Exploring the Great Myths of Wireless

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Table of Contents

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It's been six months since I wrote my "Adventures in WiFi" piece, and as you will see, I've been thinking and talking about some of the myths of our industry for a LOOOONG time. To those of you who have worked with me or interviewed me, you will recognize some common themes. Once again, it's all written by me, so errors and omissions are mine.

I've actually been sitting on portions of this piece for a few months, but I've had "oh no, another sequel" fears. The WiFi piece was a personal travelogue, and I think a lot of folks out there could relate (painfully) to some of my experiences. As a result, I've been reticent to send out this piece, since it covers a lot of topics that are much drier than my last effort.

Like my last piece, I will apologize now for the length. However, also like the WiFi piece, part of the problem is that simplistic views of very complex issues somehow get accepted as conventional wisdom, and we end up seeing them ad infinitum as fact. When, like many things in life, the reality is not quite so simple.

My "Adventures in WiFi" piece got much broader global readership and comments than any of us could have ever imagined, and I think six months later there is a reasonable track record of accuracy; now I'm going to go out on a limb and put another piece in front of folks.

In this piece, I would like to explore what I see as three consistent "myths" of wireless.

- The "GSM vs. CDMA" Myth
- The "What is 3G?" Myth
- The "3G Economies of Scale" Myth

I've included "proof point" sections, integrating a lot of the comments on the three myths listed above, covering camera phones, 3G evolution in Japan and the emerging wireless market in India. Plus, if I have not worn folks out by that point, I've included an optional "bonus" section on wireless infrastructure economies of scale.

Any comments, questions, feel free to contact me:

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The "GSM vs. CDMA" Myth and How it Gets Mixed Up with the "What is 3G?" Myth

There has been an entire industry based on the "conflict" between GSM and CDMA. In a market where there is uncertainty, lots of folks at lots of companies need to find information. They read articles, they read white papers, they attend conferences and conventions. From the mid-'90s onwards, for those folks in the technology world, and especially those folks involved in the wireless industry, the terms "GSM," "CDMA" and "3G" were surefire means for generating controversy and discussion.

But the world has moved on. In the telecoms industry, it has become painfully clear over the last few years that hype and imaginative stories do not build revenues. Dueling PowerPoint™ presentations of "my theoretical peak rate is faster than your theoretical peak rate" do not add new customers or bring new and innovative applications and services to the marketplace. Execution does. And that is where conventional wisdom breaks down. And why the "Gs" concept and "GSM vs. CDMA" are no longer useful parts of a meaningful technology discussion for the wireless industry.

Recently, I was in a meeting with one of the world's leading technology industry analyst firms. The company was giving its view of the wireless landscape, and we were reviewing its global wireless forecasts by technology. Its forecasts, going back to 2002 and out through 2007, were neatly boiled down to two technologies – GSM and CDMA. This led me to ask a few questions: "CDMA2000 has been deployed on dozens of networks globally. Where are your CDMA2000 numbers? WCDMA/UMTS is being deployed around the world. Where are your WCDMA/UMTS numbers?" This led the presenter into a spirited defense of his company's forecasting methodology, which, for the reasons I describe below, is fundamentally flawed. And flawed in a manner that many, or even most, folks looking at the wireless industry clearly recognize. I kept on probing. Finally, after about 20 minutes of probing, the analyst gave in and acknowledged the methodology of the forecast was defined by his firm's largest customers. Not by market realities.

Hmm. Well it seems to me that to avoid the problem described above, we must begin by defining some terms in the context of the pre-3G world. This will help us understand how the wireless world has evolved, and how some of the nomenclature needs to move on. For Wireless Industry Veterans (you know yourselves, you bear the scars), feel free to skip this part, but I still go through the descriptions below with innumerable journalists around the world, especially folks from the IT world, who were blissfully able to stay on the sidelines for many years.

- **Analog Cellular**, known largely as AMPS in the Americas and TACS or ETACS in other parts of the world, is now, in hindsight called "1G;" although it wasn't

called 1G back in the '80s or early '90s when the systems evolved and were deployed.

- **Digital Cellular**, now widely called "2G" in retrospect, or in some of its evolved nature called "2.5G," "2.75G," (I've even seen "2.85G"); 2G comes in many flavors, PDC, GSM/GPRS, TDMA (IS-136), or cdmaOne™ (IS-95).

Now, each of these systems is extremely complex, but can be boiled down to three major components: radio-equipped handsets, cell sites for those handsets to transmit to/from, and a fabric of communications switches that handle the calls. To make the system work, companies and standards bodies devised a set of standards which would allow many, many different makers of equipment to play well together. This meant a consumer or business user could actually use their phones. To develop the standards, the vendor community developed, analyzed and agreed upon different technologies to adopt for various parts of the systems.

So, if we look at analog cellular (which, remember, is 1G even though we did not know it then as 1G, since the "G" did not yet exist to confound us all) and deconstruct the system into its components it would look like this:

Standard Name	Network	Radio
AMPS	IS-41	AMPS
TACS	IS-41 (variant)	TACS
ETACS	IS-41 (variant)	ETACS

See a pattern here? Forms of IS-41, now known as ANSI 41, were the basis of the network standards for ***all*** of the analog systems of the '80s and '90s. And relevant to some of my comments below, believe it or not, analog still exists, not just in the U.S., but also in Europe and many other parts of the world. There are still millions of analog handsets in the U.S. and many TACS/ETACS handsets in use in Europe and elsewhere. This fall, at a press briefing in Milan, Italy, one of the journalists bravely described how his wife still had an ETACS handset.

Now we move to digital cellular, now known as 2 or 2.something G.

Standard Name
GSM
cdmaOne (known previously as IS-95 or later ANSI 95, or often just CDMA)
U.S. TDMA (known also as IS-54 and then as IS-136)

Confused yet? I'll take you back in time to sort all of this out…

Go back to the early '90s. In the U.S., analog cellular (AMPS) was beginning to take off. In Europe, a patchwork of analog systems was hitting the capacity and interoperability wall (TACS/ETACS), and folks were eagerly awaiting the full commercial deployment of GSM. Even though wireless standards bodies were discussing something they called

"3G," the world at large was blissfully unaware of the term. By the mid-90s, analog cellular was still growing rapidly in the Americas, digital TDMA was being deployed in North America, South America and Asia, the "God Send Mobiles" phase of GSM was in the past and GSM was growing rapidly around the globe. Upstart CDMA was getting its kinks worked out in preparation for what was to be its first launch by Hutchison Hong Kong in October 1995 – in defiance of folks who said that CDMA as a technology "violated the laws of physics." And the technology wars of GSM vs. CDMA were in full swing.

