Computer History Museum

Oral History of Jeff Abramowitz

Interviewed by:
Rich Redelfs, with Marc Weber

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Rich Redelfs: Hi, this is Rich Redelfs, and I'm here with Mark Weber from the Computer History Museum. And we're interviewing Jeff Abramowitz as part of our series on the history of Wi-Fi. Jeff was the originator and conceiver of the Wi-Fi Alliance and has some background in Wi-Fi before that. And we'll be digging into that here today.

Jeff and I worked together at 3Com, so we have that in common. I'm on the board of trustees here at the museum and also a general partner with Foundation Capital. So Jeff, welcome.

Jeff Abramowitz: Thank you very much. Happy to be here.

Redelfs: Great. Well, let's start off with a little bit of your background. You grew up in New Jersey, if I remember correctly.

Abramowitz: Yeah, I did.

Redelfs: And engineering degrees, and I remember-- Jeff and I worked with a guy at 3Com who he went to high school with. And I remember having a conversation with him about Jeff in high school, what was he like? And he said, the smartest kid in our high school. So tell me about high school and how you got into wireless.

Abramowitz: So I guess standard New Jersey geek slash sports-loving musician would describe my background. I did play in a band in high school as well. I just went to my 35th reunion and sang at it. So that was fun. But basically, high school was your standard, excelling in math and science, decided to go to University of Pennsylvania for a mechanical engineering degree. Because at the time, I was into cars. And I thought I wanted to be an automobile designer.

I actually turned down MIT to go to University of Pennsylvania, because--

Marc Weber: Tell us a little bit, though, also about where you grew up, your family, interests as a kid.

Abramowitz: Oh, so go back a little further? You want me to take it forward or go back?

Weber: Either way that's comfortable. Go back.

Abramowitz: Go back. All right. So I grew up in East Brunswick, New Jersey. It's right in the center, turnpike exit nine, and went to primarily public schools in New Jersey, and loved math, loved science, loved playing out in the fields.

Redelfs: Was there a parental influence? Was your dad an engineer or relative? How did you lean that way?

Abramowitz: Well, I leaned math and science, because my uncle actually was professor of electrical engineering. And he taught at Purdue. Then he taught at Stanford. And then his story is he didn't like the weather, so he moved to Hawaii. And he actually worked with Norm Abramson who I ultimately met, who, of course, is the father of ALOHAnet, so that was pretty cool for me. So that would have been kind of the tech influence.

But really it was just that I had a very analytical mind. I tended to do quite well in math. I tended to pick up concepts in science well. And so the natural progression was one towards being a geek. By the time I was in high school, I had a friend down the street who was putting together his own kind of home brew computer. And I wasn't enough of a geek to really do it myself. But we would go over, and when we weren't playing Risk, we would work on his computer. So nothing that would say, oh, this guy's going to go start a computer company or ultimately start a cloud-managed networking company, but definitely a tech influence, and had tech oriented friends as well.

Redelfs: Great. And then you went to UPenn in mechanical engineering.

Abramowitz: So I went to Penn in mechanical engineering. And the thought there was that I liked to build things. And ultimately, I got very excited about robotics. My senior thesis wound up being building a mechanical hand. And that mechanical hand wound up being really the basis for what became the GRASP Lab at the University of Pennsylvania. So--

Redelfs: Interesting. Is that still around today?

Abramowitz: You know, the hand itself is not. Although, it was in the Penn brochures for like 10 or 15 years. And it was kind of interesting. Ruzena Bajcsy was the professor who authorized it. She's now at Berkeley. She's still an icon in the industry. And there was only one hand in the industry at the time, and it was somewhere north of $100,000 to buy one. So she got me to build one for much cheaper. [LAUGHS]

And so from Penn and robotics at Penn, I actually went to MIT for grad school. And I got a degree in electrical engineering. And I had done a fair amount of electrical engineering in undergrad as well to set myself up for the robotics department at MIT. What happens is, at Penn, robotics was mechanical

engineering. At MIT, robotics was electrical engineering. I went to work for the guy that built the Stanford JPL hand, again, thinking that robotics was where my career was going to wind up. And I took robotics and control theory courses. But alas, that's not where I wound up.

Redelfs: So when did you graduate? And where did you go initially out of MIT?

Abramowitz: So I graduated in '85. And I wound up going to a startup in San Diego that did radio products for a subcontractor to the military.

Redelfs: Now that had to be a tough decision, after doing all this robotics--

Abramowitz: Right, and I missed a piece there. So what happened, the most influential course I took at MIT turned out to be a course in entrepreneurship. I was on track. I was accepted to the PhD program at MIT in mechanical engineering. I took this entrepreneurship course. And I said, that's what I want to do. And so I got bit by the bug. I wrote a business plan for a floor cleaning robot at MIT.

Redelfs: You could've been Roomba.

Abramowitz: I could-- except that the economics were completely upside down. And there was no way-- I couldn't see a way to make it successful. And then when I was looking for jobs, what I realized is that there really were no jobs in robotics per se. So the attraction to this startup in San Diego was I was going to learn to design radio products and then I was going to automate the production of those radio products.

Only there was no automation to be done. It took me about three or four days of being at the company to realize I'd kind of been hoodwinked in some sense. And I became a radio designer. Then I became a manager of the team that was designing these radio products.

Redelfs: When you say a radio designer, what did that mean?

Abramowitz: Oh, Microwave components. You know, the actually--

Redelfs: So you were actually a chip designer.

Abramowitz: Not really chip, it was actually filters and switch filters, et cetera, that go into military subsystems. I skipped the part where I worked for Hughes Aircraft during the summer. So I worked at

Hughes Radar Systems, and I'd done some target amplitude errors equations. One summer I did some other things in and around radar. So I had some familiarity with wireless systems. But now--

Redelfs: Designing SAW filters or something?

Abramowitz: Basically, and other types of standard components RF filters, yeah. The advance that had been made was really taking personal computers and using them to be able to design custom components for the military. And it was when I joined, the fastest growing military subcontractor in the history of the United States. That was the lure.

So I went there and did what I didn't think I was going to be doing. And I stayed there. First I was just managing the team. Then I wound up actually managing the product line, which was great experience and helped get me into business school, which is where I went next.

Redelfs: Great, and that was Stanford?

Abramowitz: So I went to Stanford and got an MBA. And again--

Redelfs: Finished what year?

Abramowitz: 1990.

Redelfs: OK.

Abramowitz: What's interesting there is I graduated with my class, but I actually stayed a little bit longer. I did a semester in Japan. And then I worked in Japan. And, again, still interested in automation and robotics, or still thinking I was going back to automation and robotics, I worked on a factory floor in Japan. And I designed a production process for a smart gas chromatograph. That's what I remember.

Redelfs: Because in that era, Japan was really leading the world in robotics.

Abramowitz: That's exactly the right.

Redelfs: I was an industrial engineer, and I had that same desires. But it was hard in the US to get a job in robotics.

Abramowitz: Yep, yep. So that's what I did. And I came back and I graduated.

Redelfs: Was that automotive related, tying back to your interest in autos?

Abramowitz: You know, the automotive went out the-- the US auto industry was--

Redelfs: Right, but Japan? That's what a lot of their robotics were developed around, right?

Abramowitz: That's actually true. I had got a job through Honeywell, so it was control systems, home automation, which actually ties, looking forward, but not auto yet. Let's see if we can do that some time in the future, I guess is the thought there.

Redelfs: Yeah. OK, so you were in Japan. And then?

Abramowitz: So I came back, looked for a job, and I wound up at a startup, only just incredibly funded startup, $183 million, mostly from Kleiner Perkins. Domestic Automation was a distribution automation demand-side management to essentially automate the communication systems for utilities. So everything from a smart meter, to a pole top radio, to a cellular-based station. So that's where I really got into radio systems.

Redelfs: So this was CellNet.

Abramowitz: Right, so Domestic Automation changed its name to CellNet. And I took a side course on a networking to kind of understand how all of these pieces and all the data would flow. And that was a great, great experience, except that I learned that the utilities are not the right end customer for innovative technology. So you can build the best mouse trap, and you can potentially get a pilot. But after they've got the pilot going, you might have to wait five, 10, 15, 20 years until things actually get deployed.

Redelfs: So, you were a Stanford MBA with an MIT and a Penn engineering degree. You probably had your pick of jobs. Why did you pick that one out of business school?

Abramowitz: Well, I definitely wanted to be in Silicon Valley technology. And I was excited about radios and wireless connectivity. I remember sitting down-- I've forgotten the gentleman's name, but sitting down with the VC and him giving me the big vision. I was sold. So Paul Cook was the CEO. And he was an industry icon. Doug Spreng was the president of CellNet Data Systems at the time. And he was very convincing. I had an offer to do a lot-- to have a much better title at Honeywell, for example. But I thought that this would offer me the best growth opportunity.

Redelfs: And it tied in with your entrepreneurship interests as well, it sounds like.

Abramowitz: That's exactly right.

Redelfs: Great.

Abramowitz: Yeah.

Redelfs: So there how long? And it sounds like you figured out pretty quickly that was a tough place as well?

Abramowitz: No, no, no. I was there actually for-- I was there for about 3 and 1/2 years. And what happened was things were going gangbusters. Then Schlumberger had a competitive product on the meter side. The company went from 180 something employees down to 43. So--

Redelfs: So it was going gangbusters in revenue, and yet you lost market share, or?

