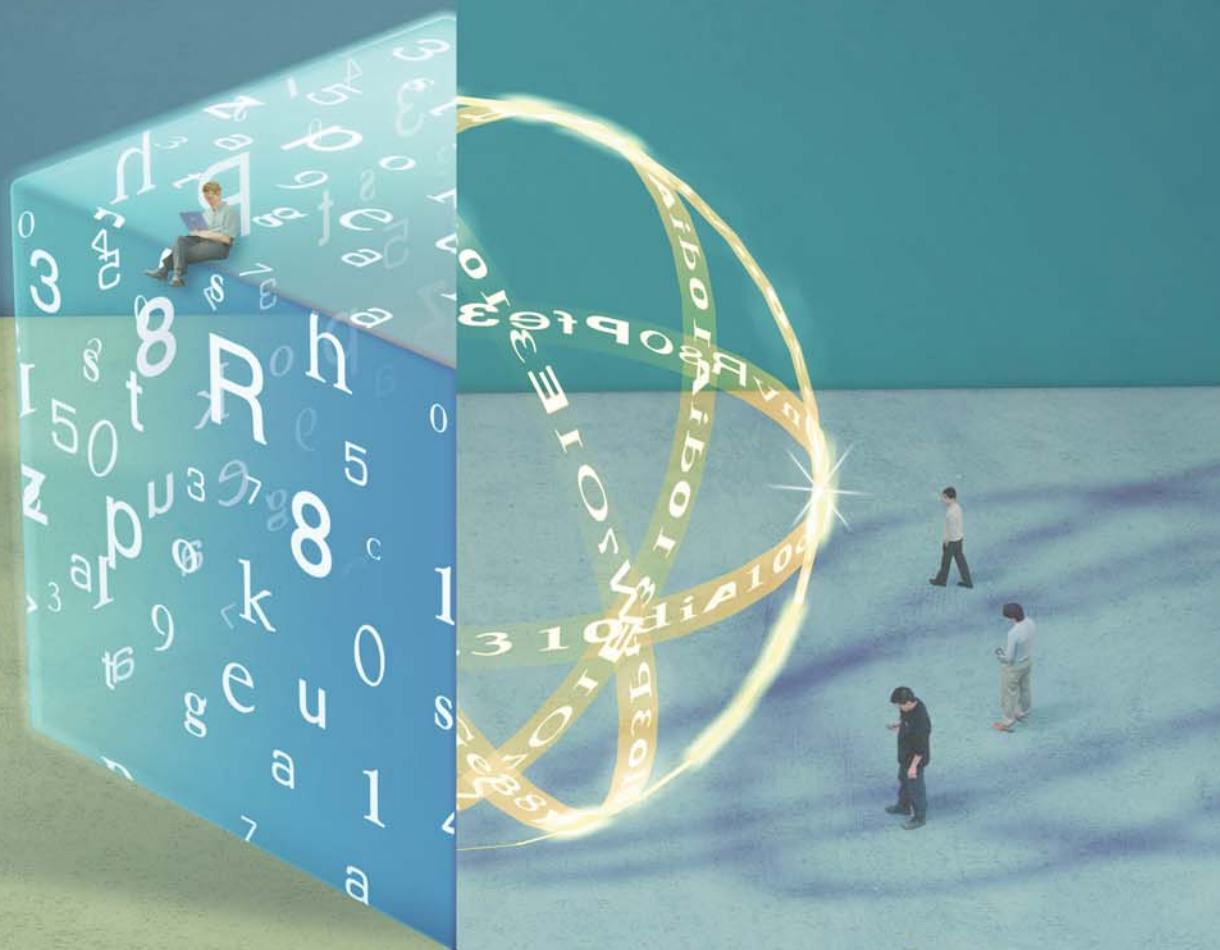


WiMAX WIRELESS BROADBAND

Fixed-flavor questions abound,

mobile



CHIP VENDORS BEGIN TO DELIVER ENABLING PRODUCTS DESPITE SKEPTICISM ABOUT WHAT—OTHER THAN A MOBILE ESSENCE—DIFFERENTIATES WiMAX FROM EARLIER WIRELESS-BROADBAND SCHEMES.

