

## Irwin Jacobs: Captain of CDMA

Qualcomm cofounder Irwin M. Jacobs wins the 2013 IEEE Medal of Honor for his pioneering work in digital communications

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Photo: Gregg Segal

**It was September 1989**, and the cellphone industry was booming. Companies were building new towers as fast as they could, using the prevailing analog technology, but they were encountering problems with capacity and quality of service. Earlier that year, the industry had decided to move to digital transmission using time-division multiple access. TDMA shared the airwaves by slicing up each available frequency channel into time slots. A caller's phone transmitted digitized signals in short bursts during the slot assigned to the handset. It wasn't a particularly efficient use of the broadcast spectrum, but it worked.

Irwin M. Jacobs, chief executive officer of what was a little San Diego company called Qualcomm (<http://www.qualcomm.com/about/history>), believed he had a better approach. He wanted to take an idea then being used for - secure military communications—Code Division Multiple Access, or CDMA—and adapt it to commercial cellphone networks, which would allow multiple conversations to share the same frequencies at the same time. He knew this technology could

serve many more customers with fewer towers. But an awful lot of people didn't believe he could pull this off, and time was running out. The more companies and consumers purchased TDMA equipment, the harder it would be for a new technology to gain a foothold.

In June, Jacobs had pitched CDMA at an industry meeting in Chicago. But talk would go only so far. He had to show industry executives that CDMA worked. The trouble was, it didn't. Not yet. Still, Jacobs believed that if 1989 ended before CDMA went live, neither CDMA nor his company would survive. He set a November date for a demonstration and sent invitations to more than 100 executives of companies that built cellphones or operated cellphone systems. Most of the engineers working for him thought he was nuts.

7 November 1989: Demo day arrived. Qualcomm had installed CDMA equipment on two cellphone towers and in a van. The people Jacobs assembled heard a few presentations about how CDMA worked and why it would help the industry. Jacobs then took the podium, prepared to make a few remarks before sending the executives out to drive around in the van and make phone calls, when he spotted one of his engineers in the back of the room frantically gesturing at him to keep talking. Jacobs didn't know exactly what was going on, but he could guess—the gear wasn't working. Forty-five agonizing minutes later, he got a sign that he could release the crowd. The CDMA equipment was fixed.

## Irwin M. Jacobs



Photo: Gregg Segal

**Current job:** Founding chairman and CEO emeritus, Qualcomm; philanthropist

**Date of birth:** 18 October 1933

**Birthplace:** New Bedford, Mass.

**Education:** BSEE Cornell (1956); SM MIT (1957); Sc.D. MIT (1959)

**Family:** Wife, Joan; sons Gary, Hal, Paul, and Jeff

**First jobs:** Retail clerk (sold fruit in his uncle's store, helped in his grandfather's meat market, and worked at a clothing store), lifeguard, lumberjack

**First start-up:** Created photo books of class field trips and sold them to fellow fifth graders

**Patents:** Fourteen related to CDMA, one on a method for data compression

“If that demo had failed, we probably would have been dead,” Jacobs recalls. The problem, it turns out, wasn't with the CDMA technology. The two demonstration base stations set their clocks to synchronize with each other via signals from the then-nascent Global Positioning System. That morning, one of the GPS satellites was itself out of sync. While the engineers working to diagnose and solve the problem were certainly sweating, Jacobs was remarkably calm. He believed in CDMA with all his heart.

Today CDMA technology powers all 3G cellular networks and continues to expand its reach with 4G. It is for making that happen, for “leadership and fundamental contributions to digital communications and wireless technology,” that Irwin M. Jacobs is being awarded this year's IEEE Medal of Honor.

**Nonprofit board memberships:** Salk Institute for Biological Studies, Digital Promise, Pacific Council on International Policy

**Person he most respects:** Claude Shannon

**Most recent book read:** *The Signal and the Noise: Why So Many Predictions Fail—But Some Don't* (The Penguin Press, 2012), by Nate Silver

**Favorite composers:** Igor Stravinsky, Antonín Dvořák

**Favorite restaurant:** The Veladora at the Rancho Valencia Resort and Spa in Rancho Santa Fe, Calif., (owned by all four sons, operated by sons Jeff and Hal)

**Catchphrase:** “Let’s look for the elegant solution.”

**Cars:** 2012 Ferrari California (a recent gift from his sons); 2008 Lexus sedan

**Major awards:** 2013 IEEE Medal of Honor “for leadership and fundamental contributions to digital communications and wireless technology”; 1994 National Medal of Technology; 1995 IEEE Alexander Graham Bell Medal

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[http://www.ieee.org/about/awards/bios/moh\\_recipients.html#sect1](http://www.ieee.org/about/awards/bios/moh_recipients.html#sect1)

**Jacobs’s story starts** back in Massachusetts, where he worked from the time he was in fifth grade or so as a grocery-store clerk, a lifeguard, a photo developer, and even a lumberjack. As he approached his 1950 high school graduation with top grades in math and science, he expected to study engineering in college. His guidance counselor, however, told him there was no future in science or engineering and suggested agricultural school. When Jacobs rejected that idea, the counselor asked about his parents’ work. Jacobs’s parents then had a small restaurant, so the counselor pointed him to Cornell’s School of Hotel Administration.

