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Filling The Generation Gap With SOFTWARE-DEFINED, BROADBAND RADIO

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With "third generation" (3G) wireless technology just around the corner and seemingly everyone looking to get a leg up, it's no wonder that software-defined radio (SDR) has become a focus of attention. Due to their inherent flexibility and adaptability, software-defined radios offer the most secure path for service providers as the approaching GPRS (General Packet Radio Service), EDGE (Enhanced Data rates for GSM Evolution), and 3G standards become realities. It is also important to consider the impact that broadband technology, which is expected to be an ITU-mandated requirement for 3G systems, will have on base station design. Considering these issues as a whole, software-defined, broadband base stations provide significant advantages in the rapidly changing field of wireless technology.

ADAPTABILITY

Traditional hardware-defined base stations are a complex mixture of radios, control architecture, and communication and control infrastructure. Many separate transceivers provide the communication pathways for the transmission of user signals, and subscriber conversations must be aggregated, digitized, and multiplexed within the communication infrastructure. The biggest problem with this architecture is that the signal processing, because it is performed by fixed hardware components, cannot be easily updated.

A "hardware radio" can process only one type of protocol. In contrast, the software-defined radio is able to do this for multiple protocols, such as AMPS, GSM, and CDMA. A software-defined radio can be easily upgraded from one standard to another simply by loading different software into the processing elements. The ability to fundamentally change the way a wireless base station operates through software upgrades rather than expensive hardware replacement is a valuable asset in the fast-changing world of wireless technology.

Broadband software-defined radios also have the ability to process more than one type of signal at the same

The Operator	Backhaul Free	Backhaul Intensive
• Business Profile. • **2 million population.** • **Average monthly revenue per user — $48.** • **Cost of money — 12 percent.** • **Handset subsidy — $45.** • 0.75 percent penetration year one. • 12 percent interest rate for equipment financing.	• Cash flow break even end of year two. • $50M valuation fifth year (10x EBTD). • IRR of 35 percent from EBTD stream. • Cash requirement $17M over 10 years.	• Cash flow break even end of year three. • $0 valuation fifth year (still incurring losses). • IRR of 15 percent from EBTD stream. • Cash requirement $34M over 10 years.

Table 1. Profitability chart for typical independent operator.

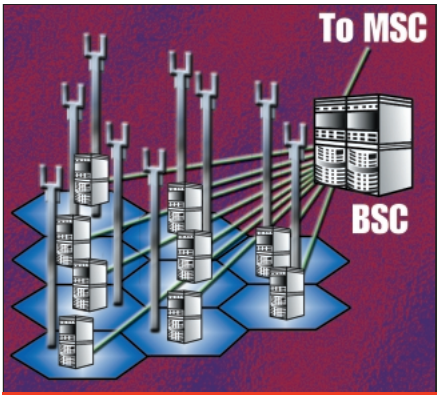

Figure 1. Conventional backhaul with one T1 span per base station. A backhaul with 9 cells means a $162,000/year T1 cost.

