

Wireless MAN Standard Signals Next-Gen Opportunities

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The finalization of the IEEE's 802.16-2004 standard for wireless Metropolitan Area Networks is bound to make life easier for both existing providers of fixed wireless broadband service and those who've been waiting for a lower-cost way to enter the market.

"We have been waiting for it with bated breath," says Graeme Gibson, CEO of Computers & Tele-Comm, a company providing wireless broadband service to approximately 250 customers in the Kansas City, Mo. region, including several of the city's luxury hotels. Gibson jokes that his wife has suggested his company's logo should be a hyena, as CTC has managed to survive in a market littered with the corpses of companies that entered the fixed wireless market with high-profile launches and left it with equally high-profile flameouts; Gibson's company, in contrast, has managed to expand to serve customers that his more ballyhooed competitors were forced to abandon.

But to both serve his end-user customers and provide wireless ISPs with equipment, Gibson had to cobble together nonstandardized architectures of proprietary 5.8-GHz wireless broadband for data backhaul through his system, coupled with 802.11b Wi-Fi technology.

The new standard (www.wirelessman.org), finalized in June 2004, will let Gibson and his ISP customers reduce the inherent latency in wireless transmission while avoiding expensive proprietary equipment upgrades. Gibson says the new standard, dubbed WiMAX, will let his small-town ISP customers expand their range and offer more people in areas without broadband options a way to literally get up to speed.

Going the distance

For example, Gibson supplied an ISP in Abilene, Kansas, the equipment to offer wireless broadband to the town, which has a population of 5,600. Using Wi-Fi equipment on grain elevators, Gibson says the ISP was able to provide 1.5 megabits-per-second service without suffering undue performance degradation in town. However, the technology's range limits, designed for an optimum range of 100 meters or so, also limited how far the ISP could market broadband.

"When you're using wireless for backhaul, latency builds up," Gibson says, "20 to 25 milliseconds in every radio repeat, and once you get up to 100 or 120 ms, that's when voice over IP stops working. So you don't want to do that."

With new WiMAX equipment, which can provide service up to 30 miles, customers will suffer less latency with a technology designed for point-to-multipoint transmission and be able to offer more people better service at lower cost.

"There are a lot of towns 15 miles from Abilene, so he'll be able to cover Enterprise and Salina," Gibson says. "It will be more cost-effective to get to the next town."

The new standardized gear should start rolling out in the first half of 2005, according to Margaret LaBrecque, past president and current regulatory working group chairman of the WiMAX Forum (www.wimaxforum.org/home), an industry consortium with more than 100 members dedicated to ensuring the interoperability of 802.16 products.

Longer range just a part of the solution

Roger Marks, chairman of the IEEE 802.16 working group, says the key principle in designing the standard to offer more robust service than Wi-Fi wasn't range in and of itself.

"It's a little more complicated," Marks says. "Range is a kind of physical layer issue, and the thing that really distinguishes the 802 standards is the MAC [Medium Access Control] layer. In 802.11, you could get high-gain antennas and operate in point-to-point fashion and go 30

miles, but it's just one radio talking to another.

"The thing that makes 802.16 so effective is that it was designed to be point-to-multipoint over a wide range. It has the ability to service multiple customers and be able to schedule all this stuff in a coherent fashion, so you can share your spectrum in an organized way and maintain quality of service. With 802.11, sure, you could use it as a WISP (Wireless ISP), but you have a real problem with scaling. As the number of users goes up, the efficiency goes down because the MAC wasn't designed for that environment. The specific problem is that 802.11 is a 'listen before talk' protocol, and if you try to go over a long range, each one of those customers' antennas has to be a directional antenna that points to the base station. In that kind of configuration, none of the customers can hear each other, and if they can't hear each other, they can't follow the 'listen before talk' principle. We try to address that problem in 802.16, and, yeah, in the case of a rural WISP, I think it'll be ideal."