Lurks

LIKE A BASEBALL ROOKIE that tore up the Cactus League in spring training, the WiMax wireless-broadband standard has lots of potential: at least 40-Mbps data rates over a five-mile range. But phenoms come and go in baseball camps without ever learning to hit a curve ball. And, in many ways, WiMax is like a great springtime hitter that can't make it in the big leagues. We've been hearing about

miraculous last-mile wireless schemes for a decade. What will allow WiMax to succeed when others have failed? Major chip vendors, with stalwart Intel in the lead, seem dedicated this time around to making the equipment cheap. There are plenty of opportunities in the global sense even if North America features entrenched competition. And WiMax has a designated hitter in the form of a mobile technology that may become a position player a few years hence.

WiMax is a MAN (metropolitan-area-network) technology that fits between wireless LANs, such as 802.11, and wireless WANs (wide-area networks), such as the cellular networks (Figure 1). Bandwidth generally diminishes as range increases across these classes of networks. Proponents believe that WiMax can serve in applications such as cellular back-haul systems, in which microwave technologies dominate, back-haul systems for Wi-

Fi hot spots, and most prominently as residential and business broadband services (Figure 2). Doubters poke holes in the likelihood of any of these three opportunities' occurring.

Industry veteran Sayed-Amr El-Hamamsy, president and chief executive officer of wireless-broadband-equipment provider Wi-LAN, understands the skepticism. El-Hamamsy states, "We've been pushing for wireless broadband for 12 years and have lived through the false starts. This time, however, we have a standard and a forum with many players. And we'll get to a price-point threshold that we've never met before."

The forum that El-Hamamsy speaks of is the more-than-200-member WiMax Forum. According to its mission, "The WiMax Forum is working to facilitate the deployment of broadband wireless networks based on the IEEE 802.16 standard—specifically 802.16d—by helping

Illustration by Randy Lyhus

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to ensure the compatibility and interoperability of broadband wireless-access equipment.” So, it’s probably incorrect to characterize WiMax as a standard, but the industry clearly uses the term in that way. WiMax is instead a brand that vendors will use to stamp a validity label on equipment that the WiMax Forum certified as interoperable.

The organization is following the path of the Wi-Fi Alliance as a certifying agency that bases itself on the work of an industry-standards body. In the case of WiMax, the group has developed “system profiles” of the technology that the IEEE 802.16 standard specifies. The organization’s members feel that these profiles will serve the needs of the broadest segments of the potential market. Moreover, the dialogue between the 802.16 group and the WiMax Forum goes both ways, because the forum feeds conformance documents back to the 802.16 group.

Although the WiMax Forum is following the path that the Wi-Fi Alliance blazed—in part hoping to ride the Wi-Fi momentum—the WiMax Forum has a much tougher job. Wi-Fi is a well-defined standard in a couple of frequency bands, whereas WiMax is not. It’s probably improper to oversimplify the Wi-Fi world, but WiMax is far broader. In fact, WiMax will include LOS (line-of-sight) profiles in various frequency bands rang-

AT A GLANCE

- ▶ WiMax will face stiff competition from DSL and cable in the United States, but regions such as South America and parts of Asia will welcome wireless broadband.
- ▶ SOCs (systems on chips) from companies such as Intel and Fujitsu should drive end-user-equipment cost to approximately \$100.
- ▶ Base-station designs will rely on programmable technologies, including DSPs and FPGAs.
- ▶ Many companies expect mobile WiMax to provide a greater opportunity than the fixed flavor.

ing from 10 to 66 GHz and data rates as high as 134 Mbps. Lower-than-11-MHz NLOS (non-LOS) profiles will offer the point-to-multipoint operation that last-mile broadband schemes require. The WiMax Forum most often promotes NLOS operation with rates as high as 40 Mbps. The forum claims that such an implementation will, with a single channel, support hundreds of businesses with T1-like performance or thousands of residences with DSL-like performance. Get more background on the WiMax Forum

Web site on Intel’s Web site and in **Reference 1**.