As the '90s progressed, somewhere along the way, the "Gs" took hold. Even as digital technologies such as GSM, TDMA and cdmaOne were being deployed, the fascination/obsession with 3G began.

But looking back from the context of the user of wireless services, through the lens of time, the past looks very different.

So, let's look at the U.S., since that's the market where analog grew the largest prior to digital wireless taking hold. By 1993, when the first U.S. TDMA (IS-54) systems were launched, or by 1995, when the first U.S. GSM systems were launched, or by 1996, when the first cdmaOne (IS-95) systems were launched, the U.S. wireless market was dominated by analog cellular (AMPS), with tens of millions of users.

The attributes of these analog phones were very similar, at least in North America. They were large, often 200-300 grams or more. They had single-line LED or LCD monochrome displays and NiCaD batteries with lousy performance and undesirable "memory" characteristics (i.e. the battery life was lousy and the battery was prone to "remember" your typical usage and consider itself drained long before the life specified by the manufacturer – so you had to carry several batteries and enjoy lifting weights). Coverage was spotty but improving. Wireless service, due to the fact that analog was very spectrally inefficient (in hindsight), was very costly. People did not leave their phones turned on, for fear that someone would actually call them. And receiving an unwanted call was A Bad Thing, since service often was in the $0.70/min. range – on phones where the batteries died in no time at all. Cloning (i.e. stealing someone's cell phone number, for those who missed this phase) was rampant, with massive fraud losses for wireless operators. Even with these constraints, the freedom, flexibility and convenience of having a wireless phone drove ever-accelerating adoption rates.

So, along came digital wireless. In the U.S., in three flavors, GSM, TDMA and cdmaOne, were deployed. At a store near you. What, then, did digital mean from a consumer or business user perspective? Especially since (then as now) they really don't care about digesting acronym soup.

- A smaller phone
- Better coverage
- Fewer dropped calls
- Better battery life
- Better displays/user interface

- Better voice quality
- Less expensive air time
- More extensive selections of devices and service plans

In the U.S., what is now known as the "digital migration" began in earnest. Much of the incentive for the operators to migrate to digital came from the need to expand voice capacity. At first in a trickle, then by the millions, then by tens of millions, users moved to digital wireless services. Many were migrating from their analog phones; others, who had been on the sidelines, were enticed for the first time into getting a phone and service by the advances listed above. But here is the punch line (supported by research that I personally funded when I headed marketing for QUALCOMM's handset business, and supported by every other research report that we bought and every other article that we read). And I gotta go with all caps here: NOT ONE OF THE TENS OF MILLIONS OF USERS THAT MIGRATED FROM AN ANALOG PHONE TO A DIGITAL PHONE IN THE MID TO LATE '90s SAID TO THEIR FRIENDS OR COLLEAGUES, "GEE, I GOTTA DUMP MY 1G PHONE FOR A NEW 2G PHONE."

Why? 'Cause the "Gs," as we know them today, did not exist in the mind of the consumer or business wireless user. Why? Because the industry had not created the "Gs" yet. Consumer and business users made decisions at the margin to shift from analog service to digital service because one or more of the reasons listed above created a compelling reason to shift/churn/buy a new phone. The devices were different. The services were different. The economics to the operator were fundamentally different, allowing innovation in service plans and segmentation. New manufacturer entrants and growing phone volumes increased operator choice and handset selection.

OK, here's another key point to remember, relevant to the 3G discussions around the world: Near ubiquitous coverage in the U.S. was achieved via the analog wireless networks. This was independent of whether the wireless operator ultimately migrated to GSM, TDMA or cdmaOne. So, that meant that the majority of the TDMA and cdmaOne devices sold in the U.S. in the late '90s were dual mode devices. This meant that on a TDMA network, such as Cingular (then Bell South) or AT&T Wireless, the phones would operate on TDMA in digital coverage areas, and in analog in areas that were not covered by digital. For Verizon Wireless (then Airtouch, U.S. West, Bell Atlantic Nynex Mobile, GTE, etc.), same thing. In Verizon's ever growing digital coverage area, the phones would be operating in cdmaOne, and in rural areas, the existing analog standard. Sprint PCS was a bit different because it was a new entrant. So it built its network from the very beginning to be all digital, and had broad digital coverage from day one. But even Sprint offered many models of dual mode phones, so its customers, via Sprint's roaming agreements, could use the phones in rural areas not covered at that time by its PCS network.

If we looked at the forecasts of the major industry analyst firms around the world, they broke their market and technology forecasts down in the following fashion:

- Analog
- TDMA (IS-54, then IS-136, including TDMA/analog dual mode)

- CDMA (the name cdmaOne did not exist yet, and the forecasts included CDMA/analog dual mode)
- GSM
- Other (TACS/ETACS, PDC, PHS, etc.)

A key point here, one that I will also put in caps: NOT ONE INDUSTRY ANALYST FIRM IN THE WORLD COUNTED DIGITAL/ANALOG PHONES, EITHER TDMA/AMPS, OR CDMA/AMPS AS "ANALOG" PHONES IN THEIR FORECASTING METHODOLOGY. NOT ONE! Keep this in mind as we move forward.

So the industry invented "Gs" and all the wireless technology holy wars at the end of the '90s ensued. But I'm going to ignore the industry debate, and focus on the consumer and enterprise user, circa 2001. By 2001, the Great 3G Debate was at its height. In February 2001, Irwin Jacobs, our CEO and chairman, was pilloried in the global press because he said that WCDMA (UMTS) would take until 2004 for the technology to mature and begin large-scale roll-outs. He said (I'm paraphrasing here): "I hope I am wrong, but all technologies take a certain amount of time to mature, and it will take until 2004 for all the technical issues to be resolved and broad deployment to begin." Vendors around the world responded (paraphrasing again): "QUALCOMM does not know what it is talking about, we'll have WCDMA (UMTS) commercialized with millions of users around the world by the end of 2001." But the industry debate then, as now, is irrelevant. Adoption and revenues are not driven by press releases, interviews, white papers or PowerPoint presentations; they are driven by real execution, and the products and services that real consumers and businesses pay for.