Abramowitz: Yeah, it was going gangbusters when they hired me. And then Schlumberger introduced a competing product. Prices got cut in half. And the company started bleeding cash like crazy. So we had a riff of the month for the next 12 months. It was incredibly painful. But we still needed to get the product out. So we just cut down to a core team.

Redelfs: So the product, when you say it was going gangbusters, was that in revenue or just in terms of--

Abramowitz: No, so what was happening-- when I joined, for example, the smart meters were seemingly going gangbusters. But then when Schlumberger announced the competitive product, it cut sales, cut revenue, cut the margins.

Redelfs: 'Cause you said you had to get a product out. And I wasn't sure if that was a second gen product or initial product.

Abramowitz: Yeah, I'm sorry. A little more complicated than that. So CellNet had an electric meter business, which was their core business. And then they had this whole, call it, the CellNet radio system, which was going to be the meter, the pole top, and the cell tower. And so the goal at the time was that this meter business was going to help fund the investment in this whole communication system. So what happened was--

Redelfs: So you went from a dumb meter to a smart connected meter.

Abramowitz: Exactly. And what happened was, was when Schlumberger basically entered this market or cut prices in this market-- I don't remember which-- they basically killed what had been thought to be the cash cow. And now all of sudden everything that's being built over here had to be scaled down. But we still needed to deliver this complete communication system.

Redelfs: Got it.

Abramowitz: So we went from-- when I joined, it was kind of a plush company. And I would say a year and a half later, we were pretty tight. And in fact, so I'll tell a little prank that I pulled. The company was DAC. And we had a very nice building. We had all these-- a huge space, because we were going to expand. And then when we cut down, we had all the office equipment that we had, I guess, leased. And so we wound up putting all of it in one half of the building to give back to whoever we were releasing it from.

So I put a sign on the front of the building one night, working late. I put a sign, and it said, instead of-- I'm going to get in real trouble for this. Instead of [DAC/] Domestic Automation Corporation, I changed it to say [DAC/] Dividers and Chairs and put pictures of all the dividers and chairs.

Redelfs: Were people knocking on the door the next day to buy your chairs?

[LAUGHTER]

Abramowitz: All right, that was my prank story. So--

Redelfs: By the way, did the management figure out it was you who did this? Or this was a big secret?

Abramowitz: It was a secret for a while, but I had also changed all of the conference room names at some point. So I think I was known.

Redelfs: You were a trouble maker.

Abramowitz: I was a prankster. I was not a trouble maker. [LAUGHS]

Oral History of Jeff Abramowitz

Redelfs: That's good. Every company needs a little sense of humor, particularly when you're going through tough times.

Abramowitz: Yeah, yeah. I actually just remembered. When we changed the conference names, I put a poem on each conference room explaining the new name. Unfortunately, the names didn't stick.

Weber: [INAUDIBLE] more creative names, like for instance?

Abramowitz: We would not have used Princeton. That would've been bad. And I--

Weber: No, for instance?

Abramowitz: Oh, yeah, yeah. But I don't remember--

Redelfs: You don't remember any conference room names?

Abramowitz: No, I don't. They were numbers. And I gave them personality.

Redelfs: Sure. That's become a Silicon Valley trend, actually.

Abramowitz: Yeah, actually-- I'm sure I didn't start it. I'd heard that other folks did that. And I said, yeah, that sounds like fun. And we could use some fun.

Redelfs: That's great. So then layoffs at CellNet.

Abramowitz: Yeah, but actually things started to grow-- so actually, here's what happened. Things started to grow. I was put in charge of the engineering team, became--

Redelfs: So you went from product management to engineering?

Abramowitz: Well, I was really-- right, I was an engineering group manager. And I'm thinking to myself, wait a second. That's what I was before business school. So I don't know that I was actively looking. But what happened was 3Com, somebody at 3Com found me. It turns out that Doug Spreng was the EVP in charge of adapter division. 3Com was gangbusters at the time. That was truly gangbusters. CellNet was kind of mouse nuts compared to what was going on at 3Com.

It was '93, '94. You were there, right? You were probably already hanging on by your fingertips. Yeah. So powerhouse in Ethernet, it was already investing in token ring and other technologies.

In the late '93, I learned that they had bought technology from a company called Pacific Monolithics. And so the vision that was told to me was, we want to be the dominant player in wireless networking. And they had-- I don't remember whether it was already thought to be enterprise, then small business, and home. But it pretty quickly became that with this understanding that 3Com really was going to take this technology to the next level.

Redelfs: Yeah, if I remember, the belief at the time was 3Com really dominated the ethernet and NIC business over 50% market share. And wireless was--

Abramowitz: Was just the next step--

Redelfs: the next generation, and it was ours to lose.

Abramowitz: Yeah, it was truly remarkable too, because it was a great standard-based story. It was founded on Ethernet. And then 3Com had parallel tasking, which was really just a slight proprietary enhancement that got marketed well. And it enable 3Com to grow the business which enabled them to drive down costs and get a lot of profit in a business that was seen as a commodity.

Redelfs: And huge gross margins that Wall Street didn't understand.

Abramowitz: That's exactly right. And then what that also enabled was just a nice channel build out. So the 3Com channel really was the envy of everybody in the space, which became important as we move forward talking about Wi-Fi. From the perspective at 3Com, people wanted to do business with 3Com. My entire career at 3Com, people would come, in the wireless space, would come to 3Com and say, if you would just take our technology, this would be ginormous.

Redelfs: Right, right. So you came over basically to lead marketing of the whole wireless initiative.

Abramowitz: Exactly.

Redelfs: And you came after the Pacific Monolithics?

Abramowitz: I came six months after. The project had already started. And my first meeting there was actually a review of the program. I think it was supposed to get delivered in late '94. When they bought the technology in late '93, it was supposed to get delivered in the late '94. And my first meeting was the first real audit of the project. And it really was masterfully laid out. But that was also the first time that the project got postponed, which as you know happened time and time again.

Redelfs: Yes, this is a project that was a year away for three years, right?

Abramowitz: Unfortunately, true. Now potentially fortunate for the industry but unfortunately for 3Com.

Redelfs: And talk a little about what that technology was and why did it attract you? Because this was before, well, way before Wi-Fi but even before IEEE 802.11 had any momentum. The original spec was--

Abramowitz: The original spec-- so people were working on a spec. It was a time for wireless data hype. People had started to envision this notion of wireless connectivity. You had Palm, but you didn't have a connected Palm. You had computers, but they weren't-- you know, laptops, and laptops were growing. And 3Com was making money shifting from desktop NICs to PCMCIA NICs, which you ultimately led the division for.

So that's where the industry was. And so it became clear that-- not clear, but it seemed for folks in the space that wireless was the next great thing. And there were conferences going on espousing the different technologies. Actually, step back, I went to a conference right when I started at 3Com, maybe even actually just before. It was helpful for me to try and make my decision.

Craig Mathias was one of the speakers who has been the analyst icon now for years, but this is in the early days. And I signed up for 15 minutes with Craig. You could sign up for 15 minutes with an expert as part of this conference. So I signed up for 15 minutes with Craig Mathias. And in the conference, you had Proxim talking about their technology, Symbol talking about their technology, Intermec talking about their-- everybody was talking about their proprietary technologies. And I sat down with Craig Mathias, and I told him, you know, I got permission to have this conversation. Here's what 3Com's planning. He was like, wow. He was standards oriented, but he said 3Com can really propel, help propel, the industry.

Redelfs: And what did you think made 3Com so compelling versus all these other proprietors? Because 3Com, what they were working was proprietary as well.

Abramowitz: Correct, but none of those companies had any type of marketing. In fact, if you went back and looked at what was being promoted at the time, Symbol's marketing collateral would say, our technology is better than Proxim's technology. And Proxim would say, our technology--

And if you're an end customer, it's like, OK. What am I using the technology for? [LAUGHS] There was kind of this missing overlay of, well, what are the benefits and uses of the technology?

Redelfs: But wasn't a lot of it very vertically oriented?

Abramowitz: It was vertically oriented.

Redelfs: It was factory automation, and it was retail POS systems. It wasn't office automation. It wasn't connecting PCs.

Abramowitz: You are exactly correct. But even for somebody that was-- I mean, health care was thought to be a target application. And they didn't say, here's what you can do with your wireless as part of health care. It just said, our technology is better.

Assuming you want to do wireless, we've got it better than they do. So the thought was, OK, 3Com's a great place to go help move the industry forward. And one of the interesting things is that 3Com's perception of where the industry was when they made the purchase was not actually accurate. So--

Redelfs: Tell me more about that. Where was the perception? Where was the reality?

Abramowitz: So one of the first things I did when I joined 3Com-- the best first thing I did was go out and talk to end customers. And we wound up running market studies. I'll come back to that. The other thing I did was I looked at the market research to try to understand how to steer the product that we were building.

And what I discovered was that market research in the wireless networking space was horrible-- horribly optimistic, but horrible. And the one stat that I remember was that Proxim had gone public in December of '93, just about the same time that 3Com bought the technology. And their sales were something like $8 million revenue for the whole company. And I had a market research report that showed they were selling $40 million worth of wireless network equipment.

Redelfs: As a publicly traded company, you could see that.