Back to skepticism surrounding WiMax, the naysayers include prominent experts. Greg Raleigh, president and chief executive officer of Airgo Networks, has spent most of his career working on wireless networks. He was co-founder of Clarity Wireless, an earlier wireless-broadband player that Cisco acquired. Raleigh states, “I have no idea if WiMax is ever going to be successful, and I wouldn’t bet a dollar on it.” Raleigh helped develop MIMO (multiple-in, multiple-out) wireless technology while earning his doctorate at Stanford University.

When starting Airgo, Raleigh had to decide where to try to leverage MIMO technology. His first target was Wi-Fi, in which Airgo is finding success. Raleigh admits a potential interest in cellular but has no plans to develop MIMO-enabled WiMax products. Raleigh points out that other technologies, such as microwave, serve back-haul applications. As for rolling out WiMax as a broadband competitor, Raleigh states, “It will cost billions of dollars to roll out a nationwide footprint, and you have to compete with DSL and cable at \$30 per month.”

THE BUSINESS CASE FOR WiMAX

Could a service provider make a go of WiMax’s competing with DSL and cable

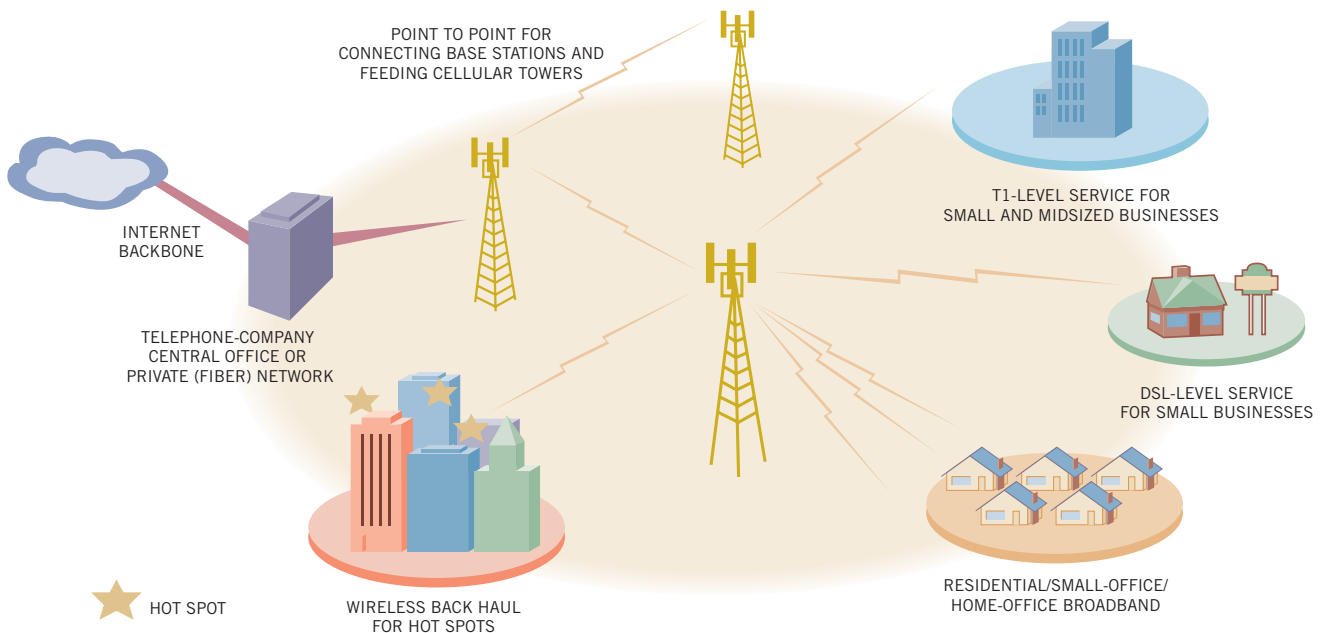


Figure 1

WiMax will serve as an alternative to T1 for businesses, as an alternative to DSL and cable for consumers, and as a back-haul option for cellular base stations and 802.11 hot spots.