So, from the consumer or enterprise user perspective, what did 2G and 2.5G circa 2001 mean in the U.S. and European markets ('cause many Asian markets including South Korea and Japan were already a long way beyond this dialogue – and still are):

- Ever smaller phones (150g. or less)
- Better battery life (LiOn battery technology helped)
- Better user interfaces (black and white bit-map graphical displays)
- Beginnings of Internet access (slow, high-latency browsers, on B&W displays)
- Excellent voice quality
- Lower tariffs for voice calls
- SMS (much better executed in Europe, but this was mainly an economic function of Calling Party Pays as well as operator cooperation, which is another topic altogether)
- Data access at 9.6 kbps (GSM) or 14.4 kbps on cdmaOne networks. These data speeds were painfully slow for the user, but at least starting to exist. An added problem is that the latency of browsers over these slower networks did not provide a good user experience (the exception being i-mode in Japan). Surprise, users in the U.S. and Europe did not use the 2G data services very much, and the operators were therefore largely unable to monetize the services.
- In Europe, faster data rates over GPRS (20-40 kbps) were starting to be delivered, but on black & white phones – an example of massive over promising and massive under delivery to users, who, not surprisingly, kept their wallets closed.

> Several years into "2.5G" GPRS, things still have not changed much, regardless of what the press releases claim.

Bottom line: When people began migrating en masse to digital technologies, they did not do it for reasons of alphabet soup; they did not do it for reasons of claimed capabilities (except for the early adopters); they purchased and migrated to digital for a fundamentally better experience than had on the phones they were replacing. And, around the world, the compelling advantage of digital wide area wireless networks caused hundreds of millions of people to purchase their first (and then second, third, etc.), wireless phone. So the operators were compelled to migrate their subscribers to more efficient digital networks.

Enter 3G

On the industry side, the great debate of the last few years was: "Which technologies are 3G?" Believe it or not, this debate still rages in the media and with analyst firms. Certain folks like to change the definition as they go along, to meet their business imperatives. This sometimes includes telling the world that 3G is not necessary. I was at the International Telecommunications Union (ITU) show in Geneva in November and had a reporter from a top-tier global business publication come in with a handwritten sheet with one vendor's definition of 3G.

The handwritten piece of paper, in October 2003, read as follows:

2G	2.5G	2.75G	3G
GSM	GPRS	EDGE	3GSM
IS-95	CDMA2000	1xEV-DO	1xEV-DV

The problems with this handwritten chart are so manifest that I had a hard time keeping from laughing. First of all, whoever wrote on the piece of paper wanted REALLY, REALLY hard to keep the reporter from focusing on the key issues of 3G: What are operators able to sell? What are people buying? And is it driving revenues for the operator? In the case of GPRS, I don't have to describe the history. In a recent meeting with a large global computing customer, I asked the question, "Is selling GPRS to enterprise customers in Europe like rolling a boulder up hill?" They all laughed, and then agreed, albeit, off the record. In the case of EDGE, after about five years of press releases touting speeds (still) of 473 kbps and 384 kpbs, the latest claims are "average speeds" of 100 kbps to 130 kbps. Well we tested the initial EDGE commercial systems in Indianapolis and did not get anywhere near these speeds. However, with AT&T Wireless' recent announcement, folks can go and test for themselves and come to their own conclusions.

"3GSM" is a fun one. 3GSM is a term that we see showing up in more wireless industry presentations and white papers. Remember we discussed the role of standards. Well, the 3G standard now being deployed around the world by many GSM operators is called,

somewhat interchangeably, either UMTS or WCDMA. These terms have been defined by the ITU, which is the telecommunications arm of the UN. 3GSM is an interesting marketing construct, which folks are definitely entitled to devise at their choosing, but Marketing Terms Do Not a Standard Make!

In my view, there are two valid ways of defining 3G. The first, quite reasonably, comes from the ITU. Go to their site at www.imt-2000.com

The ITU are the folks that, in conjunction with regulatory and standards bodies worldwide, over the course of about 10 years, defined 3G in the first place. They chose a "family of standards" approach, under which the "CDMA" family, both CDMA2000 and WCDMA (UMTS) were classified as 3G. EDGE is technically classified as 3G, but under a TDMA system migration that was not followed by any operator in the world; it is not classified as 3G within the GSM migration path. But if folks want to call it 3G on the GSM path, that's their prerogative.

So what are the two appropriate ways of classifying 3G systems? In my opinion:

1. Use the ITU definition (not one from a vendor, an "interested party," one found on a ripped piece of paper at a trade show, or one offered by a London Black Cab driver on the drive in from Heathrow).
2. Or use this: A combination of devices, services and applications so compelling to a consumer or enterprise, so different from the prior devices and services, that they actually buy a new phone, try new services, and continue to pay for those services over time. The same way tens of millions of folks switched from 1G to 2G before the G ever showed up!

I especially like my second definition.

Also complicating clear thinking about migration paths to 3G is confusion over the economies of scale manufacturers supplying operators on the two primary paths can expect to enjoy.

The "Economies of Scale" Myth

With economies of scale, the cost of products drop as production volumes rise (but you knew that). The official *American Heritage* dictionary definition is: "The decrease in unit manufacturing cost that is due to mass production." This process has allowed all phones of all technologies to come down in price over time. Mobile phones of all technologies share many of the same components which drive down the same cost curves regardless of technology.

