

# Why MAX?

**A Wireless Primer and Discussion on Wireless Reality**

By  
JEFFREY K. BELK  
Senior Vice President, Marketing  
QUALCOMM Incorporated  
Jbelk1@qualcomm.com

## Table of Contents

Introduction.....	3
Radio Frequency Technology 101 .....	6
How We Actually Do and Will Use Wireless 101 .....	13
Making a Product 101 .....	18
Creating a Wireless Standard 101 .....	23
WiMAX and 3G WWAN .....	28

## Introduction

They say history repeats itself. Whoever “they” happen to be, when it comes to wireless technology evolution, they are right too often. Three years ago, we had to deal with a broad swath of the technology world telling us that “Wi-Fi is going to crush 3G Wireless” and dominate the future of Internet connectivity. “Not so fast,” we said, and I personally spent the greater part of 18 months telling folks that Wi-Fi is great—I’ve got it at home and QUALCOMM has hundreds of access points across its campuses—but not so fast with the Wi-Fi will crush 3G thing. Wi-Fi will work with, complement, augment—all that stuff makes sense—but replace? That was silly.

Fast forward. We’re now in fall 2005. There’s this thing called “WiMAX” out there. For a bunch of folks in the technology community, it’s been a great opportunity to recycle some of their opinions and sometimes writings on Wi-Fi by just doing a “search and replace,” removing the “Wi-Fi” and replacing with “WiMAX.” Just like with Wi-Fi a few years ago, for some unfathomable reason, audiences usually critical of “overhyping” are remaining silent, and are continuing to give the WiMAX folks a free pass.

The problem with this approach is the same problem as with the Wi-Fi hubbub of a few years ago. Every part of a story that sounds great in sound bite form gets more complex when you examine the details. And the truth is often in the details.

Folks who have heard me speak publicly, whether on a WiMAX session at Networkworld Interop, a WiMAX panel at 3G CDMA Americas or in the hundreds of one-on-ones with media or industry analysts, have heard me say the same thing.

The real world is not that easy, and the answers are not simplistic. Wish it was, but it's not. And what really makes me nuts is that the primary proponents of WiMAX keep on purporting claims on the technology that are unsupportable. Right now, go to Google. Put in the search term "WiMAX 75Mbps 30 Miles" or "WiMAX 75Mbps 50 Kilometers." Or WiMAX Mobile 2005. You will get thousands of hits, with new citations daily, and they will mostly be wrong.

Like the Wi-Fi hype of a few years ago, one of the major issues is that many of the folks reading/writing/analyzing this stuff are looking at these issues from an IT perspective. These folks have a long history, expertise and comfort level with things connected to a PC. That side of the tech industry is being guided by a vendor set who produce products connected to a PC. But there are these nasty things called *radios* that don't play well in this environment. Long ago at QUALCOMM, as a non-engineer I came to the realization that *radio* is akin to voodoo, and the engineers that can tame a wireless technology and work with a value chain to make a wireless standard operate in the real world should be considered the high priests of the technology world. Every time you push the green button on your cell phone, you are tapping into what is arguably the largest and most complex network on the planet.

So let's dissect some of the things about WiMAX that are just off base. Part of this will be "Wireless for the Non-Technical," but as I just said, I'm a non-engineer, so I can do this. And if you don't like it, guess what, you don't need to read it. And like with my other writings, I welcome a challenge, but you better have your facts straight. Hyperbole need not apply.

**First a caveat:** I am not making, and will not make the case that WiMAX does not exist. The "fixed" version of WiMAX is standardized and is beginning interoperability testing in Spain, per a recent spate of press releases. The standardization of the "mobile" version of WiMAX (802.16e) is being circulated (as of this date, September 2005), and could be ratified in the next six months.

But that aside, we are going to go "beyond the hype cycle" and examine some of the issues involved in bringing a mobile standard such as WiMAX to fruition. The issues I describe are solvable for "any" wireless technology with the application of three things: time, money and smart people. The challenges that the Mobile WiMAX folks will face are similar to those that have been faced by "every" current, defunct or failed wide area wireless standard.

**And a second caveat:** In August 2005, QUALCOMM acquired an innovative developer of wireless technology named Flarion. As the transaction is still in process and undergoing regulatory review, I am going to keep away from describing how Flarion plays into this dialog. However, assume there will be more to say in the future.

**We're going to take a tour of the following topics:**

- **Radio Frequency Technology 101:** Everything you wanted to know about radio but honestly, really did not want to know.
- **How We Actually Do and Will Use Wireless 101:** We are human, and humans are predictable. Some descriptions of a real human and his individual uses of advanced wireless technology follow. Or, for those of you that have read my prior pieces, my personal travels and experiences with wireless in the real world.
- **Making a Product 101:** Why there is no such thing as a magic wand in making technology products.
- **Creating a Wireless Standard 101:** Why making a wireless standard is akin to sausage making and herding cats, but more difficult.

## Radio Frequency Technology 101

Do the terms *MHz*, *GHz*, *licensed*, *unlicensed*, *morphology*, *zoning* and *NIMBY* mean anything to you? The painful truth is that if you want to have any understanding of the future of wireless, including the claims of the WiMAX folks, you gotta have a bit of grounding here, at least enough to be an appropriately skeptical consumer of information. Trust but verify.

In radios, like life, there are tradeoffs. If you saw an ad for a future SUV that weighed 5,000 pounds and got 1,000 miles per gallon 'cause it used new "jello-based" tires, would you be skeptical? Eat pizza all day and lose weight? Risk-free 150% per year returns on your money? Well, for just as obvious reasons to anyone in the wireless space, the "75Mbps at 30 miles" mantra falls in the same category.

There are basic tradeoffs in wireless. Throughput, power output, and distance. Speed and distance. Effects of interference. Performance characteristics arising from where on the radio dial that a given service is located. How efficiently a given service utilizes its bandwidth. How many people want to use a given service, and the need for ever more towers to support the services (the NIMBY or "not in my back yard" thing). Plus a bunch of others.

### Power and Distance

Let's do an experiment. Your voice is a wireless communication device. Go in a room with a friend. Whisper to one another. Hey, no phone needed and you don't need to pay by the minute. Go further away from one another? Do you have to speak louder or softer? Now go across the room from one another, down the hall from one another, to the point you are yelling at one another. This is the tradeoff between power and distance.

At the most simplistic level, the further transmitters are from one another, the more power is needed to get a signal from here to there.

Now go outside in a rainstorm. At the same distance from one another are you speaking as softly or loudly as when you were in the hallway inside? At a heavy metal concert, the same distance away? Louder or softer? This is the effect of interference. Back in the office, try the whisper thing again. Now put a wall between you. Put two walls between you? Are you talking louder or softer to communicate? Now we're getting into the effect on the physical environment on communications capabilities.