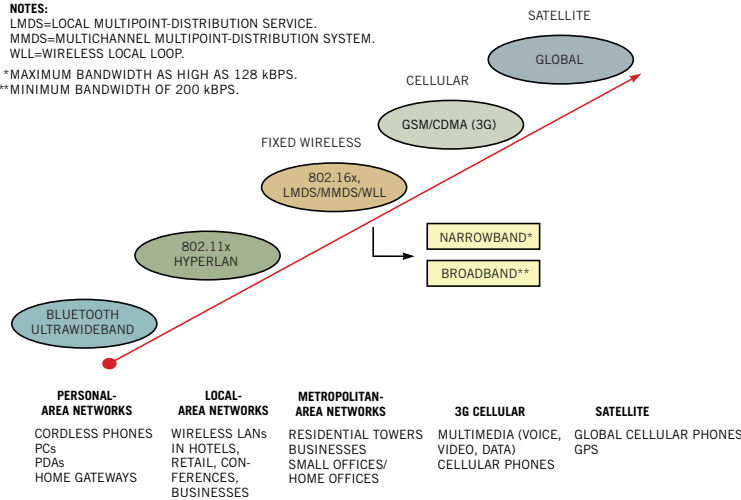


Figure 2

A MAN (metropolitan-area-network) technology, WiMax fits between Wi-Fi and cellular technologies in data rate and range.

Internet access in North America? In the free report *WiMax: The Rebel Broadband* from our sister business unit In-Stat, Senior Analyst Eric Manton presents a theoretical business case he built on the idea that a carrier might build a WiMax network that covers 75% of the US population at a cost of \$1.5 billion covering 85 million potential subscribers. The theoretical case relies on a \$45-per-month charge and results in the carrier's breaking even at 3.35% penetration, or 2.87 million homes.

WiMax, proponents, however, don't

believe that a nationwide rollout in the United States is a prerequisite for success. Many developing nations have no entrenched wired infrastructure and no plans to dig ditches and install one. A technology such as WiMax will look attractive in regions of South America, China, and other parts of Asia in which the desire for connectivity is growing.

Joe English, director of marketing for Intel's Broadband Wireless Division, remains bullish on WiMax in all regions of the world. English points out that wireless-service providers, including Intel partner

TowerStream, are succeeding in selling wireless alternatives to T1 to small and mid-sized businesses. Service providers, such as TowerStream, and equipment providers, such as Wi-LAN, will have even lower priced options once standard WiMax products come to market.

Indeed, El-Hamamsy of Wi-LAN states, "WiMax is an exercise in cost reduction more than a boost in performance." The company's Libra systems now offer WiMax-like performance. But Libra CPE (customer-premises equipment) costs approximately \$1000, whereas El-Hamamsy believes that WiMax SOCs (systems on chips) will reduce that price to \$500. Note that the Libra CPE goal is for business service. Those targeting residential customers hope to decrease the price point to \$100.

CONSUMER PRICES REACH LESS THAN \$100

The less-than-\$100 price point is precisely what Intel hopes to enable with its Rosedale chip, according to English. The Rosedale design integrates both MAC (media-access-controller) and PHY (physical-layer) protocol processors; a MAC hardware block; and front-end PHY functions, such as forward error correction and OFDM (orthogonal-frequency-division-multiplexing) blocks (Figure 3). The design includes a 10/100-Mbps Ethernet MAC that would connect to a PC or router. English claims that the

WiBRO WILL FIRST ROLL OUT IN SOUTH KOREA

Lately, the interest in WiMax here in North America seems to be at least as intensely focused on the 802.16e mobile version as on the 802.16d fixed version. Although the 802.116e group is six months or more from completing a mobile spec, the rest of the world isn't waiting for WiMax. Indeed, South Korea's Telecommunications Technology Association has approved the WiBro mobile-broadband standard, which will deliver 1-Mbps rates to each user. The association based the standard on the technology in 802.16e, but it isn't necessarily compatible with the mobile profile that WiMax will ultimately define.