The UMTS Forum, a trade organization dedicated to the adoption of the UMTS (WCDMA) flavor of 3G, put out a white paper in August 2003. On page 17 of their white paper, "Mobile Evolution: Shaping the Future" they state:

> It could be assumed that the cost of 3G handsets will be high. This is revealed not to be the case when the individual cost elements of a handset are examined. The overall cost may be divided into two categories: the part supporting radio functions such as GSM/GPRS, EDGE, or WCDMA; and the part supporting applications, including colour displays, application processors, camera, and expanded memories. In reality, it is the cost of this second element that dominates in high-tier, feature-rich models.
>
> Research indicates that the lower-end WCDMA segment will be only marginally more expensive than a 2.5G handset. In view of the customer's total spending on mobile services, this may not be significant.
>
> The most important price factor for handsets is volume. Due to higher market volumes, GSM handsets are less expensive than CDMA equivalents. With 3G, this volume effect suggests that handsets in the GSM/WCDMA family, will, taking a longer-term perspective, be substantially cheaper than CDMA2000 handsets.

I find this is especially interesting, since in ***MARCH 2002***, I circulated the note below to various folks in the industry. Although I agree with the UMTS Forum that phones have much in common, I believe the hardware/feature characteristics of CDMA2000 devices have more in common with WCDMA (UMTS) devices, than WCDMA (UMTS) devices have with GSM devices. The UMTS Forum's assertion that UMTS will be less expensive than CDMA2000 because of large GSM volumes is flawed. I had written the stuff below in the lead up to the 3GSM show in Cannes in March 2002. (Looking back, I believe, even though QUALCOMM had been active in development of WCDMA (UMTS) products for several years, the facts on the ground of QUALCOMM WCDMA (UMTS) interoperability/test units being used on the show floor in early 2002 made our dedication to all 3G CDMA incontrovertible, as much as some folks have tried to keep the technology war flames burning.) But back to what I wrote ***almost two years ago*** on economies of scale:

> Both cdmaOne and GSM have been a tremendous success, making wireless take off around the globe. GSM, due to its strength in Europe, is the current volume leader, and due to its lower technical complexity, has a lower cost structure than current cdmaOne phones, However, there is a common misconception that because 2G GSM currently enjoys higher volumes and lower costs, that these benefits will transfer to UMTS at the expense of other CDMA-based technologies. This commonly believed conception is false.
>
> **Let's look at a GSM phone. Any wireless device consists of radio and digital content housed on an array of semiconductors on the device. This typically consists of +/- 60% or so of the device manufacturing costs. The other +/- 40% of the wireless devices are components such as the plastics, battery, LCD, memory, keypad, antenna, screws, passive components, etc.**

[Bold added by me in Dec. '03, but you gotta admit, it's a bit weird to see the kernel of the idea 18 mo. later in the UMTS Forum August 2003 paper.]

The economies of scale of these devices are predicated not on the volumes of any given technology such as GSM, but are predicted on global wireless volumes, currently more than 400 million units per year for all technologies such as analog, TDMA, GSM, cdmaOne, CDMA2000, etc. A battery or LCD does not know or care what technology is in a phone.

The radio side of a GSM phone is a TDMA device, in the same family of radio technology now abandoned by U.S. operators such as. . .

[Dec. '03 note: to be nice, I'll leave the operator names out]

There is little to zero of this part of a GSM phone which will translate into economies of scale for a UMTS single mode device.

[Dec. '03 note: in late '01/early '02, all DoCoMo devices were single mode, now things have progressed such that it is apparent that UMTS devices will be multiband and multimode]

UMTS single mode devices use a CDMA-based radio and UMTS/GSM dual mode devices will need to have both a CDMA-based radio and a TDMA-based radio, resulting in higher costs.

*[Dec. '03 note: there **is** a marginal cost, but advances in the silicon roadmap have drastically reduced this marginal cost from a few years ago]*

The migration for cdmaOne handset providers and operators is much simpler. Since both are based on CDMA, the transition from 2G cdmaOne to 3G CDMA2000 1X is largely a matter of a migration to pin-compatible CDMA2000 chipsets, and a change in software. As a result, the economy of scale transition is very different from the UMTS case. In 2002, it is expected that CDMA2000 handsets may be marginally more expensive than similar cdmaOne handsets. However, in 2003 and beyond, due to the implementation of QUALCOMM's ZIF architecture, which reduced components by up to 30%, apples-to-apples 3G CDMA-based devices will be less expensive.

[Dec. '03 note: regardless of the billions of press releases and pronouncements by certain camps, this is what has happened]

Given the timing of both CDMA2000 and UMTS systems described above, it is evident that CDMA2000-based handsets and devices have much higher volumes

and much better economies of scale than similar UMTS-based handsets for several years to come. Again, it is expected in 2002 that there will be tens of millions of CDMA2000-based devices shipped, versus hundreds of thousands to (very) optimistically one million UMTS devices shipped. In 2003, one would expect CDMA2000 volumes to continue to increase to "more" tens of millions, even if, as QUALCOMM is working towards, the number of UMTS devices number in the millions.

By the middle of the decade and beyond, as UMTS begins to ship in volume, we expect that the volumes of both CDMA2000-based devices and UMTS-based devices will be shipping in volumes significant enough that both will have reached a "cost floor," with both types of devices producing compelling economies of scale. The advantage at that time will still be marginally in favor of CDMA2000 due to lower technical complexity, and the projected need for WCDMA (UMTS) devices to be dual or tri-mode UMTS/GSM/GPRS.

Additionally, we expect that by the middle of the decade and beyond that "multistandard" silicon from QUALCOMM and others will create a new class of devices which make problems with true global roaming a thing of the past.

Lastly, in the largely misguided debate about economies of scale, a key point gets lost. Ask which costs less for pre-3G technologies. Which has the lower cost? The answer. . .

> *[Dec. '03 note: from conventional wisdom and pundits who forget the past]*

. . .would be GSM. The ***real*** answer is, pre-3G, the lowest cost technology is ***analog***. Although GSM will still enjoy high volumes for the next several years for its voice, roaming and limited messaging capabilities, the fact remains that GSM/GPRS will ***not*** deliver the same type of compelling consumer/enterprise experience or compelling operator business models as 3G services and devices based on CDMA2000 and UMTS. The behaviors, shown by both consumers and operators during the transition from analog systems around the world to CDMA2000- and UMTS-based systems will be repeated, and may dramatically accelerate the adoption of all flavors of 3G CDMA.

> *[Dec. '03 note: see the story of the "Gs" above]*

Back to the present. I think I've laid out a good case on why some of the conventional wisdoms of CDMA vs. GSM, 1G/2G/3G, and economies of scale are misguided at best. If you look at the world though the lens I have put forward, it leads to a different view of wireless device forecasts.