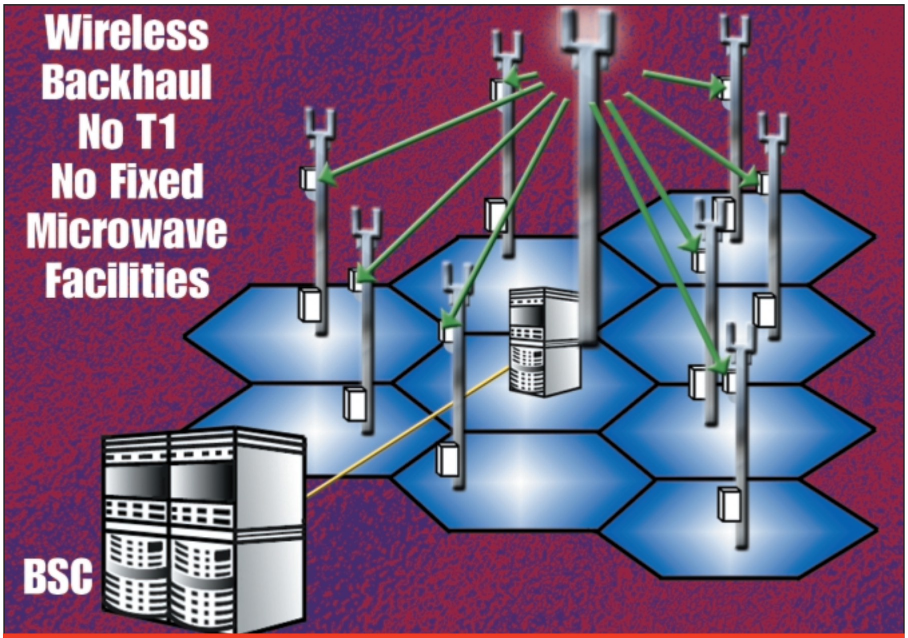

Figure 2. BSS with one T1 serving 9 cells leads to a $18,000/year cost.

time. For instance, since analog AMPS and digital TDMA (IS-136) share identical spectrum and channel bandwidths, they can be processed simultaneously by downloading different software into different SDR elements assigned to process the spectrum. This also means that as the population of subscribers changes and new air interface protocols need to be supported, the base station can be dynamically reconfigured, shifting resources to optimally serve subscribers' needs.

COMMERCIAL ATTRIBUTES OF SDR

The Backhaul Problem

One of the biggest problems wireless operators have is backhauling traffic from the base station to Base Station Controller (BSC), which then connects to the MSC and PSTN. Traditionally, service operators have to lease a T1 line from a CLEC or LEC. Deploying a new copper T1 facility or fixed microwave facility is also an option, but no matter which way you do it it's going to cost (Figure 1).

The broadband, software-defined base station solves this problem handily. By using some of the RF spectrum to backhaul traffic from remote base stations to a centralized broadband, software-defined base station, the service operator saves the cost of one T1 line per remote base station deployed in this manner. Thus numerous base stations can be deployed off of only one T1 line (Figure 2).

Considering the high cost of backhaul, it is easy to imagine how much an operator can save in operating costs. In some of the rural places operators deploy services, a T1 line can cost as much as $2,500 a month — particularly if the operator has a wireless system which crosses LATA boundaries. Accruing monthly, leased backhaul costs add up to be a considerable amount.

Eliminating this recurring expense lets service operators use precious capital to expand other aspects of the business. For example, let's assume a typical wireless service provider with 2 million total pops, a 0.75 percent subscriber penetration rate, $48 average monthly revenue per subscriber, and a 12 percent annual interest rate for equipment financing. By eliminating recurring backhaul costs, this operator becomes cash-flow positive one year earlier, becomes profitable by the end of year five, and requires half the total cash over a ten-year period versus a traditional nine solution (Table 1).

In addition, software-defined base stations contain fewer components than their hardware-defined counterparts. Fewer components means lower overall cost and smaller footprint. The low cost, small size, and low power consumption allow operators to deploy software-defined base stations in new and innovative ways. For example, customers may mount the base stations on telephone poles or billboards, thereby reducing the time and cost associated with deploying a conventional cell-site by eliminating zoning and tower construction issues.

This "backhaul-free" architecture can also be used to solve coverage hole problems. In any deployment, there are always coverage gaps. For example, a particular office complex may not have adequate in-building coverage. With the above architecture, this issue is easily solved by installing one of the base stations that do not require a backhaul link. The compact base station can be quickly and cost-effectively installed on the building.

This type of architecture also allows the service operator to continually modify his network to meet coverage and capacity demands. Because lines do not have to be relocated, base stations can be quickly and easily moved to match changing usage patterns. This allows the operator to add system capacity in a pay-as-you-grow fashion as opposed to deploying a traditional, high-cost, full-capacity infrastructure and then hoping revenues catch up.

The Future Standards Problem

Wireless telephony is driven by standards. Today there are four main wireless air-interface standards: analog AMPS, and the digital standards IS-136 TDMA, GSM, and IS-95 CDMA. In the future it is likely that AMPS will remain popular in less developed regions because it is less costly to deploy and simpler to support. In the rest of the world GSM enjoys dominance. IS-136 and IS-95 are confined primarily to North America, but there is some impetus behind the notion of IS-95 as rival to GSM as a world standard.