Jacobs went through a year and a half of training there, and he worked as a cook at a country club the summer between freshman and sophomore years. He might have stayed on that track had it not been for his college roommate, a chemical engineering major who teased Jacobs about his easy courses, insisting that Jacobs wouldn’t be racking up such good grades were he studying engineering. “You can only listen to that for so long,” Jacobs says. Halfway through sophomore year he changed his major to electrical engineering and never looked back, going on to earn a doctorate at MIT and eventually teaching there. Then in 1966, drawn by the opportunity to help launch a new engineering school and by California’s weather, he put his family in a used Ford Falcon van and drove cross-country to accept a post at the University of California, San Diego (UCSD).

Before he left MIT, Jacobs and fellow faculty member John M. Wozencraft had written a textbook on communications theory, *Principles of Communication Engineering* (<http://www.amazon.com/Principles-Communication-Engineering-John-Wozencraft/dp/0881335541>), first published in 1965 and still used. The book helped bring Jacobs consulting work, and in 1968 he joined with professors Leonard Kleinrock and Andrew Viterbi of the University of California, Los Angeles, to start a consulting company, *Linkabit Corp* (<http://en.wikipedia.org/wiki/Linkabit>). It began developing products of its own, including very-small-aperture terminal satellite systems for business use and *VideoCipher* ([http://articles.latimes.com/1987-07-14/business/fi-3806\\_1\\_dish-owners](http://articles.latimes.com/1987-07-14/business/fi-3806_1_dish-owners)), a home descrambler for satellite television. In 1972, Jacobs left UCSD to manage Linkabit full time. In 1980, Linkabit merged with M/A-Com, and on 1 April 1985 Jacobs left, having netted about US \$20 million from the deal.

He could have retired more than comfortably. But starting a company, something he'd initially had doubts about, turned out to be "great fun," he says. "I liked doing the systems and the overview and the long-term thinking, but I also liked all the detail work, going through each aspect of the company, learning best how to do each job, and then bringing in very good people to take over that responsibility."

So after he was finished with Linkabit, he decided to do it all over, joining with six others, including, once again, Viterbi. The group started Qualcomm in 1985, each founder putting in \$1500 or so. They intended to initially fund themselves with contract work.

One of those first contracts, a technical review of a proposal by Hughes to develop a mobile satellite system, lit the firecracker that turned out to be CDMA.

**The Hughes proposal** used conventional spectrum-sharing techniques, which split up the available bandwidth by time slots or by frequencies. Providers of commercial communications weren't considering CDMA, then used for jam-proofing military communications, because it was generally thought to be too complicated.

But on the drive back to San Diego from a meeting with Hughes engineers in Los Angeles, while chatting with Viterbi and another cofounder, Klein Gilhousen, Jacobs got to thinking about gaps in conversations, those moments when people pause to gather their thoughts. He wondered whether you could somehow squeeze parts of other conversations into those gaps. "I realized that CDMA might be able to do this," Jacobs says, "and that this was a significant potential advantage for a mobile communication system."

A few days later, Gilhousen observed that CDMA offered another advantage for cellphones: It's designed to work with interference. TDMA couldn't do that, so cellphone operators had to avoid interference by making sure they weren't using the same frequencies at nearby locales, much the way adjacent cities don't use the same television broadcast channels. Being able to use the same frequencies at every cell site would mean that a cellphone network could handle a lot more calls.

Given these two big advantages, Jacobs and his partners thought that perhaps working through the complexities of CDMA would be worthwhile.

One of the biggest complexities involved controlling the power of the signals sent from the phone and received at the cell tower. A cellular communications system in which different conversations are separated by time or by frequency is like a conversation taking place in a private room; it isn't really critical how loud two people in the room talk. But in a CDMA system, conversations take place in the equivalent of a noisy room, where a few loudmouths can drown out everyone else. Jacobs and the other engineers at Qualcomm had to make sure this didn't happen.

Jacobs and his engineers laid out a plan that managed the power of the communications signals in three ways. First, he envisioned a rapid-response system: CDMA phones would monitor the power of the signal coming in from the tower; if the signal suddenly dropped, say, when a user walked into a building, the phone would crank up its transmitting signal, figuring that if it was having trouble hearing the tower, then the tower would have trouble hearing the phone. Next, equipment at CDMA towers would take a handful of received bits and calculate an average signal strength; if that signal fell above or below a preset threshold, then the tower would prompt the phone to lower or raise its power. And, finally, the thresholds for each conversation would be adjusted depending on the rate at which incoming packets of information had to be dropped because they couldn't be decoded properly. Digital communications depend on decoding sequences of bits. But these sequences don't have to come through perfectly; the decoders expect some errors. And a strong signal will have fewer errors than a weak one. So the Qualcomm engineers designed the decoders to report when the error rate got higher or lower than normal, so that this information could also be used to adjust signal strength.