Find forecast reports from reputable industry analyst firms that actually break out their predictions by actual technologies. PDC, GSM, cdmaOne, CDMA2000, UMTS. Not

marketing constructs like "3GSM." (To confirm this, go and buy a bunch of reports from reputable research firms – and tell them QUALCOMM sent you. ;-)

What you find is very interesting. CDMA2000 has a volume advantage over WCDMA (UMTS) until typically somewhere in the 2007-08 timeframe. But if you ***add up 3G CDMA volumes*** (i.e. CDMA2000 + WCDMA), global 3G ***unit*** volumes approach 50% of total volume in that same timeframe.

There is a second piece of this puzzle that is never discussed.

Aggregate revenue. As we discussed above, the CDMA2000 + WCDMA (UMTS) part of the forecast may constitute 50% of total global unit volume. Average wireless phone selling price (ex-factory, not operator subsidized price) by wireless technology is harder to find. When you dig however, you will find that somewhere between 60% and 70% of ***aggregate revenue*** of wireless handset manufacturers could be driven by CDMA2000 + WCDMA (UMTS) devices by 2007-08. And the revenue of the "others," GSM/GPRS only devices, GSM/GPRS/EDGE, PDC, TDMA, cdmaOne, TACS, ETACS, NMT, etc. have either gone to technological oblivion, or have, ***in aggregate,*** a decreasing share of the wireless unit and revenue pie. And those old phones will join our phonographs and cassette decks in our various garages and closets.

Another point: I have gone through this framework with ***dozens*** of industry analysts from most of the global wireless industry analyst firms. For almost two years, I have asked someone to come back at me with ***evidentiary*** proof (bills of materials, comparative ex-factory pricing, etc.) that my premise was off base. Not PowerPoints, opinions, theoretical behavior, or unsupported claims. ***Nobody*** has challenged this framework in any way for any year before 2007, but that has not stopped many firms from continuing to propagate the GSM economies of scale myth.

And after 2007, it's not really clear whether there will be a cost differential between WCDMA (UMTS) and CDMA2000; whether an increasing percentage of handsets will have both technologies built-in (plus GPS, plus Bluetooth, etc), making the question irrelevant; whether the technological differences from the development and production of devices is so minor at that point that any ex-factory device cost difference is likely to be trivial.

So now I've gone through three wireless myths. Below I "deconstruct" three topical items in the wireless industry as "proof points" for my "deconstruction" of the myths above. Camera phones. India. Japan. All timely topics, and all represent views that are not being accurately represented by the conventional wisdom of the Myths above.

Need for Higher Speed Network Proof Point: Camera Phones

Camera phones are all the rage around the world. The advent of the camera phone, combined with Moore's Law, is accelerating the need for 3G networks as cell phone makers are incorporating higher and higher resolution cameras. Let's take a closer look.

Would a camera phone be successful on a black and white bitmap display? Or the single line LED or LCD displays of our phones of five or six years ago? Or without any memory in your phone to store the photos? Or without a wireless network with the ability to transmit the pictures from one phone to another, or from a phone to a PC via email? Don't think so.

So, the success of camera phones is a function of a broad range of developments that have occurred in wireless devices and networks over the past two years. CCD (charge coupled device, the camera itself), ever-higher resolution active-matrix LCDs, ever-bigger memory, and network capabilities that allow a consumer to actually use the service. As a hardware guy, for the sake of this "model," I'm going to leave out all the massively important stuff that happens after the picture goes from your phone to the cell site; I'm just trying to lay out a framework for thinking here.

First there were color phones (or colour phones, take your pick). The first color phones were small, and the displays were also tiny. The first color phones, only a few short years ago, were low-resolution passive-matrix LCD (Google all these terms if you want to learn more). The manufacturers made a lot of noise about these phones and told the world, "We have color phones!!!" in magazine ads and airport displays. Although any company in the technology world is to be commended for leading the way with new innovations, in reality, the limitations of these displays kept users from doing anything really new with the phones. The phones had small memories, slow, high-latency wireless Internet browsers, and were connected to slow networks (see the discussion at the top of the paper).

Then what happened? The phones got larger, brighter, higher resolution displays (now active-matrix LCD) and more memory to actually store the photos you took on your phone. The user interfaces improved over early tries. And, often overlooked, as things moved to 3G networks – CDMA2000 and now WCDMA (UMTS) networks – the networks were faster (meaning better experience for the consumer and enterprise) and, just as important, could "ship" the bits over the air more efficiently, so operators could charge reasonable tariffs, and actually ***encourage*** folks to use camera phones that actually ***worked*** and were seen as a ***value*** to the consumer. Not infinite PowerPoints on how my MMS is better than your MMS.

Let's look how some of this played out.

The first camera phones had "cameras" or CCD resolution of 30,000-40,000 pixels. This generated a file size of typically about 10-12 Kilobytes (KB) per picture. Keep in mind that a "byte" is "8 bits," so a 10-12 KB file size is 80-96 Kilobits. Nice toy, but on

phones with rudimentary color displays, and slow transmission networks, it was a slow start. And many of the first models (and some today) had detachable cameras. It was obvious from the first that detachable cameras were not what users really wanted. For me, after I broke my first connecting pin on an early detachable camera, integration became an obvious direction.

But, thanks to the pace of innovation in wireless devices, these limitations did not last long. On networks, starting in Japan, followed by South Korea, the dynamics changed quickly. The phone displays grew in size. The resolution and brightness of the displays increased. Battery life improved commensurately. The resolution of the CCD improved, first to about 110,000 pixels, and then to 330,000 pixels. The file sizes of the photo images grew to typically 50-60 KB for the 330,000 pixel camera phones. And the memory in a typical mid-tier phone grew to the point that a user could store a few dozen photos on their phone, in addition to sending them over the network. So, what did this mean to users? Better pictures. Better experience. And folks bought them. By the tens of millions, in an ever increasing list of countries around the world.