## Speed and Distance

Let's go with signal flags on this one. We're in the 1800s on a navy ship (pick a navy, any navy). The ships are 100 yards (or 100 meters, take your pick) apart. Two skilled signal flag guys are flashing signals back and forth at high speed. Someone on either side is transcribing the signals and acknowledging them back and forth. (Quickly, as the grog is waiting.) Now a few hours later, the same ships are a few miles apart. The captain is far enough away that he is at the edge of the distance that his ship's telescope will function (we're already using technology to improve performance in this example). Will the signals pass as quickly and with the same number of errors? Nope, it will take longer, there will most likely be more errors that will need to be corrected, and more time will be needed to acknowledge the messages.

## The Radio Dial

Now we need to get a bit technical, and the analogies can't be as simple. First a *Megahertz* (MHz). That means a million radio cycles per second. Then a *Gigahertz* (GHz). That means a billion cycles a second. There is an IMPORTANT RULE HERE: The further you go up the radio spectrum dial, the shorter your wavelengths will be, meaning for a given power level, the shorter distance your signal will go. Do the math. Light travels at 186,000 miles per second. Open up Excel, and you can actually figure out the length of a radio cycle for a given bandwidth. Trust me, as you go "up" the radio dial, the wavelengths get shorter. Some definitions are needed here, about how the spectrum is parsed between different services, and the differences between licensed and unlicensed spectrum.

### Some common radio frequency bands (again, oversimplified):

- 450MHz: Public service radios, some cell phone services for rural areas
- 700MHz: UHF bands for TV in the United States (and elsewhere), future wireless services
- 850MHz\*: Cell phone services (including advanced 3G wireless wide area network, or WWAN, services)
- 900MHz\*: Cell phone services
- 1700MHz / 1.7GHz: Cell phone services
- 1800MHz\* / 1.8GHz: Cell phone services
- 1900MHz\* / 1.9GHz: Cell phone services (including advanced 3G WWAN services)
- 2100MHz\* / 2.1GHz: Cell phone services (including advanced 3G WWAN services)
- 2300MHz / 2.3GHz: In the United States, amateur and satellite broadcasting
- 2400MHz\* / 2.4GHz: Wi-Fi, home cordless, baby monitors, microwave ovens, “unlicensed” or technically the *ISM* band for “industrial, scientific and medical,” believe it or not.
- 2.5-2.6GHz: Proposed for WiMAX and other services, also IMT-2000 extension band, BRS
- 3.4-3.6GHz: Proposed for WiMAX and other services in Europe and China; utilized by the government for radio location and amateur radio in the United States
- 5.7GHz\*: More “unlicensed,” Wi-Fi, cordless phones, commercial use, proposed for WiMAX (Fixed BWA in Europe)

### Licensed Spectrum

This is spectrum assigned to a service provider by a specific country’s regulatory body for specific use(s). In the United States, it is the FCC (Federal Communications Commission) that is responsible for this role. In many instances, folks are using spectrum granted years ago, like the television broadcast folks, or spectrum granted for the original cell phone systems 20 years ago. Other chunks of licensed spectrum were auctioned by the FCC to the highest bidder, with the revenues going back to the U.S. Government.

Think of the auctions as the government selling “property,” or in this case “property rights” to the highest bidder.

This concept of property rights for wireless spectrum is critical. In this case, if the wireless operators did not have full and clear use of their spectrum, Johnny down the street with his toy radio transmitter set could blow your local radio station off the air. Or blow your local cell tower off the air in the middle of your phone call. Bad, bad, bad Johnny.

### Licensed Spectrum with an “\*”

You will see above that many of the bands have an asterisk next to them. These bands are (generally, but there are exceptions) “harmonized” globally. Every government around the world has a regulatory body that coordinates the use of its radio spectrum, for public safety, military, government, university, broadcast, radio, cell phones, 3G services, Wi-Fi, etc. reasons. Periodically, they get together to “harmonize” as much as possible the various spectrum bands around the globe. There is a group called WARC that does this (Google it). This is VERY complicated stuff. When your cell phone works when traveling from Canada to Mexico or from London to Hong Kong, this is a result of the harmonization efforts. Harmonization of spectrum across regions helps wireless standards get broadly adopted and is critical to the ability of manufacturers to mass produce devices and get the price curves down. Hold this thought for later.

### Frequency, Distance and NIMBY

Now we’ve got a few different factors that are coming together here. The higher you go up the spectrum dial, i.e. from 900MHz to 2100MHz (2.1GHz), or from 1900MHz to 5.7GHz (5700MHz), the shorter the wavelength of each individual “cycle” and the shorter that signal will travel for a given amount of power. For example, if you have a signal of a given technology on top of a 100 foot (or 30 meter) tower with a 30 watt transmitter, that signal will go MUCH further in a 900MHz system than 2100MHz (2.1GHz) system. In fact, some of the bands depicted above could need up to six to eight times as many wireless transmission towers and commensurately more base stations than systems deployed further “down” the radio dial. Any new system, especially a system at higher bands, will need several times more towers to cover a given region. Taking into account that municipalities often take YEARS to approve a wireless tower location and that there are often hundreds of thousands of dollars of legal/zoning/technical costs to put up a single tower, this is a big hit to any new service provider’s business model.

As an example, QUALCOMM and other technology companies in San Diego have worked with wireless operators for YEARS to try and get cell sites up in certain locales in the county; you can imagine just how daunting this challenge can be.

## Cell Sites and Morphology

The physical environment that a wireless tower goes into also matters. Remember the example of trying to talk with one wall and then two walls between folks trying to have a conversation? The planning and laying out of wireless networks is an amazingly complex technical challenge. Take a 100 foot high wireless tower in flat farmland in the Midwest, with one-story wooden structures, all in line of sight. Now take the same hundred foot tower (at the same frequency) and put it in a suburban area, with lots of four-story office buildings, concrete or steel tilt-up buildings, and a bunch of hills. Which tower will cover more area with more consistency? Now these towers are at the same frequency, and there will be HUGE differences in how they perform. Now move another tower “up” the radio dial where the signal will go half as far for a given power level. In this case you might need FOUR times as many cell sites in the suburban environments vs. the one tower in the rural area. This is known as *morphology*. You have never seen this word involved in the Wi-Fi debates of a few years ago, as Wi-Fi was for local/indoor/fixed use, or in the Mobile WiMAX debates of today, but when you get to outdoor or mobility networks, morphology matters. A lot.