Abramowitz: So I call the analyst. Of course, at 3Com I have access to the analysts. I said, well, how could they be selling $40 million worth of equipment if their total revenue is only $8 million? And they're like, well, how do you know that? It's like, because they're a public company.

So 3Com had the market research. It said that there were going to be a million nodes of wireless networking equipment sold in 1995. And that was building off of the current base. And I remember going in one weekend and having seven market research reports and trying to cross check them. Basically I came up with the fact that the industry is going to be about 100,000 nodes in 1994. And maybe it was to see 20% 30%, maybe 50% growth in 1995. But it was 1/10 the size of the market that 3Com thought when they bought the technology.

So what then became a priority was, well, if we're going to introduce some more product into the space, it needs to be meaningful space. So you don't have a product to promote yet. Product actually just got delayed. Go promote the industry. And so--

Redelfs: But you also did a lot of market research on-- I mean I remember you're initiating a lot of market research. Now what was the market really looking for?

Abramowitz: Yes, thank you for--

Redelfs: Because one of the things-- most of the stuff shipping was 1 megabit.

Abramowitz: No, you're exactly right.

Redelfs: And wired Ethernet was 10 megabits. And I remember the Pacific Monolithic technology was 10 megabits. And all the IT guys said, we want it to behave like wired.

Abramowitz: That's exactly right. So we went out and we did a market research with folks that had-- we did both. We did--

Redelfs: And you hired [Anderson Consulting with a team member] Carl Temme.

Abramowitz: That's exactly right. Actually, so that was one research project. We had-- and we actually did multiple research projects. 3Com really keen on getting this right. So the idea was to go and talk to the actual end customers and get that feedback, which we did. Then we audited folks that had wireless networking and got feedback there. And then we audited-- we surveyed folks who didn't have wireless networking to find out, well, what would they want?

So what we discovered was folks who had wireless networking, regardless of whose wireless networking they had-- and you're right, it's all 1 and 2 megabit-- loved it. 95% of the people we surveyed, and it was-- I don't know if it was north of 100, but a couple hundred people at 100 companies-- 95% said they wanted

to buy more. And this is at one or two megabits. Their primary knocks on what they had was they wanted it faster. They wanted Ethernet speed. And they wanted it cheaper. Because access points were I think $2,000. And adapters were $500 or $600 a pop.

So there's one thing you know about technology is it's going to get faster. And it's going to get cheaper, and--

Redelfs: So what would the wired make? So these were $500 for that 1 megabit wireless. What would 10 megabit wired NICs cost?

Abramowitz: Well, I don't remember what it was at the time, but I remember that the threshold-- 3Com said that the threshold for adoption was $300. If you could get a NIC under $300, it would be a mainstream product. And so the 3Com project really was targeted at that $300 price point for the NIC. And we actually were certain we could get under $1,000 for the access point, which would be big, a significant drop. We didn't know that we needed to, because it's an infrastructure product. And so it wasn't clear what pricing needed to be.

So I saw the market research. And I was totally hooked, and I became wireless networking evangelist. Like 95% of the people wanted to buy more. That's a pretty good repeat rate. And, of course, the people who didn't have wireless, the key reason they said they didn't have wireless, because it wasn't fast enough. So there's all this excitement with 3Com, got to get the product out, got to get the product out. And there's other stuff happening in the industry. But it's all seemingly moving forward.

Redelfs: Where did the original 802.11 come out? Somewhere in this time frame, wasn't

Abramowitz: Not quite yet. So it was--

Redelfs: It was later. OK.

Abramowitz: It was hatching very slowly.

Redelfs: Because it took like six or seven years to get through the standards. And then it was three different PHYs, non-interoperable--

Abramowitz: That's exactly right.

Redelfs: --and 1 megabit.

Abramowitz: 1 and 2 megabit. So yeah, the notion that 802.11 was going to be--

Redelfs: This is IEEE 802--

Abramowitz: IEEE 802.11, in 1994, 1995, the notion that it was going to truly be competitive was kind of, well, it's taking forever. But there's still promise there.

Redelfs: Right. Well, Proxim got some momentum behind HomeRF, right? Which was their--

Abramowitz: They actually had--

Redelfs: Was that later too?

Abramowitz: That was a little bit later. They had OpenAir, which also came a little bit later. So what I remember is in 1995-- and I think by this time, you were now in the wireless group, around the wireless group. I worked for you. And I went to the IEEE meeting-- I got to go to Hawaii. That was good. I actually was a voting member of the IEEE-- I signed the original standard. And I believe I may have signed the high speed standard as well. It winds up being important for a later story, because you have to go to a certain number of meetings, and participate, and also provide feedback on the sponsor ballots in order to have your voting rights. So I had voting rights. I went to the meetings to understand what was happening with the standard.

So I went to the Hawaii meeting in '95. And I pitched this concept of an industry organization [the wireless LAN alliance (WLANA)], the "Got Milk" organization, to promote the benefits and uses of wireless networking. And I got people to agree. And I got frequency hopping folks, and direct sequence folks. I don't know if I got the IR folks. I don't remember.

Redelfs: So explain direct sequence, frequency, hopping and IR, and what this had to do with this.

Abramowitz: Right, so as you mentioned before, the IEEE 802.11 standard actually had a common MAC, medium access controller, and three different PHY layers that you could use to be standards compliant, which creates kind of the interesting predicament that says you could be 802.11 compliant and be completely non-interoperable with another standard product.

So Symbol, for example, and Proxim were big on frequency hopping. And Lucent, who probably had the most market share, was big on direct sequence. And it wasn't clear at the time whether frequency hopping was going to win, or direct sequence was going to win. They were both 1 and 2 megabits. And this--

Redelfs: And by the way, Lucent was Vic Hayes and Cees Links who also have done interviews for this series. And Lucent became--

Abramowitz: Well, they started as NCR. Then they became Lucent. Then they became Agere.

Redelfs: Right. Many different names with the same company.

Abramowitz: Right. They did yeoman's work for the standard. And IEEE 802.11 wouldn't exist without Vic's stellar leadership as part of the IEEE committee and the support of Cees and other folks behind them in the Netherlands. Now they were making money-- or seemingly making money, or had a prospect of making money-- but not only did they continue to support it, but Vic as a chair of 802.11 was squeaky clean. He really did a really nice job running the meetings. He was squeaky clean. That actually will come up again in a story I'm about to tell. Because you knew that Vic was always going to do the right thing. And I think in terms of the overall industry coming to a fruition, everybody knew you could depend on Vic as the leader of the--

Redelfs: But there were a lot of politics underneath Vic's leadership, right?

Abramowitz: Huge politics.

Redelfs: You had all these different PHY's and different proponents. . .

Abramowitz: Yeah, that's exactly right. And in the early days-- so the thing about IEEE is, you were an IEEE member as an engineer, presumably. I was kind of a pseudo-engineer, technical enough to make some contributions but not really down in the nuts and bolts. But the notion was, you're there representing yourself and your own ideas not necessarily your company.

And in the early days, it was pretty easy to be altruistic, because there was no money to be made. There wasn't much of an industry. So people actually proposed the best technology. And there was this real [altruism]-- and there were people who were consultants who would then get jobs at other companies.

One of the guys I remember was Greg Ennis, was a consultant to Symbol. He was just a voice of wisdom in the IEEE committee. We later hired him at 3Com as a consultant, and then obviously he wound up being the technical chair for the Wi-Fi Alliance. And there's a pattern there.

But people would go to these meetings and try and move the standard forward. But then you had the politics of companies trying to either position their company to be able to take advantage of technology or block somebody else's technology. And so it really was this slow moving beast that was happening in the background. So I would say late '95, I went to the-- maybe it was July '95-- IEEE meeting, to form this organization that's really just going to be, "why can't we all just get along?" And we're going to go promote the benefits and uses.

And people said, if 3Com's going to use their marketing muscle to move the industry forward, that sounds like a good thing. And so we signed on. I got seven, then 11, then some number of companies to all say we were part of this organization. And we helped straighten out the market research companies, because they didn't really understand what was going on in the industry. And we were attempting to just get the press and the technical community to understand that there was this big opportunity coming. And people would say, well, what's happening with the standard? And the standard was coming. It was coming.

By middle of 1996, it actually looked like the standard was final or going to be final. It didn't get formally approved till September of '97. But it was pretty well baked. It's just there's a bureaucratic process that takes almost a year before things get officially approved. So by the middle of '96, it looked like there was going to be a standard. It still wasn't clear whether direct sequence or frequency hopping was going to win. But there was a migration towards using the 802.11 MAC.

3Com, we looked at, well, can we make ourselves standards compliant in some way, shape, or form? The [internal] 3Com project actually pushed out again. So now it looked like it was going to come in 1997. And the standards committee was already talking about higher speed extensions. I'd given a talk-- I used the 3Com market research -- and I gave a talk at the IEEE meeting and said, OK, we need to get one and two [Mbps] done so that we can get to higher speeds.

And so that got put on the docket. [802.11]"a" got put on the docket as-- why did "b" come out before "a"? [LAUGHS]

Redelfs: --IEEE 802.11"b" and "a", which followed the original one.