So, let's look at this a bit closer. On CDMA2000 and GPRS networks in North America or Europe, you've got phones that can do the job, with 100,000-330,000 pixel cameras that can take acceptable but fuzzy low-resolution VGA pictures. The file size for a 330,000 pixel camera is about 60 KB, which is roughly 500 kilobits. So, to send a photo, it takes 15-20 seconds on a GPRS network, and about half of that on a CDMA2000 network. The CDMA2000 networks can ship the bits more efficiently, ergo a CDMA2000 or WCDMA (UMTS) network can ship the bits at a lower cost to the operator, at less impact to the network voice capacity (that is still paying the bills).

If a consumer has a lousy camera phone, connected to a lousy network, on a phone with a substandard low-rez color screen, do they use it? Do they pay recurring revenues for the service? Don't think so – and the evidence over time demonstrates this fact.

Now, if the same customer has a camera phone and service that they ***like***, do they use it? Yep. And what happens when they buy a new phone in the following 12-18 months? Do they go into the store and say, "I want a phone that takes fuzzier pictures, with lower resolution, and less memory in the phone." Or will they say, "Oh yeah, and I want to make sure that the better pictures I take with my new phone cost me more to send." Nope and nope.

Instead, they potentially go to their local electronics store and say, "Hey, I want a better camera in my new phone than in my old phone." The sales guy says, "How about megapixel plus, approaching standalone digital camera resolutions?" Customer says, "I want a crisper display in my new phone than my old phone for better gaming, photos and readability in my applications." The sales guy says, "How about QVGA (320 x 200 or quarter VGA resolution)?" Customer says, "I want more memory in my phone to store my photos and other stuff." The sales guy says, "We have phones that not only have 32 MB of internal storage, but have an SD slot for putting low-cost memory cards into your phone."

None of this is rocket science. We've seen this dynamic in the PC world since the early '80s. We see this dynamic with digital camera evolution globally. But somehow folks think something is going to be different because the quantity of spurious white paper and PowerPoint presentation noise is higher in the wireless industry than the PC or digital camera industries.

So, let's look at a two megapixel camera phone (see www.3GToday.com for information on several megapixel-plus camera phones). At two megapixels, a file size can be 400-500 KB, which translates into 3,200,000-4,000,000 bits. That's a whole lotta bits.

Let's ask the same questions. Does the same consumer want to wait from 100-plus seconds to several minutes to send ***one*** photo on a GPRS network? Do they have the willingness to pay high costs to send that file? Do the GSM/GPRS operators have the incentive to drop the per bit cost for sending large picture files (since this camera phone user is using scarce radio spectrum that could/is being used for voice – especially in congested European urban GSM networks)? I believe the answers to these questions are no, no and no.

Another point to raise here, one that harks. . .great word, harks. . .back to the economies of scale myth. We've discussed ever-higher resolution CCD cameras, advanced LCD displays, internal memory, external memory such as SD cards. All of these costly components will decline in price due to aggregate volumes of ***all*** phone manufacturers making phones for various regions and technologies. And frankly, I think it's a fairly safe bet that the economies of scale on megapixel camera phones, 15-30 frame/sec. video phones, and other advanced functionality are ***not*** going to be driven by GSM/GPRS devices. GSM/GPRS/WCDMA (UMTS), yes. CDMA2000, yes. GSM/GPRS, no.

On CDMA2000 networks around the world, the camera phones are increasing rapidly in resolution. The speed for sending those larger files is more than twice as fast as a competing GPRS network, and more economical for the operator. And future developments that improve the speed of the reverse link (an alphabet soup of CDMA2000 1xEV-DO Rel. A, CDMA2000 1xEV-DV Rel. D) will change this dynamic even more dramatically over coming years. On WCDMA (UMTS) networks, an equally painful acronym, HSDPA (high speed downlink, packet access) will grow the WCDMA (UMTS) pipe size even more. Not too simple, even though certain parties would love for all you folks out there to see the world simplistically and erroneously as "CDMA vs. GSM."

We can examine a ***small*** portion of the list of other emerging applications/services which will have ***exactly*** the same dynamic:

- Downloadable Applications. The first BREW applications a few years ago were downloaded onto monochrome, bit-mapped displays. One that I think is destined for the Gaming Hall of Fame is JAMDAT Bowling (www.jamdat.com). The monochrome version of this game I believe is destined to be the PONG™ of wireless gaming (for those of you old enough to remember PONG). This app was

about 40 KB. Most early BREW apps were 12-45 KB. Two years later, Sony Online's EVERQUEST™ is more than 550 KB, and most apps are in the hundreds of KB and growing. As these ever-growing-in-size, ever-more-appealing apps get married to better displays, better multimedia and larger memory in the phones, and better network capabilities for economic high-speed data access, this dynamic will only accelerate.

- Video (download): Although a lot of attention in the WCDMA (UMTS) world is focused on video telephony – and I believe video telephony will continue to be a very interesting and growing application/service area – folks are not paying attention to what's happening ***quickly*** in other parts of the world. And that is the downloading of ever larger, ever richer, video and audio content to wireless devices with faster network access, better displays and more internal memory. From 15 second low-resolution video clips, services in South Korea and Japan have evolved to the downloading of multi-megabyte video files (music videos, sports info, movie trailers, etc.). In a way that is usable by the consumer, and economical for both the consumer and the wireless operator.

- Internet access via PC Card: I wrote extensively on this in my "Adventures in WiFi" paper six months ago, and the interceding six months have not changed the dynamics. Looking at things from an enterprise perspective, IT departments want access as ubiquitous as possible, the fastest data rates possible, and the lowest costs given those two constraints. Wireless operators want to keep their customers, which maximizes revenues and reduce their costs. And they do ***not*** want data services to cause nasty, deleterious things to happen to their voice networks. The advantage here remains on every point for CDMA2000 systems today migrating to 1xEV-DO, and to WCDMA (UMTS) systems migrating to HSDPA.

There're lots of other examples that I can deconstruct, but in the interest of keeping this document a bit manageable, I'll leave other examples for individual debate. Feel free to email me if folks want to discuss my views. And by the way, if black and white text SMS ends up being the ***be all and end all*** of wireless data, as some pundits suggest, then I'm wrong. But that's not what's happening.

The bottom line is that Moore's Law is working just as effectively in the mobile phone world as it has been in the PC world. And the new WCDMA (UMTS) and CDMA2000 networks allow these large photo and multimedia files and applications to be shipped at ever-lowering costs – more efficient networks, more stuff the operator can offer, less cost to the operator, cool new stuff users are willing to buy because prices are reasonable. Don't let folks tell you that you do not need 3G.

