Software Radio enables the carrier to tailor call capacity per cell site – Firmware Radio uses custom hardware designs that are tied to specific capacity levels. Software Radio gives carriers access to a great diversity of off-the-shelf servers, enabling the carrier to select the precise capacity desired for current needs or planned growth. There is no need to "over-buy".

Software Radio delivers improved price-performance over time – With Firmware Radio, each product is tied to a particular hardware platform that is used throughout the product's lifecycle. That platform quickly becomes obsolete over time. Software Radio, using standard servers, actually improves in price-performance over time, due to Moore's Law improvements in the underlying server platforms. As the carrier expands its network, newer sites or site capacity expansions always exploit the latest advances in computing capabilities.

Software radio reduces site visits and speeds deployment – If standards growth or system capacity increases were planned when the hardware was purchased, carriers can add new wireless standards or increase traffic channels quickly via remote software downloads from a single location. Costly cell site visits are significantly reduced and new wireless standards and additional channels can be added to multiple sites within hours instead of weeks. Faster deployment means quicker revenue realization.

Vanu® Anywave® – A Proven Implementation of Software Radio

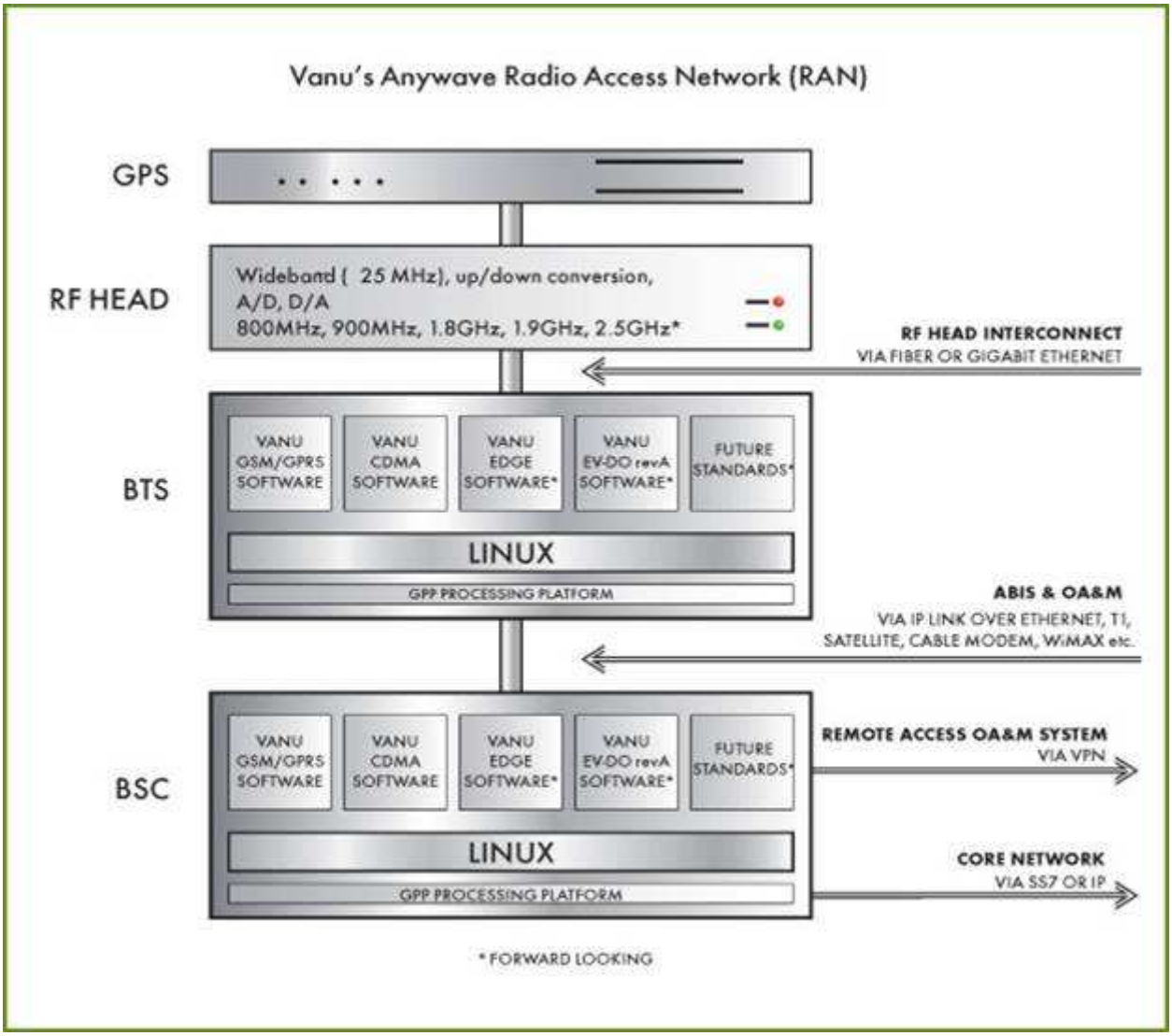
The Vanu® Anywave® Base Station is the most complete realization of the Software Radio vision anywhere in industry. Each wireless standard (GSM, CDMA, iDEN and more) is developed in the form of Vanu's Anywave software. This technology sits on off-the-shelf, industry-standard servers, which are used for all signal processing and higher layer functions. The Anywave Base Station is available in both server and blade chassis configurations so that it scales more easily and cost-effectively than traditional base station architectures, while occupying a small footprint. Its open standard hardware approach enables flexibility that translates into significant savings in both capital and operating expenses. Each server or blade simultaneously supports multiple channels and/or multiple wireless standards. A quick break down of the Anywave base

station components includes:

- An RF head performs RF up/down conversion, digitization, and digital channel filtering. It exchanges multiple digital baseband sample streams with the processing platform.