Abramowitz: That's right. Thanks for clarifying. And the answer, as I recall it, is that 802.11a was at 5 gigahertz. And the standard [which was originally written for a physical (PHY) layer at 2.4 GHz] didn't say anything about 5 gigahertz. So you could propose a high speed [standard] at 5 gigahertz. You couldn't actually propose a high speed standard at 2.4 [GHz] until the original standard was completed. So "a"

was made as a proposal, or was offered to Exec-Comm first and then "b" came second, even though obviously in the market, "b" came first and "a" came second.

So what's happening with all this? WLANA is starting to promote benefits and uses. People are moving towards the standard. 3Com, we wound up canceling our internal development effort because we'd had conversations with folks that said, you know, the high speed standard is going to be comparable to what we were planning on doing internally. It's going to be a standard. We [3Com] still have the market power. We think that we can do better with less investment by leveraging a high speed standard. And I wound up going on a [technology audit tour] tour. We hired Greg Ennis as a technical expert to accompany me and the guy who had run our engineering project, David Fisher.

And we went to Palm Bay, Florida, to talk to Harris, which became Intersil. We went to the Netherlands and talk to Lucent. We went to Israel to talk to a small company called RDC and we talked to BreezeCOM, and then we went to Ohio and talked to Aironet. So we basically did an audit to find out whose high speed technology we thought was going to win the IEEE-- because the thought here is to potentially jump the technology. Partner with the folks who are going to win. Bring that technology to market and grow it.

So that was all happening in the '96, '97 time frame. And it was exciting times. But it was kind of Waiting for Godot, because the standard wasn't quite there yet.

Redelfs: So this was-- when you say the standard wasn't quite there, you're talking about the "b" standard?

Abramowitz: No, actually--

Redelfs: Because the original was--

Abramowitz: So the original was '97, right.

Redelfs: Ratified in '97.

Abramowitz: '97. As soon as that got ratified, then all this effort went into 802.11b. And once people realized that there was going to be a greater than 10 megabit per second standard, there were rumblings of Apple getting involved. Microsoft put out an RFP. Ultimately Cisco wound up buying Aironet in 1999. You had--

Redelfs: And if I remember, Cisco bought Aironet to get the Microsoft campus business.

Abramowitz: So that's the rumor. And it makes perfect sense. And to grow the wireless business as a whole, because once Microsoft became a bona fide deployment, that obviously is mainstream. That's a marquee customer that somebody could use and say, "Microsoft's got wireless networking. You should too."

Redelfs: And they did a huge campus network.

Abramowitz: They did. They did. 3Com was obviously part of that audit. By that time-- so let me just back up a second. So 3Com has decided that we're not going to do our internal development. We're going to partner. This is interesting history. The results of our audit in early '98 were we liked the Lucent technology best. I went to the Netherlands, met with Cees, further conversations with Angela Champness in San Diego, which was kind of one this chh chh, where you go figure out--

Redelfs: And Cees was the VP/GM of the unit and Angela was the--

Abramowitz: Head of marketing for-- thank you-- I don't remember whether it was Lucent at time or whether they changed the name. But it was the WaveLAN technology. And the challenge was that they wanted to be a systems vendor. They didn't want to become an IP supplier or semiconductor.

Redelfs: But just to be clear, this was their 802.11b that was in development.

Abramowitz: This was-- that's exactly right. It was not quite "b" yet. This was the technology that was vying to be 802.11b.

Redelfs: The "b" to be.

Abramowitz: [LAUGHS] That's going to be tough for folks to follow, but yes. [LAUGHS] Yeah, so what we but we actually looked at was the Lucent proposal for "b," the Intersil proposal for-- everybody's proposal for b. And we decided on Lucent. And then we couldn't come to deal terms, because they were not willing to license the technology or sell semiconductors to 3Com. And we wound up putting together an alternate path to market, which was to leverage the Harris technology. And Symbol, who had heretofore had been [a promoter of] frequency hopping, realized that frequency hopping technology was not going to be able to go faster than 2 [Mbps] or potentially 4 – [they thought they could find] a way to get it to 4-- megabits per second. So they were going to make the switch from frequency hopping to direct sequence.

And they were going to partner-- it was going to be this triad, Harris, Symbol, 3Com. And there was a little uneasiness with all members of the--

Redelfs: Just be clear, Harris became Intersil, and they were the chip company.

Abramowitz: They were a semiconductor company. They were going to provide the semiconductors to Symbol. Symbol was going to build modules, both a PCMCIA card and then also an access point that 3Com would then brand and sell as 3Com's wireless infrastructure.

Redelfs: With the idea of Symbol being more vertically oriented toward retail and industrial systems. And 3Com would take it--

Abramowitz: Into the mainstream.

Redelfs: --into the mainstream office automation space.

Abramowitz: That's correct. Yeah, that worked well from divvying up the market standpoint. Great. Retail was really their strength. So we would take that technology, take it to the mainstream. We had a network management software effort that we were going to overlay on top of it to help differentiate the solution for the enterprise. We had some other things going to try and figure out, well, how are we going to get this technology into small business and the home? Because we knew we couldn't OEM from Symbol and get the low cost. But we thought we would get the quality from Symbol.

But we were a little concerned about how committed Symbol was to direct sequence. So what I wound up doing is signing a letter. And I remember this pretty distinctly. Ron Van Dell ran the wireless business for Harris. And Rich Braverman ran the--

Redelfs: Bravman.

Abramowitz: Bravman, thank you, ran the business for Symbol. And we wrote letters of agreement that we would form an interoperability organization based on the 802.11b high rate standard. And that really was the basis for what became WECA and then the Wi-Fi Alliance. So those two vendors were already part of WLANA. So we were having these quarterly wireless LAN association [WLANA] meetings. People were asking, well, why isn't--

Redelfs: Well, WLANA we hadn't talked about that.

Abramowitz: OK, so WLANA was that organization. So I started on it, then I distracted myself. So when I went to the IEEE meeting [in July '95] and started this "Got Milk" organization, it was WLANA. Originally it was called the Wireless LAN Alliance. We actually changed the name to Wireless LAN Association. And the reason we changed the name to Wireless LAN Association was we knew we wanted to form an alliance that was actually going to have interoperability tests. There was no real alliance in WLANA. It was just a bunch of companies that came together for marketing purposes.

Redelfs: They were just marketing wireless as a whole without any sort of value add.

Abramowitz: Right. And then people said, well, why can't WLANA do interoperability testing? Say, OK, now you have an 802.11 spec. The IEEE doesn't say anything about interoperability. And you could have 802.11 products from one company and an 802.11 product from another company and they could [potentially] not work together.

So there was a clear issue that needed to be addressed. There was an industry association that needed to be formed. It had happened with the Ethernet Alliance. It happened with Fast Ethernet Alliance. By the way, it happened with the Token Ring Alliance. And in all three of those cases, by the way, 3Com was the company that formed the alliance. And I used the charter for Token Ring Alliance-- Wendy Walleigh had been the chair of the Token Ring Alliance. And she gave me her charter. And I used that -- for cost saving purposes -- to start WLANA. And we stripped out the interoperability test, because we didn't need to do any. But then WLANA had no provision for interoperability testing. And we had folks who didn't necessarily want to do interoperability testing. We still had folks like Proxim who were developing their own proprietary technology.

So we realized, you have this WLANA organization, which is just marketing, that we needed an interoperability organization. We signed with what became Intersil and Symbol to do an interoperability organization. We said, well, who else do we need? And we wound up, of course, contacting the folks at Lucent and at Aironet. Those were the two market powers-- they were both in WLANA-- and said "we want to do this interoperability organization [that became the Wireless Ethernet Compatibility Alliance (WECA)]. Are you guys in?"

So one other key piece of information here is that at 3Com, with this notion of doing Wi-Fi for the enterprise, Wi-Fi for small business, for the home, sometime in late '98, early '99, I hired David Cohen to be our small business/consumer Wi-Fi guy, but then also presumably to help with this new organization. Because I didn't think I was going to do both organizations. I didn't know that I really wanted to do any organizations.

Redelfs: So you were still doing WLANA at the time?

Abramowitz: I was still doing WLANA. It wasn't really a big effort. But the WECA, getting something off the ground is a lot more-- when I got WLANA off the ground, there wasn't a lot of product stuff to do. But I saw that WECA was going to be a fairly significant effort.

Redelfs: Ensuring interoperability is a lot of work.

Abramowitz: It is a lot. That's exactly right.

Redelfs: It takes resources as opposed to just general marketing.

Abramowitz: That's exactly right. So I sat down, talked to David. He was excited about it. So he actually made the--

Redelfs: David?

Abramowitz: David Cohen.

Redelfs: Oh, got it.

Abramowitz: So sometime in '99 told him about the letters [LOI with Symbol and Harris (which spun off in July 1999 as Intersil)], told him about the plan for WECA. And then, I don't remember whether it was July or August, we had our WLANA meeting. And--

Redelfs: You mentioned WECA. I just want to clear, what is the name WECA?

Abramowitz: So WECA stood for Wireless Ethernet Compatibility Alliance. And again, I don't remember if we called it that-- whether we referred to it as that before it was formed. But that was the initial name for what is now the Wi-Fi Alliance. So you had WLANA. You had this concept of Wireless Ethernet Compatibility Alliance. We had a meeting at 3Com with the WLANA folks. And we had a pretty good team.

We held that meeting, decided whatever we were going to decide. We marched downstairs to the 3Com front entrance. We said goodbye to Proxim. We said goodbye to the WLANA director. And then a bunch of folks marched back upstairs, and we had the first WECA meeting and came up with, OK, here's what WECA is going to be.