"Someone else might have looked at all the complexities and the concerns and concluded that it just wasn't possible," said Richard Atkinson, former president of the University of California. "But Irwin didn't back away."

Making CDMA work was perhaps the easy part. Selling it to an industry already on the TDMA bandwagon was much tougher. The successful San Diego demonstration helped a lot, but it took years for CDMA to be truly accepted. Jacobs repeated the demonstration in January 1991 in New York City, where skeptical executives at wireless carriers thought CDMA would fail when confronted with a sea of tall buildings. He weathered the critics, such as the professor at Stanford who told people that CDMA violated the laws of physics, and *The Wall Street Journal*, which ran a [September 1996](http://www.siliconinvestor.com/readmsg.aspx?msgid=28299569) (<http://www.siliconinvestor.com/readmsg.aspx?msgid=28299569>) article claiming that Jacobs's hype was causing carriers and cellphone manufacturers to throw away billions of dollars. "He was a lot cooler than I was," recalls Viterbi, who went on to receive [the 2010 IEEE Medal of Honor \(/geek-life/profiles/2010-medal-of-honor-winner-andrew-j-viterbi\)](#). "I got upset with the detractors. He just carried on."

So Qualcomm went ahead to develop the chips needed for handsets and base stations. Jacobs, meanwhile, offered to create an experimental network to test any problematic scenario the skeptics could come up with. "We had a whole group of manufacturers working with us to try to break the system," Jacobs recalls. "The data produced turned out to be very handy when we went through the standards process."

The Telecommunications Industry Association approved CDMA as a standard in July 1993, and the first commercial system began operation in Hong Kong in late 1995. Today, CDMA is the dominant cellphone technology, and Qualcomm, with Jacobs's son Paul at the helm, is a \$115 billion company. His dad's being smart "was just table stakes," says Paul. "What made Qualcomm successful was passion and persistence—even though everyone said it couldn't be done, even though he was getting personally attacked, he had a fundamental belief that he was right and that would lead to victory."

**Jacobs himself, according to Forbes** last year, is worth about \$1.5 billion. Thanks to the way he's spending that wealth, Jacobs won't be remembered only for CDMA. In fact, many don't connect him at all with technology. Instead, he's the guy who pledged about \$120 million to put the San Diego Symphony on solid financial ground. He put another \$120 million or so into engineering education at UCSD, where the school of engineering is now named after him. He also made significant donations to MIT, Cornell, and Technion—Israel Institute of Technology. He and his wife, Joan, also support the La Jolla Playhouse, the Museum of Contemporary Art San Diego, the San Diego Natural History Museum, and local public radio and television. They recently funded a new central library for the city. *The San Diego Union Tribune* has called him the city's philanthropist in chief.

His current passion is High Tech High (<http://www.hightechhigh.org/>), a charter school focused on STEM education. Since 2000, it has grown from one high school to five high schools and four middle schools and will soon include three elementary schools. And he's been involved in supporting local and national Democratic candidates for decades. He has joined a philanthropic campaign cofounded by Warren Buffet called The Giving Pledge, promising to donate at least 50 percent of his wealth before he dies.

Jacobs himself isn't a flashy billionaire: Movies aren't made about him, he doesn't wear an iconic turtleneck or hoodie, and he lives fairly modestly, at least from the outside, in an older neighborhood of average-size ranch homes. His son Gary says his father taught them that "just because you have it doesn't mean you get to spend it all on yourself."

Jacobs's house, built on land purchased in 1968 for \$37 000, has a spectacular view. The interior boasts art collected from around the world and a large room designed for chamber music concerts. But, Jacobs points out, he has only one house. He received his first Ferrari as a 70th birthday present from his four sons. Paul Jacobs says his father had wanted a Ferrari for 45 years and had been able to afford it for decades, but he would never have bought it for himself.

When people do recognize Jacobs and his wife, they're likely to stop and say, "Thank you." What for? Well, Jacobs says, it depends on the person. The music lover will thank them for supporting the symphony; the educator for support of the university; the art lover for support of the Museum of Contemporary Art; the book lover for support of the Central Library; the theatergoer for their efforts with the La Jolla Playhouse. And then there are the folks who worked for or invested in Qualcomm over the years, who thank him for making it possible for them to buy their houses. The funny thing is, most of the people who stop him are carrying mobile devices that work as well as they do only because of his patents and persistence. But that's something they rarely mention.

*In an interview with IEEE TV, Irwin Jacobs discusses his career, the challenges ahead for today's engineers, and how he avoids burnout.*

*This article originally appeared in print as "Captain Cellular."*