## Cell Sites and Cost

For this example, we will assume we have a 300 foot (or 90 meter) wireless tower in the rural area and a 100 foot wireless tower in the suburban area. Assume both use Wireless Technology A. Near both those towers, in the rural and suburban areas are identical towers, identical in size and height, but using Wireless Technology B. Before both the towers were built, both operators had to purchase land, get zoning and construction clearance for the towers. What’s the cost difference here between the towers of Wireless Technology A and Wireless Technology B? ZERO. Now both operators have to go and source the physical towers—those big steel things. Can’t buy them at Home Depot. This is specialized stuff, with huge structural issues. Seen any news coverage of bad storms and wind in your life? Think high wind knows what technology a structure is transmitting? Cost Difference: ZERO. Now both have antennas on top. Wind loading Issues (think of antennas on radio masts like sails), more expensive engineering. Cost Difference: ZERO.

Now, the signal has to get from the top of the mast to the radio equipment at the base of the mast, need expensive specialized cabling. Cost difference: ZERO. Now there is equipment to manage the radio link, called base stations. The base stations need to be housed in something that provides power, protection, etc. Cost difference: ZERO. Now we are down to the actual equipment that manages the radios, and there will be cost differences. In fact, if you speak with various infrastructure vendors, they will describe that often the same “rack equipment” for base station radio cards will support multiple technologies.

## Bottom Line on Radio Frequency Technology 101

I've laid out some key radio planning issues in the most simplistic manner possible. This stuff is technical, this stuff is NASTY to implement. If somebody or some company says “75Mbps at 30 miles” there is no information content in that statement. It MEANS NOTHING, unless you know the frequency band and spectrum bandwidth being discussed, the power level of the amplifier, the morphology and interference environment of the system and a plethora of other issues, including whether the system is for fixed or mobile use.

A bit of a challenge here on the radio side. When QUALCOMM was challenging the conventional wisdom of the wireless world in the early '90s, at every step of the way there was a huge amount of skepticism. A huge amount of pressure to “prove it,” every step of the way. In the early days, when we were a company the size of (or smaller than) many of the proponents of WiMAX, every step we took had to be accompanied by detailed simulation results, test and trial results over time—significant challenges to commercialization. Our partners and QUALCOMM were often attacked across the board by a huge constituency that did not want us to succeed. I've asked folks now on four continents for metrics on WiMAX, either for Fixed WiMAX, or more significantly to this debate, Mobile WiMAX. Two years... nothing. Shouldn't this raise some vocal skepticism by appropriate audiences?

## What this means

There will be over 600 million cell phones and wireless devices produced in 2005. Those devices have been driving down the cost curve and up the capabilities curve amazingly quickly.

Why? Because there are two major standards directions, both supported by a huge number of companies, but using harmonized spectrum (the bands with the “\*” above), which allows manufacturers to make the same devices for global markets.

Another way to look at it is that your cell phone has various radios at various parts of the wireless spectrum dial “embedded” i.e. “built in.” In the United States, the phone you have probably has 850MHz and 1900MHz radios built in, and you will not or should not have a clue of which chunk of the licensed radio dial your phone is using when you make a call. In Europe, odds-on your phone will have 900MHz and 1800MHz and increasingly 2100MHz (2.1GHz). It’s getting easier to add more radios into a phone, but it is not trivial, not by a long shot. And making all this work has taken years, money and lots of smart people.

## How We Actually Do and Will Use Wireless 101 (A Lesson in the Obvious)

When we hear the claims for new technologies, whether it was the “Wi-Fi will rule the wireless world” hype cycle of two or three years ago, or the strident cries of the WiMAX folks, we humans have not changed much. Not for a bunch of millennia, anyway.

We prefer pleasure to pain (most of us). We prefer less expensive to more expensive (for similar goods). We prefer faster to slower (when it comes to services). We prefer convenience to inconvenience (unless you are a masochist).

Yet somehow we forget all this when the latest technology hype cycle comes along. In fact, it's always our hope that a technology “free lunch” is finally upon us that leads to the hype cycle in the first place. So, let's take a tour of the last two years, sprinkled again (for folks who have read my other pieces) with a slice of life.

In the last two years, a lot has changed in the wireless space globally. Wi-Fi (802.11 a/b/g) is now in the homes of early adopters globally, connected up to their DSL or cable modems. Wi-Fi was not, and is not free, because if you have Wi-Fi in your house, somebody is footing the bill (i.e., paying for the cable modem or DSL connection that your Wi-Fi network is hooked up to). More and more businesses have Wi-Fi. QUALCOMM, for example, has now more than 500 access points. Some businesses let you onto their Wi-Fi networks, some businesses don't.

The “hotspot” world has proved not to be a wireless panacea. Surprise! Hotspots are a useful niche, but I doubt anybody has made any money yet. The big companies struggle on, the ventures of a few years ago are mainly a historical footnote. “Municipal Wi-Fi” is now a hype cycle rage, like we all believe that our nearly bankrupt municipalities who have enough on their plate trying to keep the schools going and the roads patched and their pension plans funded have the dollars and wherewithal to become large-scale IT providers (on a subsidized basis yet).

We go to Starbucks and rarely see anyone on a PC. We travel through airports and really don't see folks in the hotspot zones. And lately we have coffee shops turning off their access points, as they want people to talk and interact.

But we see cell phones. We see cell phones everywhere. People yakking, people SMS'ing. Billions of phone calls every day. Billions of text messages every day. All helping to fund the most remarkable transformation in telecommunications history. The past two years have seen almost 200 million users of 3G services around the globe. The next several years will see hundreds of millions more. Vast areas (not airports, not streets, not urban cores) are being covered by networks that can efficiently provide hundreds of kilobits of reliable wireless access. Not in 2007, 2008 or beyond, but today. Two years ago in the United States, Verizon Wireless was just trialing CDMA2000 1xEV-DO (I'm not responsible for the acronym). Today, about one third of the United States is covered by Verizon Wireless' network that provides peak rates of 2.4Mbps (you really should ignore peak rates in general), and "real-world" network performance of 400-700kbps (pay attention to real-world or actual rates). Faster than a lot of DSL connections, faster than a lot of your corporate networks. Over whole regions! This year, Sprint Nextel is rolling out its CDMA2000 1xEV-DO network and Cingular is rolling out its WCDMA system. By 2006-2007 there will be THREE networks covering a huge swath of the U.S. population.

A quick but relevant aside. Keep in mind there are 600 million-plus cell phones sold globally per year. About 100-120 million desktop PC's, and 50-70 million laptop/notebook computers (don't take my word for it, look to your own sources). More and more of those hundreds of millions of phones are devices that are tracking the power of the PC of five or six years ago. Plus more and more amazing capabilities are being put in the phones: Multi-megapixel cameras, GPS, 3D gaming, music/video capability. Hard drives in phones. Phones that have "video out" to hook up to a TV. A process that is not going to stop. A process that QUALCOMM will do its best to accelerate (gotta put in a few plugs here).

Additionally there is an increasing array of PDA devices with EV-DO embedded TODAY, and we have just recently had the first announcements of laptop computers from major global manufacturers embedding EV-DO and WCDMA into their products.