Cheaper silicon means more broadband

WiMAX Forum's LaBrecque says that while the technology's benefits might manifest themselves in the end of lower latencies and longer range, they begin in the manufacturing process itself.

"A lot of manufacturers use silicon from an adjacent market such as 802.11," LaBrecque says. "They use the PHY [physical layer] and bypass the MAC and have to design their own, which is very expensive. The bottom line was, there was no cheap silicon solution, and that's going to make a huge difference. Imagine a small company selling 100,000 units a year, and maybe through the life cycle of a particular unit they'd sell 200,000. If they had to spend US\$20 million to design silicon in R&D, they've just added \$100 to each unit. That was one of the key things holding back the industry, I believe."

Gibson says radios based on proprietary technology do exist to serve WISPs, with the power and frequency ranges to alleviate interference and latency, but that their nonstandardized design has been too expensive for those markets most in need of wireless broadband.

The design of the 802.16 standard also calls for vastly improved orthogonal frequency division multiplexing (OFDM) technology, which splits a given frequency into subcarriers. This lets operators transmit more signals over a given frequency with less likelihood of interference, a key factor in opening up unlicensed spectrum. 802.11 has a 64 OFDM

physical layer, while 802.16 features a 256 OFDM architecture.

"The fundamental ingredient to wireless anything is that it always costs less to put up small antennas than it does to cut up streets," Gibson says, "and at the same metrics and population density, that's true. But there's the rub. We don't have the population density the wireline guys do. Right now, we're talking about servicing—maximum—64 customers off a radio."

WiMAX, he says, will give him more frequencies to put up on the roofs he's placed his equipment on, letting him offer service to more customers and lowering his fixed costs per customer—such as the lease he pays building owners for roof rights—thanks to the improved physical layer design.

Spectrum and needs dictate actions

Marks, a physicist at the National Institute of Standards and Technology, initiated the 802.16 Working Group at an August 1998 meeting. Work in earnest began in March 1999, with the first of regular bimonthly meetings held in July of that year.

Ironically, the frequency range the group first worked on, from 10 to 66 GHz, has not been the range driving the most interest in WiMAX.

"We started out originally with the higher frequencies, and that was intended mostly to target business applications," he says. "It was fairly expensive, generally a line-of-sight propagation, and [it used] spectrum for which, if you could get a license, you usually got a pretty big swath. So for a number of reasons it was targeted at big-bandwidth users who weren't so cost sensitive, for line of sight. It made sense to think of it as putting up a tower on a tall building in a downtown area and looking down and seeing lots of buildings that didn't have fiber, and you could supply high-capacity links to them. That stuff is done, and we're still waiting to see someone jump aboard that one."

"Then we went to the lower frequencies, where we knew the physical layer was going to be trickier and more complex. That moves us to a reasonable class of fairly well-defined applications, but people still seem to think it covers a lot. You have to look at spectrum as the defining aspect. You need both spectrum and standards together to make the product succeed, so we targeted both licensed and license-exempt spectrum."

By expanding its emphasis to the lower frequencies (2 to 11 GHz), the group realized this might require a more complex physical layer design to alleviate interference, but the potential payoff was also greater. They could serve more customers than higher-frequency providers, who face more daunting deployment obstacles because of the shorter wavelengths.

Simultaneously, the Federal Communications Commission was also studying ways to improve the lower-frequency spectrum's efficiency, particularly the licensed 2.5- to 2.7-GHz range, which mainly instructional television services occupied. A month after the 802.16 standard was finalized, the FCC issued new orders (http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-04-135A1.pdf) for the 2.49- to 2.69-GHz band.

Under the old rules, the affected spectrum, particularly the spectrum from 2.6 to 2.7 GHz, was allocated in narrow alternating leaves to the instructional television users and the wireless data providers.

The effect of this allocation, the WiMAX Forum's LaBrecque says, was to inhibit potential wireless providers from deploying services.