And, of course, it was centered around the interoperability of the high rate product. I've jumped ahead. By that time, the standard had already been pretty much-- no, actually by that time, the standard had been nailed down. The standard was, if not fully ratified, essentially ratified. So there was no question what the technology was that needed to be tested. Nobody had product yet. Some folks had done some interoperability testing amongst themselves. But there needed to be a formal process.

Greg Ennis was hired to be the technical director and helped figure out how the interoperability testing was going to work. He was known to us. He was known to Symbol. He was trusted elsewhere. And Phil Belanger from Aironet became the first president and David was the vice president. So it wasn't a purely 3Com organization.

And the structure was such that only the founding members had votes, which wounded up being important going forward for the Wireless LAN Alliance. Having a seat at the table for the Wi-Fi Alliance wound up being pretty key. But the first order of business was to figure out the name for the organization that called itself the Wireless Ethernet Compatibility Alliance. But at 3Com, we were very convinced that the name for this technology needed to be something which was consumer friendly.

Redelfs: You mean IEEE 802.11b doesn't just roll off your tongue as a good marketing name, Jeff?

Abramowitz: Nor does wireless Ethernet, right? Because people didn't necessarily [want a new name] – "well Ethernet is successful" was the argument. The reality is, 3Com truly had bold plans. We had bought US Robotics at that point. Candlestick Park was already 3Com Park. And so the idea here was to hire Interbrand to do some corporate branding.

Redelfs: And HomeRF had a bit of momentum in residential--

Abramowitz: You're right, HomeRF--

Redelfs: Motorola and Intel were promoting it.

Abramowitz: Promoting it. Right. They were just-- I think that that conceptually was starting. And so the thought was, OK, this needed to be a consumer friendly name. And fortunately, the WECA started with enough [dollars] -- in order to make sure folks were committed -- and I don't remember the exact dollar amount that folks had to contribute, WECA had some money. They didn't have it have it, but they had it--

Redelfs: Committed.

Abramowitz: Committed. And you may not remember this-- I remember specifically, it was your budget, which was my budget, approving 3Com to front the money to Interbrand.

Redelfs: I do remember that, believe me.

Abramowitz: [LAUGHS] And we got them for cheap. It was only $30K, but we fronted the money to come up with the name. And I remember talking to David Cohen, because he was very concerned that we were going to come up with this name and people weren't going to like it. The question is, what's going to happen next?

Fortunately, the battle over whether we should have a name was far, far greater than what happened when we came back with the name. Because Interbrand came back with a bunch of different names. One of them was Wi-Fi, and everybody loved Wi-Fi.

Redelfs: There was some controversy about Wi-Fi, I remember, though, that it had an old school kind of like a retro feel, because Hi-Fi was sort of out of vogue. We now had digital CDs and--

there was a bit of concern about that.

Abramowitz: Well, what happened was, people would say, so the way that Interbrand got to Wi-Fi was-- they would say it was informed by the term wireless fidelity. Like Hi-Fi was-- this would be Wi-Fi. And they were saying, don't use wireless fidelity. Just use Wi-Fi. Make it an empty vessel name. But there are some potential positive connotations, and some people thought there were some negative connotations.

And so there was this debate. Did it mean wireless fidelity? Did it not mean wireless fidelity. The alliance first said, you know, oh we're not going to say Wi-Fi. And then they said, oh, we are. We put the logo that said Wi-Fi, the standard for wireless fidelity. So I think the Wi-Fi Alliance had its own mishegoss in and around, should we use it? Should we not use it?

Fortunately, the term Wi-Fi became as well-adopted-- more adopted-- than anybody could possibly have hoped for. And so it wound up being just a resounding success.

Redelfs: And what was the problem with wireless Ethernet?

Abramowitz: Oh, the key challenge is that, first of all, it's not trademarkable. So the thought was if you're going to create an interoperable brand, you want to be able to put the seal on every box that is

trademarkable. So anybody could claim they had wireless Ethernet, whereas only folks who've gotten approval could claim Wi-Fi. So that was one.

And then the thought was just that when people use this [technology] in their homes, they would refer to it as something fun as opposed to wireless Ethernet. The other competing technology, actually I just remembered, was Bluetooth, which was kind of weird name. But they had come up with their own empty vessel name.

Redelfs: That was named for a Danish king or something.

Abramowitz: Right. That's right. Intel went through this whole thing about what a wonderful name it was. OK, that's kind of weird, but we liked Wi-Fi a lot better.

Redelfs: Right. So we'll come back to some of the features of Wi-Fi, but I also want to step back to before 802.11b, there was a big battle of the standard--

Abramowitz: That's correct.

Redelfs: --to which proposal? There was a Lucent and a Harris, I think they were Intersil at this time. Were they still Harris?

Abramowitz: By that time, let's see, they were still Harris.

Redelfs: They were still Harris. And this was at the point where 3Com decided not to partner with Lucent, and they decided to partner with Harris.

Abramowitz: Right, although it's not clear-- I don't remember whether Lucent actually knew that-- I think they probably did know that-- at the time. Thanks. Yeah. So now 3Com had done our audit. We decided on Harris. But the IEEE has this process of honing the spec. And they had to hone the MAC layer to make sure that it could meet the needs of the high speed PHY. And then you have to choose the high speed PHY.

And with 802.11a, the choice came down to an OFDM proposal by Lucent that was also adopted by HiperLAN in Europe and an alternative, which I don't remember the name of, by BreezeCOM. And it was kind of a landslide victory for Lucent in 5 gigahertz. So 802.11a kind of sailed through the adoption process.

Redelfs: But I think that the mindset at the time was also like that's expensive future technology--

Abramowitz: That's right.

Redelfs: --5 gigahertz.

Abramowitz: That's exactly right.

Redelfs: So people weren't really focused on it. And were using it as trading chips.

Abramowitz: Yes, that's a good point. And the notion was, 5 gigahertz is off in the future. What's really important now is a high speed version at 2.4 [GHz] where everybody knows how to build it.

Redelfs: Just be clear, the 11a was 54 megabits of throughput. The 11b was 11 [Mbps]. And the original was 1 and 2 [Mbps at 2.4GHz]. So these were big jumps up in performance.

Abramowitz: Yes. So correct. So the OFDM modulation, and which we were allowed to do at 5 gigahertz, gave you the 54 megabits per second. And so the battle for 802.11b was, who was going to define that PHY And if somebody was already pretty far along into finding that PHY, that would give them a market edge. So you had the--

Redelfs: Time to market edge.

Abramowitz: The time to market edge, you had this battle. And odds on candidates were Lucent, who had probably the dominant share of wireless networking in the market by that time, and Intersil, who was really lining up to be the only pure silicon provider in the market at the time. And then there were some smaller companies, TI actually had a-- no, actually it was a startup that TI bought called Alantro that had a proposal. And a small company called Microlor out of Boston had a proposal. The Microlor proposal was technically very appealing, but it didn't actually have backwards compatibility to the core standard, which violated the Exec-Comm overarching goals. Nonetheless, it was part of the consideration set.

The IEEE process kind of came down to this big meeting in the Netherlands, probably somehow timed due to politics. Again, because you want to have as many voting members at a meeting as possible. And it takes time to get your voting members. And then voting members have to be present.

So the presumed decision meeting is May of 1998. And it looked like Intersil [Harris] had enough folks behind it. You know, there's the back scene of trying to get folks to support it. But Lucent might actually have gotten a shot, depending on what happens with the other folks who are not as well-supported.

So you have, I think, six proposals that get voted on. And the one that has the least number of votes, it goes away. Then you have five proposals, and then you have four. So you get down to three. And the assumption was that it was going to be Intersil [Harris] versus Lucent, when it gets down to one and two. But some weird dynamics occurred, and in the penultimate vote, you wound up instead of Microlor getting dropped, Lucent got dropped. And so now the committee is voting between Harris and Microlor, who a lot of people weren't quite familiar with. And then in that vote, Microlor actually won.

Redelfs: And they won because it was a better solution, or because the Lucent guys were sort of anti-Intersil [Harris]?

Abramowitz: So they won because they got the most votes. [LAUGHS] And you're not allowed to ask them why they voted. But--

Redelfs: Because they're supposed to vote as independent engineers, not for the company they work for.

Abramowitz: They're supposed to vote-- exactly right. So there's one guy in the room who maybe has a vested interest over here in the Harris technology. The whole IEEE process-- I think I mentioned before-- has these Robert's Rules of Order associated with it. There's a lot of bureaucracy that comes with each of these votes, et cetera, et cetera. So I pulled a--

Redelfs: So Jeff, you're famous for this. You have to tell this story, in all modesty.

Abramowitz: I posited that there was bloc voting on that last vote, based on--

Redelfs: And define bloc vote, you have to get in the details of Robert's Rules. Because you're the only guy in this group of engineers who actually knew what paragraph 47, sub-paragraph 18a meant in Robert's Rules of Order.

Abramowitz: So what it meant for the IEEE was that the engineers were not actually voting as individuals, but they were voting with their company. And I didn't have hard evidence, but on the surface, it would seem as though all of the Lucent engineers had thrown their votes for Microlor. And that was a fair number of folks.

No way to prove it. What wound up happening was Vic Hayes took that, looked at it, and said, hmm.