It's no surprise that South Korea would take the initiative on a broadband-wireless standard. The country is among the most connected in the world in broadband to the home, 802.11 hot spots, and the early adoption of 3G (third-generation) cellular technology. Asif Batada, strategic marketing manager for Altera's wireless business unit, states, "[South] Korea's success with CDMA [code division, multiple access] prompted aspirations to lead the next generation." By developing its own standard, the country will also remove the heavy burden of royalties due Qualcomm for the use of CDMA technologies. This burden affects

wireless carriers, chip vendors, and handset makers. WiBro participants are using "4G" (fourth generation) to describe the technology, although it's really just an interim step to the 4G goal of 100-Mbps mobile data rates.

The Korean Ministry of Information and Communication has issued three licenses for WiBro networks in the 2.3-GHz spectrum. Korea Telecom, SK Telecom, and Hanaro Telecom are all planning to launch WiBro networks next year.

There's no question about where WiBro fits but lots of questions about how it impacts adjacent technologies. It will offer the mobility—operating at

freeway speeds—and essentially the range of 3G networks with much higher data rates. But it is a data—not voice—network. Still, it has a quality-of-service layer, and VOIP (voice-over-Internet Protocol) will allow voice traffic. It won't offer the data rate that 802.11 does, but ubiquitous availability could allow it to usurp the hot-spot business.

Meanwhile, the backers of WiMax in North America are trying to ensure that the world doesn't wind up with multiple mobile-broadband standards. Intel, in particular, has been trying to broker a deal to synchronize WiBro and the WiMax mobile efforts.

SOC needs only an Ethernet PHY to implement a baseline WiMax residential gateway. Intel has also developed a reference design that combines a Rosedale with an Intel IXP425 network processor and a Wi-Fi chip to implement a WiMax residential router with Wi-Fi connectivity to client PCs.

According to English, the Rosedale design focused on low-cost CPE, whereas other WiMax chip developments target enterprise or base-station applications, as well. The

commitment to residential CPE shows that Intel believes that a market exists for residential WiMax. English claims that plenty of markets, even in the United States, exist in which cable and DSL don't penetrate—and never will with WiMax as an option. WiMax makes economic sense with a far smaller subscriber base. He points out that virtually anyone living west of the Intel facility where he works—13 miles outside Portland, OR—can't get DSL or cable-Internet service. Still, English concedes that WiMax makes no sense in some markets. He sates, "You wouldn't want to overlay New York City with a fixed system; that's probably true."

With Intel onboard, you might expect a number of other IC vendors to chase the CPE space, but that's not currently happening. Fujitsu Microelectronics has made it clear that it will offer an SOC that customers can use in CPE. In fact, WiLAN, among other equipment vendors, has partnered with Fujitsu in the development of its chip. Expect a formal announcement from Fujitsu within a month or so.

The other CPE chip players are largely start-ups with more "foilware" than products. Cygnus Communications is presumably working on an SOC but hasn't detailed its plans. Sequans Communications is developing the WiNetPro family of WiMax SOCs, but you can now access only an FPGA-based evaluation kit. TeleCIS Wireless, meanwhile, has announced plans for the TCW1620 WiMax SOC, but details are to come.