- A multi-carrier power amplifier (MCPA) takes in the low-power RF transmit signal from the RF head and boosts it by as much as 60 dB. The MCPA is designed to support simultaneous amplification of multiple wireless standards within a 25 MHz bandwidth.
- A GPS unit provides a highly accurate timing reference to the RF head. Both 10 MHz and 1 pulse-per-second references are used by the base station to achieve the required frequency accuracy and to synchronize it with other base stations.

- A processing platform runs the software wireless standards on top of a standard operating system like Linux. The processing platform is made up of one or more processing units, either embedded, rack mount or blade.



The Anywave Base Station is part of the Anywave RAN, which uses native IP throughout for signaling, voice, data, and management. Any desired backhaul links can be used (e.g. T1/E1, Ethernet, satellite and microwave). Because IP is used throughout the Anywave RAN, cost-effective commercial switches, bridges and routers are available, as well as tools for network monitoring and maintenance. The burst-like data traffic characteristic of 2.5G and 3G

cellular standards can be efficiently multiplexed over IP, allowing for operating cost reductions in BTS backhaul not possible with traditional infrastructure equipment designs.

The Anywave RAN connects to the carrier's mobile switching center (MSC). Multiple switch interfaces are available that gateway the IP-based Anywave RAN to legacy protocols such as SS7, GSM A or CDMA IOS. The Anywave base station controller (BSC) interfaces directly to advanced soft-switches. For military, government and PBX applications, a SIP interface to standard VoIP switches is also supported.

Vanu's Software Radio in Action

Mid-Tex Cellular is one example of a rural carrier who has acquired Vanu's Software Radio solution to meet its business objectives. With 14,000 customers in central Texas (a territory 100 miles long by 75 miles wide) Mid-Tex chose to deploy the Vanu Anywave RAN in order to offer GSM/GPRS services to their existing TDMA customers, and to gain the flexibility to add future cellular standards in order to strike new roaming agreements with national carriers. Mid-Tex is currently testing CDMA with its existing Anywave GSM/GPRS base stations and plans to start commercial service by third quarter this year, thereby becoming the world's first carrier to simultaneously operate GSM and CDMA from the same base stations.

Mid-Tex previously operated a TDMA network requiring two large racks at each base station site. Now, the equivalent processing capacity for GSM/GPRS executes on a single 2U high IT-grade rack-mount server. The BTS server and RF head are co-located at the antenna sites, while the BSC and other functions are centralized. Backhaul uses leased T1 lines and microwave links, which is typical for rural deployments. 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.

The Mid-Tex GSM/GPRS network entered commercial service early in 2005 and continues to scale month by month to support more users. As of May 2007, Mid-Tex has 31 Anywave BTS sites serving 7,400 local subscribers on the GSM/GPRS network, and is billing more than four million minutes of use (MOUs) per month. Mid-Tex is now certified and carrying roaming traffic for both Cingular® and T-Mobile®, securing incremental and ongoing sources of revenue.

The small footprint of the Vanu Anywave RAN and the use of remote software downloads have contributed to additional savings in operating expenses. Its advanced management capability has enabled Mid-Tex to perform many tasks remotely that used to require going to each site. The IP-based connectivity of the system has resulted in decreased backhaul transport costs and has allowed Mid-Tex to easily re-allocate channels and capacity across base stations.

Another commercial deployment of the Vanu Anywave RAN is the ***Arctic Slope Telephone Association Cooperative (ASTAC) of Alaska***. ASTAC selected the Vanu Anywave RAN to support expansion of its analog system to GSM, because of the Anywave RAN's ability to simultaneously operate multiple standards in a single network. A critical benefit for ASTAC was also the reduction in the need for BTS site visits in an environment with extreme weather challenges. ASTAC's GSM base station sites have created new roaming revenue opportunities for the company, with incremental roaming possibilities if they add more wireless standards onto the same network in the future.

In one incident that combined all these benefits, ASTAC experienced a surge in traffic and needed to double the capacity of a particular site as fast as possible. ASTAC was able to leverage the remote software download capability of the Vanu Anywave RAN to deploy the new capacity without any site visits—the effort was completed in just four hours. This resulted in a significant increase in roaming revenues generated by that site and was instrumental in reducing the threat of overbuilding by another carrier, who now saw their customers being adequately served by ASTAC when roaming in that region. Normally, upgrading some other manufacturer's legacy base station would have entailed ordering line cards, waiting for delivery and then installing them at each individual site—a process that can take up to two weeks or

more. In the rugged, remote North Slope of Alaska, it could have taken much longer. The Vanu Anywave solution leveraged the capabilities of Software Radio to meet ASTAC's critical operational needs quickly.

The Road Ahead…

New standards, new frequency bands, new competitors and demand for new services will continue to provide opportunities for rural carriers. Software Radio solutions, like the Vanu Anywave RAN, enable operators to exploit those opportunities. The key benefits are "one network, multiple standards" that provides substantial CAPEX and OPEX savings, and future-proofing that enables carriers to add features, standards, or capacity through remote software downloads. Additionally, through the use of off-the-shelf hardware platforms, carriers gain access to an abundant choice of vendors, price-performance continually gets better over time (Moore's Law) and an open standards hardware architecture prevents carriers from getting locked into proprietary, sole source procurements.

Software Radio can help operators expand their offerings and reduce costs, which will help them to compete more effectively in a constantly changing marketplace. Cost-effective coverage combined with high flexibility—it's what carriers have hoped for in the past, and what will enable them to succeed—today and into the future.