Redelfs: Who was a Lucent guy.

Abramowitz: He's a Lucent guy.

Redelfs: But a straight shooter.

Abramowitz: But he's a straight shooter. And actually, part of the calculus here was knowing that Vic always wanted to be above board. Obviously they [Lucent] had huge market power, but he never wanted to be seen as leveraging that power. And so he was going to do this right. And so what wound up happening was, they had a recess to figure out what to do. I think the very step of taking the recess threw the mechanics and logistics of the meeting off so that there was no way to actually get another vote in to decide the technology at that meeting in the Netherlands, which probably meant that Intersil [Harris] was going to win the vote at the next meeting, which was going to be in Texas.

But something that you'd hope would happen actually did happen, which was the Intersil [Harris] guys, the Microlor guys, and Lucent guys got together and said, is there a combination? Is there something we can do to make this acceptable to all three? And they changed the modulation scheme that Intersil proposed, which I think was called MBOK. I don't remember what that was for. And they overlaid the technology that had been proposed by, I don't remember whether it was Microlor of Lucent, to what ultimately became the CCK that is in the 802.11b standard.

And that was what got proposed at the next meeting in Texas. It just flew through overwhelmingly. And that was it.

Redelfs: And it was something that supposedly was an easy change for Intersil [Harris] to make in their silicon--

Abramowitz: That's right.

Redelfs: --that allowed them to have their time to market advantage and in your situation, and mine, helped 3Com with that partnership.

Abramowitz: That's correct. That's correct. It was a little bit of a delay from what they had but not so much of a delay that it was going to cause a problem.

Weber: What gave you the idea of the bloc voting? Were you're very familiar with Robert's Rules of Order already? Or what gave you that inspiration to look for that?

Abramowitz: [LAUGHS] Jim Zyren was the lead guy at Intersil [Harris] who's very familiar with the Robert's Rules, the politics. He and I had talked about, well, what are the things that can or might happen? And what could we potentially do if they do?

Redelfs: And if I remember, you were running around at breakfast and lunches and polling people as well and sort of doing your own. It was like a political election. You were doing surveys to figure out where the vote's going to end before the actual election.

Abramowitz: Absolutely positively. Right. And then the question is, OK, if this happens, what do we do? If that happens, what do we do? And so there was a lot of time researching Robert's Rules during the breaks or during the voting itself, which can get pretty monotonous to try and figure out, OK, what can be done here to help, either move this along or slow it down?

Redelfs: Jeff, so we talked a little bit about your experience with 3Com and how you started the Wi-Fi Alliance, and then with all of this, I mean, here you are. You founded the Wi-Fi Alliance. You got that thing going. And it's got momentum. And you leave 3Com in the middle of this. So what happened there? What made you give up on 3Com? And what was your next step?

Abramowitz: Well, great question. And I'm going to go back to a story we were just talking about off camera. When we stopped the internal 3Com product, I had gone to Doug Spreng, who was president of CellNet and then division general manager for the adapter division at 3Com. And I said, wireless networking is still going to happen, that what we have is not failure of vision but of execution. I thought, 3Com could be successful pushing forward the high-speed version of the standard.

And 3Com had a very rigorous milestone process. And this was that milestone meeting, and this was the decision. And Doug looked at me. He said, well, I understand. I admire your perseverance. I wouldn't do this if I were you. But if you really want to, go ahead.

Redelfs: This being?

Abramowitz: This being a high speed version-- pursuing additional 3Com energy into a high speed wireless LAN.

Redelfs: So this is the Symbol deal?

Abramowitz: This ultimately became the Symbol [deal] -- right, we'd tested out whether it was possible. So we had some idea that we could do it. But it was really pursuing it in earnest. So that was kind of the go ahead, if you will, to go and really ultimately do -- the Wi-Fi Alliance and all the 802.11b products and the future of what 3Com did, which wasn't that great. But really [drive] the future of what the industry did.

So there was this kind of, at that point, a big step back from 3Com's perspective on what had been a large initiative to, one, a much more of a let's see what happens.

Redelfs: So the Symbol/Intersil [deal] was more opportunistic?

Abramowitz: It was more opportunistic.

Redelfs: Doing our own from the silicon up. It was partnering--

Abramowitz: Exactly. And not to say that there was [not support] -- I think when we came back and showed what we could do, there was definitely support for it. But it didn't have the same tenor as what had happened earlier. And obviously we didn't have the internal engineering team.

And at the same time, you know, the industry was truly making great progress. And the truth is, 3Com was helping to drive it. The Wi-Fi Alliance [formation in late 1999] was a seminal moment in history of the industry. And I gave a talk at the Wireless Communications Alliance in Silicon Valley towards the end of '99 on the state of the industry wearing my hat, my WLANA president hat. It ['s title] said, "Is 2000 the year of the wireless LAN?" In 1999, there were about a million nodes of wireless networking sold. And in 2000, there were five million nodes. Five-fold growth the market is pretty extraordinary. That really was the knee of the curve. And the industry's never looked back. I mean, if you look back, the trajectory since then has just been remarkable.

Redelfs: So I have to inject a little anecdote here. So when I joined 3Com in 1989, the company celebrated their 10th anniversary, and within a month or two celebrated shipping their one millionth unit. And so it took 3Com 10 years to ship one million ethernets. And now you went from--

Abramowitz: The industry.

Redelfs: The wireless industry went from one million to five million wireless ethernets from '99 to 2000.

Abramowitz: Right, so that was on the back of this high rate. It started to become exactly what folks had forecasted we'd come five years earlier. And 3Com, who had all the vision, no longer had kind of the

stomach to do the level of investment that other folks were doing. So Cisco bought Aironet for $800 million in, I want to say, October of '99. And we talked about the Microsoft deployment. And other folks, Intel was now working in earnest on-- now, they're working on a number of different wireless efforts. Apple was including Wi-Fi in their Macbooks. So the industry was truly on a ramp up. And there were all these smaller companies looking to take advantage of the growth of the industry.

I left for No Wires Needed, because we had identified them as potential technology partner to bring us lower cost solutions in the future and to deliver on high speed solutions in the future.

Redelfs: So what did they make? A low cost solution for what?

Abramowitz: Their core technology was a high speed MAC. They built the 802.11 medium access controller--

Redelfs: So this was a software company.

Abramowitz: It was, well, the core technology was software. Because they built a MAC on an ARM processor. But they actually had worked with an ODM in Taiwan and built an end-to-end solution. They were the first company to actually introduce an 11 megabit solution to market. It turns out it was based on [? MBOC, ?] the Intersil technology that--

Redelfs: So it's using Intersil's radio chips.

Abramowitz: It was using Intersil's radio chips and their own MAC.

Redelfs: So they were competing with their partner, in a way, because Intersil had their own MAC as well?

Abramowitz: Intersil did have their own MAC. They had bought CHOICE [a wireless LAN company with their own MAC technology] way back when-- because Harris was essentially a radio company. And they really didn't understand MACs. So first they bought CHOICE. This is probably deeper history than may be interesting, but they had bought CHOICE Microsystems, I want to say, mid-'94, '95, so that they would have a full chipset. And that technology was somewhat questionable.

Then they wound up buying a company called InTalk, which was a spin out of Symbionics. Symbionics had been another contributor to 802.11. A couple guys saw the Wi-Fi was starting to happen-- Jon Edney and Simon Black-- so they formed this company InTalk. They started building a solution. And they

actually got some adoption from Nokia. And Intersil wanted to get Nokia as a customer. Actually that winds up being important to Wi-Fi Alliance's story, because the sixth [initial board member/] vendor in the Wi-Fi Alliance was Nokia. Because Jim Zyren had this connection with Nokia.

So they actually had two MACs, but ultimately they were going to need a high speed MAC as well. And so I went from 3Com to No Wires Needed, knowing, by the way, that the CHOICE MAC was limited in terms of speed it could support.

Redelfs: On a state of the art ARM processor at the time?

Abramowitz: On a state of the art ARM processor at the time.

Redelfs: Jeff, just to put this in some context, how many chips were in a Wi-Fi solution? Because we think of it today as one chip, right?

Abramowitz: Right.

Redelfs: But there were multiple RF and separate SAW filters, and MAC chips, and--

Abramowitz: Yes, I would say, the first Intersil chipset, I think for 802.11b, I may be off by a little bit, but it was really five chips. It's about to get collapsed to two. That's part of what happens here in 2000, 2001, 2002 is the number of chips, the cost of chipsets, come down dramatically as the number of devices shipped goes up. People are taking advantage of the investment in technology to really drive performance up, drive cost down, and drive integration.

Weber: What were the five and what were the two?

Abramowitz: Oh, I'm not going to remember the architecture, the specific architecture. But typically, obviously you have a separate MAC and a separate radio, and a separate amplifier. But the early chips had--

Redelfs: It was an intermediate frequency, so there was a high frequency radio and a low frequency radio. And there were some SAW filters in between, which I don't even think are even in the five chip count. I think the filters were--

Abramowitz: May have been external. So yeah, it was a lot of integration happening. And one of the trends that people talked about-- so I left and went to No Wires Needed. You left 3Com and went to Atheros. And Atheros was doing CMOS radios. And so the opportunity there was really to change the game from a front end perspective.

Redelfs: Talk about CMOS versus what were Intersil and Lucent doing before CMOS.