So we have Wi-Fi becoming more prevalent in private spaces, home and office. We have WWAN rolling out with amazing rapidity globally, leveraging the economies of scale of 600 million voice users yakking and buying cool phones and

new services, building out systems to the tune of tens of billions of dollars of infrastructure in the ground. Today, tomorrow, the next day. Plus, as a little “aside” for the road warrior, more of the hotels we stay in either have free Wi-Fi, free wired Ethernet or pay-by-the-day wired or wireless services.

Let’s put all this together for a real-life tour of a wireless road warrior, one that right now is someone on the bleeding edge of all this stuff, but moving ever more quickly to the “middle.” In this case, me. When I’m in San Diego, I use my cell phone, which is an EV-DO device. I play 3D games, my kids love playing Frogger, and there is an amazing 3D snowboarding game that I can actually use as a fortysomething. I download video, usually CNN. I SMS and use IM with my co-workers. I have an email device, in this case an EV-DO Pocket PC-based device. It’s too heavy to be my only device, and I don’t like using it as a phone, but its fine for my email and calendaring. Plus, I can get attachments, and browse full web sites with alacrity. It’s a cool device and a harbinger of even cooler devices to come. My laptop has an EV-DO PCMCIA card (PC card) with a fixed “all you can eat” service for less than \$60/month price through one U.S. service provider.

With this as background, I’m going to describe a few sample business trips. Again, I’m a human, like most of the readers of this document. Pleasure vs. pain. Fast vs. slow. Less expensive vs. more expensive. All that stuff.

This spring, I went to a Conference Board “Council of Marketing Executives” Meeting in Washington, D.C. Armed with my normal complement of devices, EV-DO handset, EV-DO PDA and laptop with an EV-DO PC card. In the car to the airport, I used my phone, no surprise there. I got my mail and checked my schedule off my EV-DO PDA. Ho hum. At the airport, no Wi-Fi in sight, I’m sure there were “pay for” hotspots somewhere, but not at the airport Starbucks Kiosk I got coffee from, so I just fired up my laptop and connected at whatever speed I connected. EV-DO works—it works well—so I like doing my email and browsing, and don’t spend much time worrying about what my “peak rates” are or what “my average data throughputs” are. I just want to do my job. Maybe some folks out there spend their life checking peak rates, but my guess is most of you have no clue of what your rates are, going back to your wireline modem days (if you have not already blocked out those horrid memories). For the things we do today, email, web browsing, VPN, Internet access, EV-DO (and WCDMA and HSDPA to come) make your tasks transparent. Don’t believe me, go try it.

So I fly to D.C. Land at Dulles. Get on those strange bus transports at the airport that somebody's cousin probably got the contract for back in the Cold War days. Used my phone. Checked mail on the PDA (again, the operative assumption here is that I'm a technology geek). I rent a car and go to my hotel in D.C., the Hotel Monaco. Great place, right next to the International. Now an anomaly to the story occurs. The hotel does not have Wi-Fi, but it has FREE wired Internet. Personally, I do much of my computing when I'm in a hotel sitting at a desk rather than wandering around the room, and the FREE wired Internet is right there staring me in the face from the desk. So I use it.

Why? Is it because it is free? No, because my EV-DO card access is a fixed price for unlimited monthly usage, which makes my "marginal cost" for another session ostensibly "free" as well. I used the wired Ethernet at the Monaco because in this case it is FASTER than my EV-DO card. This is not always the case, as even at my house my EV-DO card is sometimes faster than my cable modem.

After the conference, I went to my father-in-law's house in Annandale (a suburb of D.C.) for the weekend for a family get-together. I still needed to communicate and do email. So I used my phone for my voice calls, how unusual. I asked my father-in-law whether he had Wi-Fi, and (I kid you not) he replied, "I don't have wireless." He actually has a Wi-Fi network, but he did not know it was called "Wi-Fi." This was a Wi-Fi system that, if any of you remember from my Wi-Fi pieces, was set up by my brother-in-law who works for a Wi-Fi security company. When I first got to my father-in-law's house I used my EV-DO card again, 'cuz I could not actually connect, since the Wi-Fi network was WEP encrypted. Once my brother-in-law came back, he could give me the password for the Wi-Fi WEP protection which my father-in-law had long since forgotten.

There is a key point here...how many of you folks out there have a brother-in-law in the Wi-Fi security business that could actually get you legally onto a local Wi-Fi system? Not too many, I'd guess.

So following a fun but not so quiet weekend with father-in-law, wife, two sisters-in-law, five little girls under the age of 10, and baby Sebastian, the first boy in my wife's family for over sixty years, I went back to San Diego. For a short time, then off on a trip to the UK.

So, on this trip, I went San Diego-Chicago-London. Same thing. Admiral's Club San Diego, paid Wi-Fi? No thank you, I'll just use my EV-DO card.

Changing planes in Chicago, going from Terminal H to the International Terminal, no time, but guess what? EV-DO is live there, as my phone made clear to me. Landing in London, I made my way to the Metropolitan Hotel on Old Park Lane.

Great hotel, but as it was two years ago, connectivity is somewhat wanting in Europe (which is why WCDMA needs to roll out even faster). One gets accustomed, very quickly, to having EV-DO in most of the metros in the United States that I visit, with more coverage to come. In the Metropolitan, one has a great hotel, but connectivity options are a bit challenging. There is wired Ethernet in the room, which you discover after calling the front desk and learning that you need to turn on your Siemens/Fujitsu interactive television console to be able to access the system. Once you have done that, you connect your Ethernet cable and have two options. Option one, you get the first 10 minutes of wired Ethernet access for free and are then charged £1.50 for every ten minutes following (about \$2.70 per every ten minutes). Option two, you pay £20 for a 24-hour period (about \$36 per day, ouch!).

It was not much better for my European counterparts. Asking them about their connectivity options, there are functional and well performing WCDMA data cards, similar in performance to the EV-DO cards in the States, but priced per megabyte, and don't ask about what it's like to move between countries. Remember, I went from San Diego to D.C. (4,000 kilometers/2,500 miles), same tariff plan, ready to rock when I got off the plane. Or San Diego to Chicago (3,000 kilometers/2,000 miles). Yet when we did a day trip from London to another country about 1,600 kilometers/1,000 miles away, one of my co-workers had to jump through hoops and about an hour of customer service calls with a wireless operator to use his WCDMA card. This was not a "standard" or a "technology" issue, as there will be 45 million-plus WCDMA devices shipped globally in 2005, and is an issue that might even be solved today, but indicative of the issues that all wireless users face as new standards mature.

So what's the bottom line here? The bottom line is that I have access to a broader number of connectivity options than your average road warrior. Take solace, road warriors of the world, you are going to have the toys too, sooner than you think. However, the decisions that we will make, today and into the future, will be predicated on rational decision making. Cost. Performance. Convenience. Real-world performance. Not on the basis of PowerPoint presentations purporting fictional future world views.