"That spectrum has gone through a lot of hands over the years," she says. "Now Sprint and Nextel have a large portion of it, but the issue with it was that every market they'd go into, there would be broadcasters who could be anywhere in that 2.5-GHz area. So if Sprint wanted to deploy it, they would have to go into each market individually and figure out how they could coexist in a successful manner. Often, broadcasters, especially nonprofits like educational institutions, are using transmitters with filter technologies from the 1970s, or even before, so they're pretty noisy, and although they may be violating certain noise parameters, it's usually up to the new guy on the block to figure it all out."

The new FCC allocation groups the high-power users, such as instructional TV, and the low-powered broadband users, into wider swaths separated by guard bands. However, whether WiMAX will be deployed there largely depends on how incumbent spectrum holders view its potential against other technologies they've invested in. Globally, the WiMAX Forum predicts the most likely bands for deployment will be in licensed 2.5 GHz and 3.5 GHz, and in unlicensed 5-GHz bands. The working group LaBrecque chairs is charged with talking to governments worldwide to try to achieve harmonization of spectrum regulations. If vendors need to optimize radios for a plethora of spectrum allocations, some of the reduced cost of standardized equipment will be moot.

Because the licensed 2.5-GHz spectrum in the US is already allocated, the most likely growth

area will be in the 5-GHz unlicensed band and will likely take place in the rural areas where wired providers have not deployed equipment.

"The big story with WiMAX isn't about the US, it's about markets without any infrastructure at all," says John Yunker, founder of analyst firm ByteLevel Research. "If you talk to operators in markets where there's low income and little in the way of infrastructure, they're excited because in theory they should be able to provide Internet access and phone service combined to these areas."

In the US, observers believe the most likely first role for WiMAX is in upgrading existing fixed wireless infrastructure in the unlicensed 5-GHz band. Marks says the working group has initiated a new study group to recommend ways to reduce potential interference.

Marks says a typical WiMAX deployment could be envisioned as a mixed 802.11-802.16 network, where the same box hosts both an 802.16 radio to connect to the network, and an 802.11 radio to connect to end users' computers or devices.

Going mobile?

The next step in the standardization process for 802.16 is the finalization of its mobile component, 802.16e. Marks says the group hopes to have that finished by the end of 2004. Vendors could ship laptops and mobile devices with WiMAX chipsets by late 2005, but analysts and even industry operators say the installed base for Wi-Fi is so strong it will take a while to replace 802.11 in LANs.

"I don't need WiMAX for end delivery," CTC CEO Gibson says. "I need it for fixed wireless delivery. I don't want to get to the guy's laptop or desktop. Wi-Fi works fine for that. At short distances, it's not broken. What is broken is all the interference in Wi-Fi and the fixed wireless gear that's been deployed out there that people aren't doing good engineering jobs on. It's really a cooperative nightmare to try to figure out how you're going to divide up three nonoverlapping channels on 802.11b. We need spectrum dedicated to fixed wireless delivery."

Conclusion

But Marks says that mobile WiMAX technology has received a huge boost in Asia, where the South Korean government announced that 802.16 work would be based on the portable Internet standard in that nation.

He says the working group's recent attendance figures could be a measure of the technology's promise; as the work has advanced on the mobile standard, more and more people show up. The group's May 2004 meeting set an attendance record with 228 people. Two months later, 332 people attended the next one.

"One of the nice things about a standards project isn't just that it gives you lower cost products, but that it has a commitment to evolve in the future, and that's one of the directions in which people want to evolve, but that's not what we're waiting for. The standard we finished last month is going to support products I think will be very successful, and there will be lots of opportunities."

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- "The IEEE 802.16 Working Group on Broadband Wireless Access Standards", <http://grouper.ieee.org/groups/802/16/>
- Overview of IEEE 802.16 Security, <http://csdl.computer.org/comp/mags/sp/2004/03/j3040abs.htm> *IEEE Security & Privacy* (May/June 2003)
- Achieving Wireless Broadband with WiMax", *Computer* (June 2004)