BASE STATIONS PRECEDE CPE

You will find more chip-level work going on in the base-station area, although that work differs in nature from CPE-

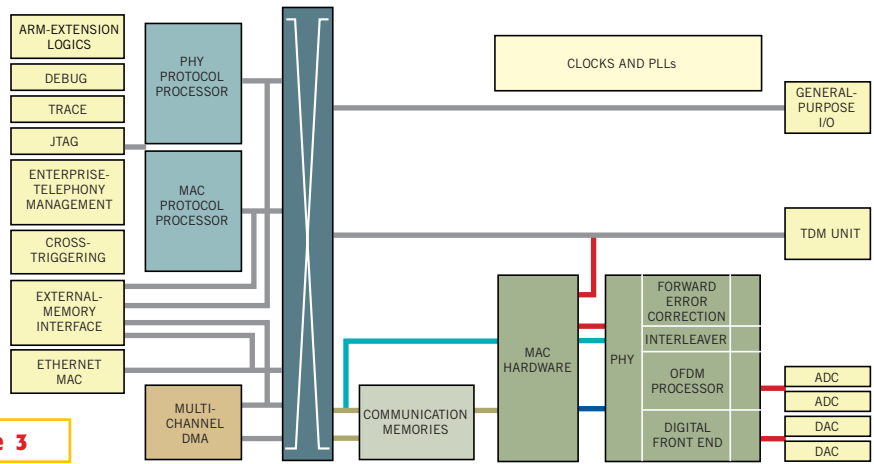


Figure 3

Targeting CPE (customer-premises equipment) in the \$100 range, Intel's Rosedale chip integrates WiMax MAC and PHY functions and is virtually a single-chip residential gateway.

chip developments. Base-station designs must handle higher aggregate data rates, because one base station supports many clients. The higher data rates often mean a different integration strategy; for instance, the combination of MAC and PHY layers may no longer be the best path. Moreover, base stations cost more than CPE, so flexibility, especially in the case of a new standard such as WiMax, is often a requisite. Jeff Stevens, manager of the broadband-wireless-access group at Analog Devices, states, "There are a lot of options in the standard. Having something programmable in the infrastructure side is an advantage."

Much of the base-station-chip development to date is software or IP (intellectual property). As you might expect, the big DSP vendors, such as Analog Devices, plan to play in the WiMax base-station space. Last fall, Analog Devices announced a partnership with SiWorks to support SiWorks' software-based WiMax radio on the TigerSHARC DSP. Analog Devices claims to be working with another as-yet-undisclosed IP vendor on a MAC implementation. Stevens states, "I expect that several of our customers will make base-station announcements by midyear or the third quarter."

Intel is also playing a role in base-station development, although the effort may focus on selling as much into CPE chips as into base stations. The company has developed a reference design based on the IXP2800 network processor and a software stack it developed in-house. The reference design relies on the ATCA (Advanced Telecom Computing Architec-

ture) as a hardware platform and other modular building blocks.

But the big guys won't have the base-station market to themselves. For instance, picoChip is claiming wins in base-station designs based on the company's PC102 chip at 10 telecom-equipment manufacturers. The company based the PC102 on the picoArray technology that picoChip described at In-Stat's Fall Processor Forum. The design uses multiple processing elements in an array to handle portions of a computationally intensive task. The company claims that the architecture is especially effective in communication applications. Longtime DSP expert and analyst Will Strauss from Forward Concepts agrees. Strauss states, "Last year, I said, 'If everything they say is true, they have a formidable product.' With the commercial successes that picoChip is demonstrating, it is clear that it was true, and the PC102 genuinely is a formidable product."

PROGRAMMABLE LOGIC SHOULD BE A PLAYER

With programmability as a requirement, you would also expect FPGAs to be players in the WiMax base-station space. And FPGAs will see usage either as the main processing engine or in support functions to DSPs or general-purpose processors. But, Asif Batada, strategic marketing manager for Altera's wireless business unit, claims that the bulk of the interest that he's seeing is for the still-under-development 802.16e standard or mobile flavor of WiMax.