## Making a Product 101

Go search Google. Put in “WiMAX 2005.” You will see a bunch (thousands?) of articles talking about “Mobile WiMAX Solutions” available in 2005. Replace “2005” with “2006” and you’ll see still more, many in articles of companies supporting WiMAX that should know better.

There are some basic dynamics to creating technology and REAL products that lay waste to a lot of the claims by the WiMAX crowd. Claims that we see in press releases and articles daily. Let’s call it the “Magic Wand Theory of Product Design.”

As much as we all want it to be so, there is no magic wand. Creating devices, whether wired, wireless, laptop or desktop is a painful and costly process. We are now almost through 2005. Let’s take a hypothetical “top five” laptop manufacturer. Does it wave its wand and \*poof\* a new laptop line shows up? Not likely. There are engineers, marketers, product managers, finance folks and lots of layers of management that needs to make difficult decisions and trade-offs to decide which products get “green lighted” for development, and which do not make the cut. Those folks need to define what the products do and what features they contain, within the constraints of their business models.

This is not just about wireless. This is about a whole range of tradeoffs—of cost vs. features vs. manufacturability vs. segmentation vs. projected market demand—that many of these folks need to make. It’s not pretty, it’s not fully science.

I had a conversation several months ago with the GM of a top five global PC manufacturer. I asked him explicitly, even though this company puts out the

prerequisite hype on WiMAX, where, on the scale of 1 (least likely) to 10 (imminent) is embedded WWAN vs. embedded WiMAX on their product plans.

Answer: embedded WWAN is more likely (8-9.5) and WiMAX is not too likely (1-2). My guys have had similar conversations with two of the other major PC vendors and have gotten the same responses. There are a lot of reasons for this.

For the next few minutes, we are all going to play the role of a product manager for a “global top five” PC manufacturer. Specifically, the folks that do the product definition for laptop and notebook lines are largely irrelevant to the folks defining and specifying out desktop computers.

So we are a product manager for the theoretical company “Laptop Co.” In your job at Laptop Co., you have limited budgets, limited staff, huge financial pressures and a sales staff screaming at you for a laundry list of futuristic and equally unachievable feature and price targets for your hypothetical new product lineup.

First of all, it’s Q4 2005. Are you looking to design products for your November 2005 introductions? Nope, that product roadmap is long since history from your perspective and your OEMs and ODMs already have parts in-house for your first product runs. That dinner is already cooked. If you are a “fast cycle” manufacturer, you are examining and developing at your product roadmaps anywhere from 9-18 months out. This means that you are specifying and designing products for the late 2006 or even well into the 2007 timeframe.

You have constraints already. Can your new products cost more than your competitors, if targeted toward the same target audiences? Do you need new functionality to attract new customers? Can you tank your battery life? Can you put in a lower-end screen, offer less connectivity or fewer multimedia capabilities? If you already have 802.11 a/b/g capabilities, can you pull out your wireless LAN capabilities? The answer to all: not likely.

So you are under pressure to examine WWAN technologies, as your enterprise sales force has been running into two competing influences. On one hand, enterprises around the globe have been trialing EV-DO or WCDMA PC cards. And loving them. The mobile professionals using these devices have often been getting ten to forty percent or more productivity gains, the IT departments have been seeing paybacks and ROIs that are just phenomenal, and when they try to take the cards back from their field sales forces, the sales folks out there say “you will pry this card out of my laptop from my cold dead fingers.” People like this stuff.

On the other hand, there is another vendor set out there talking about “Mobile WiMAX.” In 2004, they were telling folks (or even more insidiously, letting people believe) that there would be WiMAX mobility in 2005.

Now in 2005, some are still saying 2006, and more saying 2007 or even 2008. However, you, Mr. Product Manager, already have much of your 2006 product line in “lock down.” Mobile WiMAX, the IEEE 802.16e specification is not a standard and probably won’t be a standard for a while, and even early versions of a “standard” will have a lot of wiggle room for interpretation. Your sales guys are saying that there are confused IT folks out there saying “some large vendors in the IT community are saying that I need laptops with embedded WiMAX so give it to me.”

What can you do? It’s not just a matter of circuit board real estate to fit the WiMAX circuitry. There IS NO STANDARD! There is no clear picture of what it will cost to put WiMAX radios into your laptop line. There is no clear business model that shows if you put WiMAX capability into your laptop, at egregious expense in the beginning, that customers would actually buy the product and why.

Then there is this pesky issue of *radio* that you have painfully learned in the past four or five years with both the WLAN and WWAN solutions. Oh my gosh, how you hate radios. Over the years you had enough problems with FCC Class 15 emissions regulations, which have controlled the types of RF emissions that your device could emit from general issues with your microprocessor and other circuitry.

In 2001 or so, your high-end laptops started embedding 802.11b. This caused you all sorts of mechanical and emissions issues as you suddenly had to design your pesky *antenna* into your laptops that you had never thought about before. If you were a Star Trek fan, your mind was spinning with thoughts of “it’s a computer, Jim, not a damned radio.” Bluetooth followed, with more headaches. How you hate radios.

After you finally solved your issues with radios and your wife said you at last stopped waking up in the middle of the night in a cold sweat, screaming because of your RF nightmares, along comes WWAN. Your top enterprise customers start trialing WWAN cards of various flavors. Suddenly you had a FCC Class 15 approved laptop and your customers were plugging in a FCC Class 15 approved accessory WWAN PC cards. And BAD THINGS STARTED HAPPENING!

Your laptop, and the voodooesque RF emission from your laptop (remember RF = voodoo) started JAMMING the PC card. Your sales guys' customers were unhappy, so your sales force was unhappy. And who would they call? You.

This led to a crash course with a bunch of folks from the PC card vendors and the high priests of RF to solve your ground plane interference issues to keep your laptop from jamming that card. Six more months of hell, but you solved the problem. Happy sales guys and more importantly, happy customers who were putting PC cards in their laptops by the hundreds of thousands and loving it.

You are reading about WiMAX, and you have your usual suspicions about the hype cycle. You already have 802.11 b/g in your products. You have solved the problems with Bluetooth. The WWAN RF issues with PC cards are blissfully in the past. You are actively looking at embedding WWAN solutions such as EV-DO and WCDMA into mini-PCI cards for upcoming models. And these WiMAX guys keep on screwing up your life.