Proof Point: India

In October, I finally made my first trip to India. QUALCOMM has been active in India since the early '90s, but somehow I had never made it there. Perhaps it had something to do with the fact that if you pick up a globe and put one finger on New Delhi and another finger on San Diego, you will find your fingers almost as far away on the globe as one can get.

Now that I've made the pilgrimage, I can say, the marketing of India as "Amazing India" is a serious understatement – on the business, visual and cultural levels. As I told folks on my trip, during my visit to India I absorbed the most new information into my brain in a week since the week I brought my first daughter home in June 1995.

So, from a telecoms perspective, what did I observe, and how are those lessons relevant as a proof point for our discussions here?

1) India has very low teledensity. India's number of phone lines per thousand people, both wireline and wireless in aggregate, is well under 10%.
2) India has high price elasticity on services. That is, as you lower prices more folks are willing to buy services. Like other places around the world, but due to large income disparities, even more pronounced than most other markets.
3) India has scarce spectrum. Both the GSM players and the CDMA2000 players are very limited on the amount of spectrum they have access to. In the case of the CDMA2000 players, they are often limited to 5 MHz transmit, 5 MHz receive. This means that any wireless operator has to use their spectrum as efficiently as possible.
4) India has an amazingly technical workforce. This is not a surprise, but it's one thing to hear about it, it's another to see it. The folks I met in India do their homework and have the ability to get the most out of a technology, often in less than ideal situations.
5) India is very far away (I already mentioned that point).

Point #5 is especially important. We had nine meetings in India. All with very frank and open discussions (since that's the way folks in India are). And somewhere along the way I had a bit of an epiphany. The folks in #4 above are ***immune to marketing spin***. They are not reading the same business magazines as folks in the West. They are not spending entirely too much time at trade events. They are not endlessly debating some of the issues that we are endlessly debating here.

What they are trying to do, within the constraints of #1, #2 and #3 above, is ***radically*** reshape the communications landscape in India. And use telecoms, in addition to other similar initiatives, to massively reshape and grow the country. As a result, they are doing their homework. A lot of homework.

Many of the operators have both GSM and CDMA2000. Two of the largest operators, Reliance InfoComm and Tata Indicom, work with both systems. In a scarce spectrum

situation, they are trying to radically raise teledensity in a massively price elastic marketplace. They are introducing advanced voice services, as well as putting types of data services that big swaths of the world are without, and into the hands of great swaths of the Indian population. Although they complain to the companies in the CDMA2000 value chain that they would like the voice-only CDMA2000 phones to be the same price and lower than apples-to-apples GSM phones, where is their investment going? CDMA2000. The ***fact*** is that the capabilities of CDMA2000 networks enable them to meet their business objectives in ways that their GSM networks can't. If the spectrum was available, WCDMA (UMTS) could allow the same services to be delivered, but it isn't. So in India it's not a technology debate that interests the telecoms industry, it's the business reality.

I have digital photos of a CDMA2000 pedicab PCO (Public Calling Office). I have pictures of Web surfing via CDMA2000 to the *Los Angeles Times* homepage showing "Schwarzenegger In" as we were traveling in rural India the day of the now infamous California recall election. I sent email while riding on the top of an elephant while traveling to the top of the fort in Jaipur. And I sent email via CDMA2000 to George Mansho, who has our Indian bizdev effort under him, while in a bus in rural India as I looked out the window at camel drawn carts and water buffalo on the same piece of highway. George was across the aisle from me in the same bus and my email went over Reliance's network to our Exchange servers in San Diego and back via Reliance to George (who I could reach over and touch). In milliseconds. OK, so we are geeks. You already know that. But hopefully you get the point, this is not a "CDMA vs. GSM" thing, this is about delivering services, at price points and efficiencies that work for both the consumer and operator. In India, it is the "capabilities of 2G vs. 3G," even when the focus is on voice services and expanding teledensity.

In Reliance's case, they are adding subscribers rapidly, with voice usage above 600 minutes a month, with CDMA2000 data services rapidly evolving.

Following are links to Reliance and Tata. Check them out.

India: Reliance Infocomm

http://www.relianceinfo.com/Infocomm/html/aboutus/aboutus_technology_cdmawireless.html

http://www.relianceinfo.com/Infocomm/html/aboutus/aboutus_technology_network.html

http://www.relianceinfo.com/Infocomm/html/whyrim/whyrim_tariffandoffers.html
(Information on tariffs and offers. Especially interesting is the "call the U.S. or Canada for 7 rupees per minute" offer – less than $0.17 per minute USD. I pay 2 Euros per minute and up to call the U.S. from Europe. It makes me wonder. . .)

India: Tata Indicom

http://www.tataindicom.com/global/mainglobal.asp?chkpg=17

Proof Point: Japan

I want to point out something that will be a shock to folks around the world. JAPAN HAS NEVER HAD A GSM SYSTEM. I have recently seen marketing materials from industry advocacy groups stating that Japan has GSM networks. This is not true. The Japanese operators, prior to their 3G evolution, used two technologies, PDC and PHS. Somehow, however, PDC, which is a close cousin to the U.S. TDMA network, is now being classified as a GSM system because it makes the numbers put out by certain trade groups look more impressive.

Dow Jones Newswire on November 5, 2003, stated the following: "NTT DoCoMo Inc. (NYSE: DCM-News) of Japan is one GSM-based operator whose multimedia phone service is finally beginning to take off."

Reality? No GSM in Japan, never has been. DoCoMo launched the country's first 3G network in October 2001. We all know the story, but it seems to be having a happy ending. As the network has matured, as the services have stabilized, as the handset selection has grown, as the handsets have shrunk and gotten better battery life, traction has occurred, and will continue to occur in 2004 and beyond. Success not from PowerPoint presentations and white papers, but through focus on users and execution.

The present and the future. KDDI launched their CDMA2000 network in 2001. Since that time, they've introduced ever more innovative handsets and services. Vodafone KK (formerly J-Phone) has launched their WCDMA (UMTS) network, with an ever increasing number of handsets, including dual mode multi-band handsets with UMTS/GSM/GPRS for the international traveler crowd.