Most WiMax supporters view mobile applications as the third and final com-



ponent of a WiMax deployment—after fixed-LOS point-to-point and NLOS point-to-multipoint deployments. Mobile-deployment visions range from sporadic coverage in cities to an almost-cellularlike infrastructure. The WiMax Forum projects 15-Mbps data rates at a minimum in a Mobile WiMax channel. Intel says that it will, around 2007, offer mobile WiMax support in its note-

book chip sets. But remember, the forum won't complete the spec until the third quarter at the earliest. Ultimately, getting an 802.116e radio into a portable power and heat budget—a Moore's Law problem—will gate mobile deployment. Base stations have no power and heat worries, but clients certainly do.

Still Altera's Batada claims to have 35 customers working on some flavor of

mobile WiMax base station. Batada cites the EP2C35 member of the Cyclone 2 family as the FPGA of choice for WiMax work. The FPGA has more than 33,000 logic elements. Batada believes that a single chip can implement the MAC layer and that two can implement the PHY layer.

No one can define the reason for the recent pickup in interest for mobile WiMax,

FOR MORE INFORMATION...

For more information on products such as those discussed in this article, contact any of the following manufacturers directly, and please let them know you read about their products in *EDN*.

Airgo Networks
www.airgonetworks.com

Altera
www.altera.com

Analog Devices
www.analog.com

Cygnus Communications
www.cygnuscommunications.com

Forward Concepts
<http://fwdconcepts.com>

Hanaro Telecom
www.hanarotelecom.com

InStat/MDR
www.instat.com

Intel
www.intel.com

Korea Telecom
www.koreatelecom.com

Philips Semiconductor
www.philipssemiconductor.com

Sequans Communications
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SiWorks
www.siworks.com

SK Telecom
www.sktelecom.com

TeleCIS Wireless
www.telecis.com

WaveSAT
www.wavesat.com

Wi-LAN
www.wilan.com

WiMax Forum
www.wimaxforum.org

although its fixed flavor has been under scrutiny of late. For most of the past year or two, industry participants have viewed fixed WiMax as a can't-miss proposition, but negativity lately reigns.

Part of the negative aura has come from grumbling about the WiMax Forum's certification process. In late January, the forum announced that it had chosen Cetecom Spain to handle conformance testing and that such testing would begin in July. Some members of the WiMax community expected the forum to choose multiple labs and testing to begin sooner. According to who's talking, vendors are either pushing back fixed-WiMax deployment by six months or it is still on the original timeline that the forum established.

Altera's Batada states, "The certification program has been delayed by six months." Dhvani Vyas, marketing and business-development manager at Philips Semiconductor for RF Products, agrees, stating, "The market has been pushed out at least six months."

Philips, in fact, is now working on only the mobile flavor, as well. The company is developing the RF side of the design and partnering with Sequans and WaveSAT for baseband technologies. Vyas states, "If the market emerges, we'll go in on the baseband side." Philips hopes to have its RF chips complete in the third quarter.

WHAT IS 4G?

The wild card in the mobile-WiMax equation is how the technology aligns with cellular technologies. Most players in North America are still treating the two as symbiotic but separate. In South Korea, SK Telecom, Korea Telecom, and Hanaro Telecom are pursuing the government-developed WiBro standard as a 4G (fourth-generation) data-centric cellular standard. WiBro's developers based it on 802.16e (see **sidebar** "WiBro will first roll out in South Korea"). Intel's English points out, however, that WiMax



lacks the low-latency capability necessary to operate as the basis of a voice network. But plenty of people are planning to run VOIP (voice-over Internet Protocol) over all flavors of WiMax. English claims that Intel's goal for now is to ensure a single standard for WiMax. English states, "Intel is working to make sure that WiMax and WiBro don't diverge."

Meanwhile, where are the CPE and base-station products? Almost everyone expects vendors in the next few months to announce WiMax end products. Whether those products will pass certification is another question. Wireless Broadband World, which will take place on April 21 and 22 in Las Vegas, could be a venue for numerous announcements. Watch our Web site for an update. □

REFERENCES

1. Miller, Matthew, "When, where, and WiMAX," *EDN*, May 27, 2004, pg 26.