If you make products, what are your goals? You want to serve your customers, you want to make money. You want to minimize the number of products you build and minimize service costs. Making products is HARD. Along comes WiMAX. It causes you to FREAK:

1. Folks are out there purporting 75Mbps at 30 miles and not specifying whether this is for mobility or not.
2. THERE IS NOT A COMPLETED STANDARD for Mobile WiMAX, and the dates for commercial implementation of both Fixed (802.16d) and Mobile (802.16e) WiMAX keep on slipping.
3. There is no definition of what spectrum this stuff WiMAX will be operating at—700MHz, 2.3GHz, 2.4GHz unlicensed, 2.5GHz-2.65GHz, 3.4-3.6GHz, 5.7GHz unlicensed and other bands keep on getting bandied about.
4. Unlike your 802.11 b/g and Bluetooth, both at unlicensed 2.4GHz, and your solving of WWAN issues (850/1900MHz, 900MHz/1800MHz, 2100MHz) of globally harmonized spectrum, you have no clue about where WiMAX will show up.
5. So, there IS NO STANDARD, no broadly available info on real-world performance of the proposed standard, there is not any harmonized global spectrum.
6. SO WHAT DO YOU BUILD?

If you are a laptop manufacturer, you want global scope. You want efficient manufacturing and global service strategies. So my guess is that you go to your management, you go to your sales folks, bleary eyed from the pressure and the whiskey, imploring “I need some definition about what this WiMAX thing actually is, it is driving me nuts, as I can’t spec and build a product to a press release.”

You would need to know when there will be a standard, and when that standard will be robust enough to actually put on a product roadmap. You would need to know what ‘bleeping’ radios to put in the device, as they need ANTENNAS and the antennas need to follow the wireless version of the Hippocratic Oath ‘radios, do no harm.’ And even if there is a standard, if there are a bunch of different radio bands by region/country/regulatory fiat, “just what the heck do I build?” Not fun. So, once again, it comes back to actually having a standard. This leads us to...

## Creating a Wireless Standard 101

This is an explanation of a presentation slide that I had my folks create years ago, at the height of the radio technology holy wars. Luckily, in the WWAN world, that time is blissfully behind us. My original version of the slide said that any new wireless standard started with the first step being “issue a press release” but my guys toned me down a bit. So here is my quick tour of how all this stuff happens. It might seem long when you read all this, but quick when you understand that wireless standards can be hundreds or thousands of pages long, with years of testing, thousands of changes from the original specification, with the involvement of hundreds of companies, and thousands of the world’s brightest engineers.

**STEP ONE:** Build and test a prototype system.

In this step, somebody or a group of somebodies develops a set of criteria and circulates it, and at some point submit their activities to standard bodies such as IEEE. The various standards bodies for differing technologies go about this step in differing manners, but the net of this is ultimately their efforts lead to step two...

**STEP TWO:** Establish standard specifications for system and devices.

Many standards bodies have a sort of three-phase approach. The first phase is an architectural and feature *overview*. I’m building a house, how big is the house, how many rooms, what cool features. The second phase would be to establish the standard, i.e. what would the *blueprints* for the house look like. Third would be the *details*, what do we actually build, what type of wood, how many nails, what type of plumbing, which brand of windows, etc.

**STEP THREE:** Revise and Stabilize the Standard.

Once a standard is written, that’s often the beginning. Anybody out there ever built a house, remodeled or re-landscaped? Was the project done once you had the plans?

Hell no, and you have the scars to prove it. Global wireless standards, such as the mobility standard of WiMAX 802.16e have dozens of companies involved, with hundreds of amazingly bright engineers involved. It might be an odd thing to say, but a standard needs to be STANDARD. Not “pre.” A pre-standard product is “marketingese” for “proprietary.” A fish is a “pre-land mammal,” but it’s got gills and does not walk very well. Stabilizing a standard, especially a mobility wireless standard, takes time, a lot of effort, money and pain.

#### STEP FOUR: Test Performance of Standard Release.

Back in the Wi-Fi vs. 3G hype cycle, it was great. 802.11 b (then a/g) were all standards; they were all out there; there were products that could be tested to measure claims of performance vs. actual and claims of economics vs. real costs. In the WiMAX world, this remains a mystery. Two or more years into the hype cycle, real test data is about as common as a dodo bird on Wall Street. There are claims, there are press releases, but real models and test data? Not. We have our own analysis, and surprise, the numbers don’t look like what some of the WiMAX folks are telling the world.

#### STEP FIVE: Optimize System and Device Performance.

This is one of the myriad of challenges of creating a mobility wireless standard. I outlined some of the challenges of creating a mobility device. But that is a TINY piece of the equation. That device needs to be part of a network—a network that needs cell sites, central big iron, billing systems, provisioning systems, customer service, field engineering...so much stuff it makes one’s head hurt. And none of it is easy. Think of some of the challenges that we all have with our Wi-Fi networks and with our cell phone service providers. Wi-Fi goes back to the early ‘90s and cell networks to the ‘80s. And somehow the WiMAX guys are going to have a magic wand to make it all better? If so, I will be the first to congratulate them, but I doubt it. Pain, time, smart people and lots of money.

#### STEP SIX: Develop Engineering Prototypes of Chips and Software.

Some of these steps can happen in parallel, but none can be skipped. In the case of fixed, point-to-point WiMAX (802.16d), we’re starting to see prototypes out there. The mobility standard for WiMAX is not the same standard however, something that somehow does not get mentioned very much, and it’s not clear the degree of commonality between standards. Sitting on your couch is one thing, sitting on a train or in a cab is another.

#### STEP SEVEN: Test Interoperability between Devices and Manufacturers.

For every wireless standard, from the first analog phone systems, to the first GSM systems (God Send Mobiles), to the first CDMA (Can’t Deliver Many Anways)

systems, this has always been problematic. In case you haven't got the point yet, wireless systems are complex. Massively complex. The more vendors, the more pressures to get product out. The more quickly a standard has been established, the more ambiguity in the detailed standards documents, the higher the probability that different companies interpret different aspects differently. In the case of the WiMAX mobility standard, 802.16e, in several of the standard meetings, companies with technical submissions had TWO MINUTES per submission to present to the Standards Group. For any wireless standard, moving too fast means a higher probability that the stuff does not work together well for the steps defined above. This is not insurmountable, EVERYTHING in wireless can be overcome by bright people, money and time—TIME being the key variable. Making complex mobility standards work properly, making them interoperate, takes time. ALWAYS YEARS worth of time. NEVER MONTHS of time. And there has NEVER BEEN AN EXCEPTION to this rule for the last twenty years.

#### STEP EIGHT: Test Interoperability of Multimode / Multiband Systems.

In Step 7, we've just described how difficult it is for devices of a given standard to play well with one another. We've also discussed that in the WiMAX world it is a huge muddle to figure out just what parts of the radio dial these devices will function in. Put Step 7 and Step 8 together and it's not a pretty picture, especially if you are the unlucky product manager we've been modeling.