Abramowitz: There were a variety of analog approachs to radios that I'm not going to recall. [LAUGHS]

Redelfs: There was silicon germanium, and gallium --

Abramowitz: arsenide, exactly.

Redelfs: Much more expensive.

Abramowitz: And, right. Not only were they more expensive, but they were not going to be able to ride a cost curve.

Redelfs: Or integration.

Abramowitz: Or integration. So yeah, and I'll just put a little bullet point here. I talked about a $50 chipset. Or maybe I talked off camera. You know, an 802.11b chipset in 1998, 1999 timeframe was about $50 for the whole chipset. That chipset now is one chip, and it's less than a buck at 50 times the performance.

Redelfs: I remember in my Atheros days, the prices were coming down 20% quarter over quarter, which was incredible pressure on us to cost reduce and integrate.

Abramowitz: Right. When we did the original--

Redelfs: You did the same thing in your Broadcom days.

Abramowitz: That's exactly right. And it was a dynamic that Intersil was not prepared for. But we're getting ahead of ourselves.

Redelfs: Go ahead. Finish that thought. Because we're about the chips and how the chipset's integrated and so some of the players got left behind with this transition to CMOS away from GaAs [gallium arsenide] and--

Abramowitz: Exactly. And it really opened up the whole new competitive playing field. I was really-- by 2002, 2003, you had Atheros pushing CMOS and 5 gigahertz. Broadcom really hadn't made themselves visible. But they had bought an HPNA company called Epigram and had converted that team to work on Wi-Fi. And the reason they brought me in is that they didn't have any Wi-Fi guys. They were a little unclear in terms of what they were developing. I'll just jump ahead and talk about it.

Redelfs: Hit the high level, because we'll come back and dive into that in more detail. But just talk about this sort of chip roadmap, and then we'll come back to your Broadcom experience.

Abramowitz: Yeah, well so the chip roadmap said, we're going to go from these analog-plus-MAC Wi-Fi solutions that are 10 megabits or 11 megabits. And we're going to go to digital radios and integrated solutions that are 54 megabits and greater and capable of riding down a pretty steep cost curve.

Redelfs: Which they've done to this day, as you point out.

Abramowitz: Right.

Redelfs: All right, so let's jump back. So you leave 3Com, and you go to No Wires Needed. Why did you leave and why did you go to where you went?

Abramowitz: Well, I went to an opportunity that just seemed too good to pass up. And this is the Dot Com days. They had technology. We [3Com] had vetted the technology. So I knew they had what they said they had.

Redelfs: So this was they had a high speed MAC.

Abramowitz: They had a high speed MAC.

Redelfs: No one else was really able to do 11b performance?

Abramowitz: No, people could do 11b. They couldn't do 11a. They couldn't do 54 megabits.

Redelfs: OK, got it.

Abramowitz: And by that time, people were talking about [802.11]"g," although nobody knew whether "g" was going to be real. But it was clear--

Redelfs: "g" was illegal at the time you left 3Com.

Abramowitz: Right, but--

Redelfs: You couldn't do OFDM at 2.4 gig.

Abramowitz: No, but the standards committee has started to talk about 802.11g. So what happens again, "g" was founded the minute 802.11b was finished. Then you can propose a higher speed extension. And so "g" got proposed in the committee [as the higher speed extension to 802.11b]. And then the question is, well, what was actually going to happen?

The communications industry, everyone was familiar with what happened with the modem wars, where you introduce a new technology. And if you can leapfrog somebody else, you're going to get somebody to buy your product. And if you could do it without significant incremental price increase, then that's obviously good. So there was already some momentum around 802.11g. Was it going to be a? Most people thought the next thing coming was 802.11a. But it really didn't matter--

Weber: What happened with "c", "d", "e", "f"?

Abramowitz: Each different initiative will have a different letter. So "e", for example, wound up being-- it was originally both security and QoS. Then they split in--

Redelfs: Quality of service.

Abramowitz: Quality of service. And they made "i" security. But then if you have a cleanup task force, that will get a letter as well. So the letters fill up pretty quickly.

Redelfs: But some of those got sucked into "g" and "b".

Abramowitz: That's exactly right. So what will happen is, by the time "n" came around, they sucked up a whole bunch of letters. And "n" had the whole smorgasbord included in the spec. I mean, you really have

to pay attention to know what you needed or didn't need. And, of course, the semiconductor vendors did. But the end customers, of course, did not need to. But it made for progress in parallel in some sense within the IEEE.

So No Wires Needed looked like it was going to be an up and coming startup. It was based out of the Netherlands. And the interesting story there--

Redelfs: Were these ex-Lucent guys?

Abramowitz: That's a great question. The answer is, in fact, this was a bunch of really bright guys who -- for their senior project at Enschede -- had gone to the IEEE meeting that had happened at Enschede. And so had gotten interested in Wi-Fi. Maybe they got interested before that. But they took the challenge to build an 802.11 MAC on an ARM processor.

And then, I don't know the exact dynamics. They pulled in other guys. But essentially, not only did they build the 802.11 MAC, but then they finished school-- I think they all finished school-- and they built an entire product around it.

Redelfs: And had the best one in the industry.

Abramowitz: Well, they had the best MAC. The product itself, mmm. But they sold it. And there's an interesting dynamic too. There's just all this rich tapestry of things going on in the wireless industry at this point. You've got ecosystem players looking to do software, looking to do hotspots, looking to do add-on software.

So the Taiwanese government is giving manufacturers money to build Wi-Fi product. One vendor, one ODM, called Gemtek was a small player. They had partnered with this company I mentioned before, InTalk, to build their access points. Intersil bought InTalk. Gemtek had nobody's product to build. No Wires Needed came in and took that open slot and started building product at Gemtek which turned out to be fortuitous as well.

Gemtek ultimately at some point in time winds up being the number two ODM in Wi-Fi. They just became Wi-Fi experts. So I was there for this kind of rough and tumble market expansion at No Wires Needed. And three months after I was there, we got the first offer to buy the company. And we went to the board, said, wait, wait. We're not ready to be bought yet. Give us a couple more months. And then ultimately, a couple months later, Intersil came back with an offer that No Wires Needed could not refuse.

Redelfs: It was like a hundred--

Abramowitz: $154 million to buy, essentially MAC technology.

Redelfs: Which given the revenue of the company at the time?

Abramowitz: Was a pretty sweet multiple.

Redelfs: What was the revenue? It was single digit.

Abramowitz: It was probably somewhere between $10 and $20 [million], if I remember correctly. Because it was system-- mostly what we sold were wireless LAN systems. We had a proprietary security technology called AirLock, which was kind of cool. Because we knew there was a problem with WEP in the original 802.11 spec.

Redelfs: So let's come back to security. So finish this, because I do want to talk about security and how that played in, and how that played into the Wi-Fi Alliance as well.

Abramowitz: Yeah.

Redelfs: So when you're at No Wires Needed, are you still involved in the Wi-Fi Alliance?

Abramowitz: We became a Wi-Fi Alliance member.

Redelfs: But not a voting member.

Abramowitz: I was certainly not a voting member, which winds up important. The voting members in the Wi-FI Alliance have all the power. The regular members can only influence by going and influencing the voting members. Even the director doesn't have a vote. They have influence, but the voting board members hold power in Wi-Fi Alliance.

So the answer is, I'm viewing [tracking] it. But things were so crazy that it didn't quite matter for us. We're just trying to sell the product and license the technology to as many people as we can. We did have a deal with 3Com. We were working on a deal with Compaq. It was definitely exciting times.

And then Intersil was growing-- again, the industry went from one to five [million units]. And I was really Intersil's big growth year. So we got acquired by Intersil [May of 2000] I went to Interop. We [NoWires Needed] were supposed to show our [system] product by ourselves, but all of a sudden, we were now part of Intersil. So we're not really in the systems business.

So I went to a meeting as Intersil. And we had this parade of Intersil customers come and ask for chip allocation, because Intersil could not build the product fast enough. And we couldn't foresee a time where you could get out from under having quotas for customers. So it was kind of this very interesting time in the wireless networking space.

Weber: What was your position at--

Abramowitz: At Intersil?

Weber: No, well, first--

Abramowitz: Oh so at No Wires Needed, I was a vice president of the marketing. So I ran all the product management and business development. We started the US office in my garage, but ultimately we got a facility in Menlo Park.

Weber: So you stayed here?

Abramowitz: I stayed here, and I traveled to the Netherlands every three weeks.

Redelfs: And then you get acquired.

Weber: So we acquired, and now my headquarters is in Palm Bay, Florida. And I was the head of the wireless LAN business to the consumer. So at this point, wireless-- we talked about this earlier-- it started in the early '90s as a completely vertical market. And as the standard got finalized, and particularly as 802.11b became finalized, you reached ethernet speeds, it started to go more mainstream. And the mainstream that it went was the enterprise.

So Microsoft did a deployment. Once Cisco bought Aironet, they were looking for mainstream deployments. But there was always this expectation that you could have wireless connectivity in the home.

Redelfs: Because this is when cable modems and DSL started rolling out and we went faster than our dial up modems.

Abramowitz: Right, so now you had broadband. And the question is, well, how are you going to distribute the broadband in the home? And Wi-Fi was the perfect solution. Home RF would say they were the perfect solution. But Wi-Fi was the same standard that was in the enterprise. So you could have your laptop, connect in the enterprise, take it home, go anywhere in the house and stay connected. Seemed like a pretty good, compelling vision.