My proof point here is a question and a challenge. There are two WCDMA (UMTS) networks in Japan, and another that is CDMA2000. All three networks are expected to grow subscribers and continue to add innovative services. In the case of KDDI, they are launching CDMA2000 1xEV-DO across the majority of Japan's population on Nov. 28, 2003. What happened to the cdmaOne subscribers? Per KDDI's published numbers, the majority have already migrated to CDMA2000. Oh yeah, KDDI has NEVER marketed their services as "3G" at the consumer level. KDDI has done a phenomenal job of popularizing an amazing array of new devices and services. I know. I've had them send us several hundred copies of their KDDI service bulletin each month for the last year and a half. One does not need to know how to read Japanese to recognize the exceptional pace of innovation that KDDI is driving. Visit http://www.3gtoday.com/operators for details. And what is happening to the PDC subscribers on multiple networks in Japan? Let's put it this way, PDC is not a growth industry.

Current Japanese Subscriber Numbers (October 31, 2003)

System	Groups	Oct. 2003		Sep. 2003
		Increase	Total	Total
	NTT DoCoMo Group	-188,000	43,851,000	44,039,000
	TU-KA Group	-12,000	3,687,100	3,699,100
	Vodafone Group	27,600	14,535,700	14,508,100
PDC	PDC Subtotal	-172,400	62,073,800	62,246,200
cdmaOne	au Group	-272,000	4,787,400	5,059,400
	NTT DoCoMo Group	334,000	1,337,000	1,002,600
	Vodafone Group	5,600	88,600	83,000
WCDMA	WCDMA Subtotal	339,600	1,425,600	1,085,600
CDMA2000 1X	au Group	457,900	10,661,000	10,203,100
Mobile Telephone Total		353,100	78,947,800	78,594,700

In a hyper competitive market like Japan, KDDI, DoCoMo and Vodafone KK, will be competing with one another on the basis of innovation, cool devices, services, applications, enterprise marketing, customer service, etc. Not "CDMA vs. GSM." Not "CDMA2000 Theory vs. WCDMA (UMTS) Theory." And the market for new devices will rapidly evolve to CDMA2000 + WCDMA (UMTS) > PDC + PHS.

So somebody please tell me how this lesson applies to GSM/GPRS markets where there are competing CDMA2000 networks, emerging WCDMA (UMTS) networks, or both? It should be pretty obvious by now. Sales of 2/2.5G handsets and systems have been large, but these will be declining businesses, especially on the handset side as 2/2.5G connectivity increasingly becomes a "mode" in a 3G CDMA2000 or WCDMA (UMTS) handset.

Optional Bonus Section – Economies of Scale: Infrastructure

I've focused on handsets and services, as I think they are more fun, and frankly, my personal experience makes me more comfortable writing about that stuff. But then there is the "infrastructure thing." Most (all?) consumers never think of the billions of dollars of cell sites and switches around the globe that enable all the fun stuff we've been covering above. So, in respect for folks being worn out by now, and by folks' predilection to focus on the fun stuff like the cool toys, I've made this an optional bonus section.

Another way to see that a lot of the conventional wisdoms of wireless are now off base is to visit the Web sites of some of the wireless network infrastructure providers. For them, the wars ended a ways back – as they just want to sell equipment and move as much

demand to 3G (either flavor) as quickly as possible. Five or 10 minutes on the links below would be an eye-opener for a lot of folks out there. And, as with phones, the CDMA2000 base stations share many of the same components with WCDMA (UMTS) base stations allowing them to share many of the same economies of scale.

And after you spend five or 10 minutes on the links below, I'd like you to evaluate an interesting set of quotes that I put at the bottom of this section. Then I'm done for now. I promise.

Nortel Network

http://www.nortelnetworks.com/corporate/technology/wireless/protocols.html

Ericsson

http://www.ericsson.com/network_operators/mobilesystems/buildarticle.asp?ArticleId=90CE07DB-4789-11D6-99C3-0030474E2F8A

Note also "Ericsson Further Aligns Its 3G Portfolio":
http://www.ericsson.com/mobilityworld/sub/news/SubPages/further_aligns_3g_wcdma_cdma2000

Lucent

http://www.lucent.com/solutions/3g.html

http://www.lucent.com/solutions/umts.html

http://www.lucent.com/solutions/cdma.html

http://www.lucent.com/press/1003/031029.nsb.html (press release on new radio base station)

Fun quote from the Lucent press release: "Built using Lucent's OneBTS® digital base station platform for 3G spread-spectrum technologies, much of the 4.0 Compact's hardware is common to Lucent's 3G WCDMA (UMTS) base stations."

Motorola

http://www.motorola.com/networkoperators/Access-Systems.htm (click on the link under "Orderly Transition Plans" that reads "Seamless path to the wireless future")

Samsung

http://www.samsung.com/Products/TelecommunicationSystems.htm

Alcatel

Even Alcatel is getting into the act. At the 3G World Congress in early November in Bangkok, their presentations were highly focused on the lessons for 3G. Although with a European focus, which is appropriate for Alcatel, their 3G World Congress site at http://www.alcatel.com/lead/3GWorld03.html# has some interesting tidbits.

Folks may also want to evaluate the following quote, from the first page of the same August 2003 UMTS Forum "Mobile Evolution: Shaping the Future" white paper:

"Typically, a WCDMA base station provides up to 10 times the traffic capacity compared with GSM, at a cost premium of between 1 and 1.5 times that of GSM. This implies that WCDMA technology provides network capacity at a cost approximately eight times lower than GSM."

Going back to the Alcatel Web site, you can click on a link, "Alcatel: Sharing Asian success with the world," which begins as follows:

"3G is a reality in Asia today, with subscriber take-up growing exponentially in countries such as Japan and Korea. Key factors for success have included an effective business model for revenue sharing with content providers, packet-based billing, a low fee plan and attractive handsets. Rapid growth will continue in the region, as multimedia services such as video communication progressively take off."

These vendors are leveraging CDMA2000 experience to enter the WCDMA (UMTS) world, focusing on finding any lessons and advantages that will help them execute better and drive adoption.

I think I'll leave it at that.

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