#### STEP NINE: Pre-Commercial Launch.

Unfortunately, I can give real life examples of every step above. As can pretty much anybody that has been a part of enabling over a billion wireless users over the last 20 years (only 11.5 for me). But I need to illustrate a real life example here, as some of the most daunting challenges of any new mobility standard are the things that "folks don't know that they don't know":

**Real Life Example Break:** Let's go back in time to the early days of cdmaOne, the original IS-95A standard. TIA IS-95A was first proposed as a technology in the late '80s and was fully standardized in May 1993. The standardization was led by QUALCOMM as well as some of the world's leading technologists, operators and infrastructure vendors. By mid-1995, in a VERY large American city, the first "pre-commercial launch" of the standard was ready to take place.

Devices were out there, the standard was set and the infrastructure of several manufacturers was already vetted out for interoperability. So this operator was ready to go. The infrastructure was "interop'ed" and ready to go. Let's begin the test, time to rock and roll. Going back to 1995, what was the prevalent wireless standard in the United States? Analog (AMPS).

The reason the operators were feverously moving to digital services (either cdmaOne, which has evolved to CDMA2000 and CDMA2000 1xEV-DO, or IS-54 TDMA which evolved to IS-136 that has pretty much gone the way of the aforementioned dodo bird), was that the analog systems were hitting the wall from a capacity standpoint.

At the time in this city, there were two operators bashing it out for the high value analog cell phone users. The digital system was still being tested, obviously, and the analog system was congested because analog sucked (we all know that). So how would they differentiate and get better performance from their existing systems? You already know how they did it, you've lived it. In college, if you were rocking in your dorm and the room next door turned their stereo up, what did you do? You turned yours up as well. In a cocktail party, if it gets louder, the way you get heard is to talk louder. Not rocket science in this case. Just go back to the first section of this paper. You are a whiz at this stuff now.

The analog guys turned their power amps up, they turned up the volume. All perfectly legal, in their FCC licensed spectrum. Then something unexpected happened on their FCC compliant infrastructure, and FCC compliant handsets, and FCC compliant pre-commercial cdmaOne infrastructure, and FCC compliant early commercial cdmaOne handsets. Bad things started happening—things I've already alluded to on the laptop side.

When you have a radio signal, it tends to spread out a bit (forgive me, folks with engineering degrees). In this case, when the operators turned up their analog signals, minute portions of that signal bled over into the new cdmaOne digital bands. One of the ways that cdmaOne (and all subsequent CDMA based digital standards) got tons more capacity was by operating at a dramatically lower power, orders of magnitude, lower power. So, on one hand you had guys turning up the volume, just as their new high-tech neighbor (cdmaOne) was turning down the volume. And this “out of band” interference (intermodulation) started blowing the STANDARD COMPLIANT/FCC COMPLIANT cdmaOne handsets off the air. This became known as the “Front-End Overload Problem.” This was one problem, and there were a bunch of others learned as the standard moved to mass commercialization and had a bunch of follow-on effects. The standard had to be revised (among other revisions happening in parallel). The handsets needed to be redesigned. The folks that made the RF filters had to design new types of filters that would be significantly better at rejecting “out of band” interference.

All in all, this “one thing,” and there were others, pushed back the mass commercialization of cdmaOne services in the United States by six months or more.

**Moral of Our Real Life Example Break:** Mobility standards are really, really difficult and fraught with peril. There is not any magic wand, just smart people, money and especially, time. And your competitors do not stand still over time.

#### STEP TEN: Finalize Chips and Software for Full Commercial Launch.

In a commercial mobility system, the standard/system needs to be vetted out by having lots of fairly hefty trial systems. These systems, almost by definition, need to have scale. It can't be a few people hanging out at Carlos Murphy's Mexican Irish Pub at North County Fair in North County San Diego drinking margaritas and eating nachos and calling everybody they've ever known on early IS-95A handsets. That's OK for the early testing (been there, done that, and it was much more fun than the later stuff), but at this point in the game, folks pushing the standard need to have deployed tens of thousands or more likely hundreds of thousands of devices on relatively mature base station sites over relatively mature network backbones and central offices. At the same time, they need to be sharing the issues very PUBLICLY in terms of the good and the bad. There is no place to hide here, early commercial system results need to be very public, and the findings need to be addressed. It is not a PR game at this point.

#### STEP ELEVEN: Full Deployment.

We see this stage as the millions/tens of millions stage. Not capability. Millions using the technology. In the case of WiMAX, this is a bit tricky, as there are chipset providers that say they will be putting WiMAX capability in their devices, but it's unclear what that means. If it's on a circuit board and nobody uses it, is it real? Interestingly enough, believe it or not, I've been kind to the WiMAX guys, as I've focused on the device side, and not all that much on the network side, but I'll get to that.

#### STEP TWELVE: Ramp Volumes, Reduce Manufacturing Costs.

It should be pretty clear that you just can't go from the “standard documents,” to the lab, to tens of millions of units. The steps above focus on getting to a functional standard. Establishing and driving an ecosystem for a new standard, getting factories ramped, test cases established (again hundreds or thousands of tests) to allow robust, high volume manufacturing has its own challenges and timeframes. This would require another section. However, I think you get the idea at this point.

## WiMAX and 3G WWAN

So I've laid out lots of issues that many folks would rather not take a look at. And many folks in the WiMAX hype community would rather put their fingers in their ears and bask in the press glow (in the Wi-Fi hype days, an industry analyst basically did that, but she was being quoted a lot and did not want reality to get in the way of the publicity cycle).

To reiterate: WiMAX as defined is two standards. One standard is for "fixed" usage, and another standard is for "mobile" usage. The fixed standard is beginning interoperability testing in Spain. This standard is further along, and will probably be used as backhaul (the connection from base stations to core networks) for WWAN networks as well as for point-to-multipoint applications. An interesting market, but a market which, even in the best of circumstances, will be a tiny fraction of the mobility wireless standard's size. Hence the attention to the 802.16e standard, which is the mobile variant.

The mobile standard for WiMAX was supposed to be standardized in late 2004, but this has not happened yet. No surprise for the reasons discussed ad nauseum above. One of many anomalies continues to be the dearth of real-world data on anything generated by the WiMAX Forum and the vendor community for "Mobile WiMAX."

One recent data point is the Korean example of Hanaro Wireless. The Koreans, eager to continue to drive advanced wireless (and Korean companies continue to push the wireless envelope globally) launched a variant of WiMAX called "WiBro." Hanaro had spectrum in South Korea, installed a massive amount of infrastructure and launched a WiBro network. Did they get 75Mbps at 50 kilometers? Nope. They got 500kbps-2Mbps with cell sizes of 1-2 kilometers. And Hanaro just gave the spectrum back to the Korean government (Google Hanaro WiBro).

This was an amazingly silent seminal event for the WiMAX folks. If a tree falls in a forest, does anyone hear it? Meanwhile the Koreans lead the world with seven megapixel camera phones, phones with hard drives built in, advanced broadcast TV phones, phones that you can hook up to your TV to play 3D games. WiBro will continue to develop, but it is not being positioned as a panacea.