Generally speaking, most observers believe that IS-136 TDMA and GSM will eventually coalesce into one new standard. The fact that GSM is in essence a TDMA protocol lends credence to this notion. Also, the immediate need for high-speed data services (for which IS-136 is poorly designed) virtually guarantees that GSM and IS-136 will begin to converge.

Of course, that presents a big problem. There are millions of GSM and IS-136 handsets in subscriber hands, and they're not going to go away just because base station manufacturers feel the need to merge air interfaces. Clearly, operators with base stations that can dynamically support both GSM and IS-136 handsets will be dollars ahead. Only a software-defined, broadband base station offers this level of flexibility.

And when all those GSM and IS-136 handsets are long gone, the software-defined base station is easily upgraded to support the next generation of VoIP-based cellular/Web browser handsets everyone says we'll all be carrying around in a few years.

Evolution To The High-Speed Data Network

High-speed data services will be incrementally deployed over the next few years starting in those markets with the greatest requirement for data.

The first of these new services, GPRS, is a 115 Kbps packet data service. The successor to GPRS is EDGE, a 384 Kbps packet data service. The third phase of data evolution is to 3G, which will offer data rates up to 2 Mbps. These new services will be deployed as overlays to the existing network — first GPRS, then EDGE, and then 3G (Figure 3).

This means that in some areas as many as three different base stations will be deployed at each cell site: GSM to provide voice and low-speed data, EDGE to provide high-speed data, and 3G to provide very high-speed data. Obviously, this is an unattractive proposition for the operator. Overlays will be expensive — requiring multiple base stations at each cell site — and inefficient — because there will be no way to move capacity from one base station to another (e.g., voice to high-speed data) without adding even more hardware. The software-defined base station can support multiple protocols on one hardware platform with the ability to dynamically move capacity from one service to another as required.

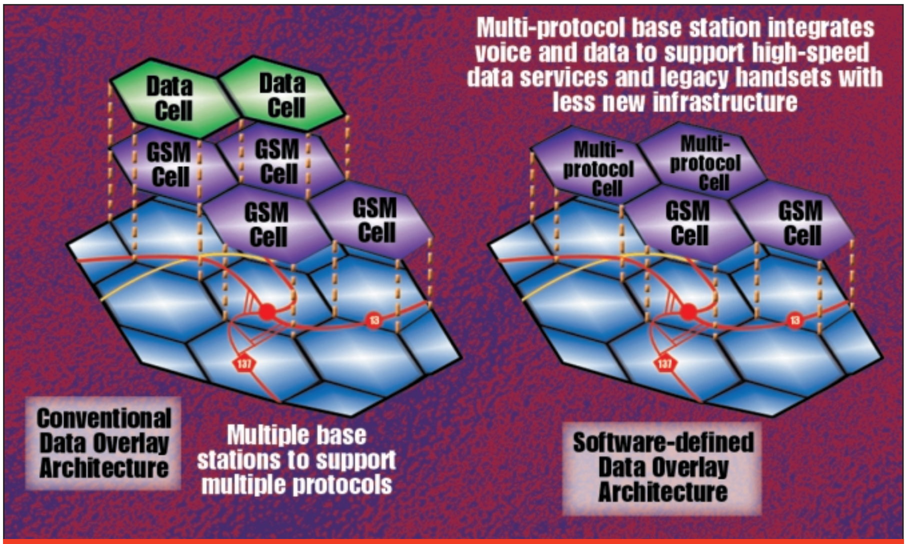

Figure 3. Overlay architecture for high-speed data.

The Base Station That Keeps On Giving

Wireless base station technology is beginning to change, and it's changing fast. In summary, here are just two reasons why SDR base stations translate into lower cost wireless services for everybody:

Common Hardware Platforms: The same hardware may be used for a variety of products and air-interface protocols. A manufacturer can buy components in higher quantities and save on volume discounts. That means lower-cost base stations and lower-cost services.

Programmability: As standards change and features are added, the base station can adapt with little or no hardware impact. Future air interface standards like EDGE and 3G will require major hardware changes including expensive "forklift" replacement of traditional base station hardware. Software-defined, broadband base stations let wireless service operators reap the benefit of lower future capital costs. And that means wireless subscribers reap the benefit of lower per-minute service charges.

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