So we believe that Fixed WiMAX has a play. But even at one twentieth to one thirtieth the size of the mobility opportunity, that's not a sure thing. In the system simulations we are doing on Mobile WiMAX, it's not clear whether WiMAX has ANY advantages over the evolutionary path for CDMA2000 or WCDMA/HSDPA WWAN. The key here is that the WiMAX folks cannot credibly show slides showing "WiMAX theory" circa 2007/2008 against 3G WWAN circa 2004/2005. Or compare the performance of a theoretical system using 20MHz of "TBD spectrum" against 3G systems using less spectrum.

So what does this mean for Mobile WiMAX? Well, as somebody without an engineering degree, I need to tread carefully at QUALCOMM. Anything I say to the world, including stuff like this has to get through a bunch of PhDs without getting massacred. But the MBA paid off in one way. Michael Porter, who wrote a seminal work on competitive strategy, laid out some basic dimensions for businesses to succeed. A business can differentiate on many dimensions, but a major challenge is for any new business/business model to avoid being "caught in the middle." In our view, Mobile WiMAX is potentially caught in the middle between the rapidly developing WWAN standards such as CDMA2000/1xEV-DO and WCDMA/HSDPA and the WLAN standards that are evolving from 802.11 a/b/g to 802.11n. And other evolving standards such as Flarion's Flash OFDM caveated above.

So on one hand, we have 3G operators that are putting hundreds of billions of dollars of infrastructure in the ground globally. A long time ago (way up above), I described how Verizon Wireless, Sprint Nextel and Cingular are all deploying 3G networks in the United States. By 2007, there will be tens of thousands of cell sites in the United States that are EV-DO or HSDPA capable. How is this happening? Because folks in the United States are paying the operators for their VOICE calls. From FCC stats, over 750 minutes of use a month for over a 170 million subscribers. Even as data becomes an ever more important strategic component of the operator's business, it is voice that is paying the bills. It is voice that is generating the revenues that are being plowed back, massively, into new technologies and expansion.

Meanwhile, Wi-Fi keeps on expanding into more and more homes and businesses. More and more folks have Wi-Fi, more and more folks have various 3G technologies in their phones, PDA's and increasingly, their PC's, now through PC cards, but in this year and beyond, increasingly built into the laptop.

Data services over wireless, unless they have specialized industrial applications, have been littered with noble attempts that have crashed and burned. Metricom crashed (twice). Proxim just got purchased out of bankruptcy. Even QUALCOMM's investments in "data-only" networks in Brazil and the Dakotas (don't ask) ended up failing. There are several industry analysts who have tried, without success, to identify ANY "data-only" networks beyond a few limited industrial systems that have consistently grown and generated profits.

On the pay-per-use hot spot front, in summer 2005, one of the large national hotspot providers finally released some subscriber metrics. Paying for thousands of costly T-1 lines at hotspots across the country, they announced that they hit 1 million user sessions per month. And that the user sessions had been increasing in time to 64 minutes. That means, after years of promotion, that there are 64,000,000 minutes of paid Wi-Fi time on their network. Let's contrast this to the voice side. There are over 175,000,000 subscribers in the United States, at over 750 minutes a month. This means over 127,000,000,000 (127 BILLION) Minutes of Use (MOU) per month. It's difficult to find metrics on WWAN data card or WWAN PDA usage in the United States (or elsewhere) but I would bet that the usage is massively above the 64M MOU of the country's largest Wi-Fi operator. We are talking about roughly a 2000-1 ratio here.

So on one hand we have the WWAN players with a standard, economies of scale and infrastructure that is being amortized daily. In the U.S., unlimited WWAN usage from Verizon Wireless on their EV-DO system is less than \$60/month and in Japan both KDDI (DO) and DoCoMo (WCDMA) are about \$40/month. Taking the United States as an example, once Sprint Nextel, Cingular and Verizon Wireless all have national networks, will prices go up? Not likely.

So the WiMAX guys have a vague vision about metro coverage, and in other areas about rural coverage. There are also vague statements economies of scale, and an intellectual property regime that is different from other wireless technologies. However, there is a basic problem that there has not been any examples of data-only systems being economically viable, and no discussion, if the WiMAX guys are going to do voice services, how they are going to penetrate a value chain/wireless

ecosystem that will be rapidly approaching a billion (that is billion with a capital B) units a year by the time the WiMAX guys get their act together. Let alone what frequency these alleged systems will operate at. Or how the standardization issues or product issues described above get solved. And remember, as verbose as I have been, if anything, I've provided a vast oversimplification of some of the issues that need to be addressed and resolved.

Early on we've identified that the towers and issues in installing WiMAX may not be any different from WWAN. And if they are using spectrum at 2.5 or 3.5GHz, they will need a TON more infrastructure than the WWAN systems that they are competing with. This summer, I went to the CommunicAsia show in Singapore. All the infrastructure that the WiMAX guys had on the show floor looked suspiciously like the WWAN cell equipment in the show booths next to them. So, if they have to put in more infrastructure, if that infrastructure is disadvantaged from a spectrum standpoint, if the standard is lower volume and from disparate vendors, if the performance is not demonstrably better than the WWAN systems WiMAX is trying to displace, and if the disadvantaged WiMAX system has to put a ton of equipment out there, fund it, sell it, market the service, service the service, just how the heck are they going to create a business? All while the Wi-Fi guys on the home and business side of the equation continue to embed more devices and improve their capabilities; while their 3G competitors advance and drive down costs on massive global volumes; and while their 3G competitors evolve their systems to equivalent or superior "cost per bit" of delivering services based on the most massive economy of scale value chain the consumer electronics world has ever seen.

If we had to go out a few years, to 2008 and beyond, it's our view that we'll see WiMAX out there, of both the Fixed and Mobile varieties. But like the Wi-Fi service providers, it's going to be tough going. It's clear in the technology world that folks are willing to follow the herd, sometimes investing millions or hundreds of millions of dollars without asking the tough questions. Whether it was the dot-com boom or the Wi-Fi boom, there is a whole industry that grows up surrounding the "next big thing" for their own motivations. However, there seems to be a tie between complexity and the lack of willingness to scrutinize and debate. That's not healthy.

Bottom line is that the changes in the way humans communicate globally have undergone, and continue to undergo, the most significant shift since we emerged from the primordial ages and developed the ability to talk. For folks involved in the wireless space, we should all be proud of the tremendous progress in driving toward the "death of distance" (thanks to *The Economist*) and to the amazing pace of innovation in WWAN networks, devices and applications.

The pace of change and innovation is accelerating and moving in directions that not too many folks would have foreseen even 10 years ago. There will be new innovations, new technologies and new advancements, but they are going to have a lot of dust to eat before they attempt to catch up. And passing the 3G WWAN value chain and operators? I just gotta say “show me.”