Redelfs: So you were running that for Intersil.

Abramowitz: So my job was to try and figure out, OK, how do we do this? And Intersil was big enough where we actually multiple product teams. There was one team doing 802.11a and that was thought to be the enterprise group. And "b" was, obviously, already enterprise. But the question was, what is the consumer really need? And "g" seemed like the perfect answer.

And I had actually brought in a team from Andersen [Consulting], the follow-on team to the Carl Temme team.

Redelfs: Who had done the work at 3Com.

Abramowitz: Who had done the work at 3Com that we talked about earlier. And we did this project and said, yeah. Gee, looks like the right home solution.

I remember pitching it to Dell. We pitched it to Apple. It didn't quite have priority at Intersil, but it was moving along. And things looked like the world was just going to be the oyster for Intersil, because there really was not any competition from a chipset perspective.

There was a potential that TI was going to have chips. And I guess they bought Alantro, they came in with a chipset. They had this proposal in 802.11g. But all Intersil had to do was execute and they were off to the races.

Then the big guys kind of decided that wireless looks like it's a pretty attractive opportunity. And Marvell, Broadcom had already been sniffing in the standards bodies. And you had a startup like Atheros who was exploring CMOS into the Wi-Fi space. And so--

Redelfs: You saw the handwriting there on the wall there at Intersil

Abramowitz: In essence, yes. I actually--

Redelfs: How long did you stay then at Intersil?

Abramowitz: I was at Intersil a year. I left actually for personal reasons. My mom was ill and subsequently passed away. But I also knew I was leaving. And for a little bit, not very much time, I wound up first getting recruited by Marvell. I didn't go there. And I wound up going to Broadcom. And the pitch--

Redelfs: So you went to Broadcom next. And you went to Azimuth later.

Abramowitz: That's correct. Yeah. So the pitch from Jeff Thermond, another former 3Com-er, he was at Epigram [as the CEO]. Epigram sold to Broadcom for--

Redelfs: Just to paint some background, Epigram was originally an--

Abramowitz: HPNA.

Redelfs: HPNA, which was a Home Phone Network Alliance that was home phone networking for home.

Abramowitz: Right so the idea here--

Redelfs: It didn't catch on very much, so--

Abramowitz: Right, so the idea still was, OK, broadband's going to come to the home. How are we going to disseminate within the home? HPNA was this industry association. Epigram was the leader in HPNA. Broadcom bought them.

Redelfs: Broadcom being the leader in cable modem chipsets. So they brought the data into the home. And they wanted to distribute it in the home.

Abramowitz: That's correct. So they bought Epigram, realized that HPNA was not the technology of the future, thought Wi-Fi was the technology of the future and turned the team towards Wi-Fi. They happen to have one of the original 802.11 MAC architects at Epigram, Matt Fischer. And so that was probably helpful in the design. And then they came after me.

They actually found me at, I think it was a COMDEX panel that I was on. It was a Wi-Fi versus HomeRF panel. And for me, it was clear-- and this was late 2001-- that Wi-Fi was going to win. But there were still some-- Intel had invested, Motorola had invested in HomeRF. You still had some--

Redelfs: Which was Proxim's technology.

Abramowitz: It was Proxim's technology. And you had this -- sense that it [HomeRF] might still happen. But I was pretty aggressive [in supporting Wi-Fi] on the panel, which suited Broadcom well. So they wanted to hire me to help drive their aggressive wireless LAN efforts.

They had no market share when I joined. But Jeff Thermond pitched to me that their product cycles were nine months. So they were doing new chips every nine months. And yes, they had not started on 802.11g. And in fact, I don't think they had started on 802.11a in earnest. They'd done some work on a "b" chip.

But he basically had the sense that he was going to catch Intersil because externally, they thought Intersil was doing new chipsets ever two years. And I knew Intersil was trying to do chipsets every 18 months and probably [delivering] every two years. So I looked at it and said, wow. If you could really iterate on a nine-month cycle, that's going to be huge.

[I]Joined Broadcom, and I had actually not officially joined [and met the whole team]. I'd not stepped foot in the office when I had my first seminal meeting at Broadcom. I'm on vacation. So I signed on the dotted line, and then I went on a Christmas vacation. I'm at my family's home on the East coast and I get a call from Jeff Thermond. They'd just pitched Apple on 802.11a. And Apple said, we don't want "a", we think we want "g".

So the question was, Jeff, what do you know about "g"? And our engineers think "a" is going to be better than "g". Should we do "g"?

Redelfs: Now Apple was already shipping "b" at this time--

Abramowitz: That's exactly right.

Redelfs: --which Cees Links back at Lucent provided.

Abramowitz: That's correct.

Redelfs: OK. So they're already in the "b", but they want to go to "g".

Abramowitz: They're in with "b", but they want to do higher speed. And they want to do at an affordable cost. And the thought was that "a" was not backwards compatible. So--

Redelfs: Because it's in a different frequency.

Abramowitz: It's in a different-- so "a" is 5 gigahertz. And "b" is 2.4 gigahertz. "g" was going to be a high speed extension of "b" [with the same OFDM technology used in 802.11a]. So Apple didn't want to go with a dual band. They wanted to be cost effective. And they gave that feedback to Broadcom. And I think at the time, Apple was probably thinking they were going to Intersil.

Redelfs: Was this Art Astrin at Apple you were dealing with?

Abramowitz: I don't remember who--

Redelfs: He did the original "b".

Abramowitz: I think that could be.

Redelfs: I'm not sure if he was still there in "g".

Abramowitz: Yeah. I'm not going to remember. No, because I wasn't in the Broadcom meeting. I wasn't there yet. [LAUGHS] So what happened was we had this meeting. And I'm on the phone. It was like a two hour, knock down, drag out meeting. And I was advocating for "g". And so Jeff said, OK. We're going to go back and talk to Apple about-- have the team dummy up -- a "g" proposal.

I came back [from vacation]. And I would say we spent the next month in debate. And we had this war room that had stuff all over the board -- market size, chip prices, potential customers, industry segments, and how this industry was going to break down. At the end of the day, we said, "OK. We're all in on 802.11g -- and we're not going to tell anybody."

And so our "a/b" chip became a "g" chip. Now so just architecturally, this is kind of interesting. So again, 802.11b is 2.4. 802.11a is 5 gigahertz. It was thought to do a dual band chip, you have to have a complete MAC and PHY for the 2.4 and for the 5 gigahertz. So that's the chip--

Redelfs: You could do it in one chip, but it's basically two chips in one.

Abramowitz: It's basically two chips--

Redelfs: --the whole radio changes.

Abramowitz: Right. And the 5 gigahertz has the OFDM PHY. So here is what we wound up doing, was taking that chip-- so rather than design a new chip. The chip was pretty far along. We basically just didn't use the second MAC.

Right, we didn't use the 5 gigahertz radio. The 5 gigahertz radio was external. And we didn't use the second MAC. We just said, you know what? We're going to go to market with a higher cost solution. And we're going to just depend on time to market. And we priced forward. And we lined up Apple. We lined up Linksys.

I tried to line up Dell. I got thrown out more than once. And then-- I'm missing one.

Redelfs: You got Netgear.

Abramowitz: Ultimately we got Netgear. But the original was Apple, Linksys-- oh, it was Dell. We thought we were going to get Dell. Dell wanted "a/b", because Intel had convinced them that they wanted "a/b". And we were thinking they were going to go to ultimately. And ultimately they did. And then we had this incredible debate internally, because we couldn't support all three. How are we going to get--

Anyway, the development effort continued. "g" ultimately got launched in March of 2003. It become just a ginormous hit. I remember the NPD numbers-- NPD does market studies for retail sales-- showed that 23% of the retail market went to "g" in the first quarter. So it was just an absolute rocket ship. And Broadcom went from zero wireless LAN sales to $250 million in wireless LAN sales in 18 months.

And we were having trouble keeping up with production. We were holding on by our fingertips. It was chh, chh, chh. Go, go, go, go. It was very exciting.

Redelfs: And you and I went from being partners in crime at 3Com to being arch competitors.

Abramowitz: Arch enemies, right. Because you were--

Redelfs: Atheros and Broadcom were the big two, really, in rolling out those chips.

Abramowitz: Absolutely true. Yeah, Intersil had thought about--, was planning "g," and then had some mishaps. And you very cleverly were focused on "a" and realized, you know what? There's a market in "g". We can get to "g" quickly.

Redelfs: Yeah, the FCC changed the rules midstream, and we had to react.

Abramowitz: Yep.

Redelfs: Right?

Abramowitz: Yep. So that worked out well for you guys, obviously it worked out well for Broadcom. And the market just completely shifted.

Redelfs: So I wanted to jump back to WECA, because "g" presented an interesting challenge-- not WECA, but Wi-Fi Alliance, because the Wi-Fi Alliance was doing "b" interoperability. And then I think the next thing was actually Atheros coming to the organization, saying, will you certify "a"? And then "g" came along. And then there was a whole branding challenge of, how do you do interoperability when you have this new gen and, you know, "b's" don't speak "g". And so talk a little bit about that whole transition.

Abramowitz: I'll do a little interjection here too, because I think the response of the Wi-Fi Alliance to "a" in particular was really important in the development of the whole industry. And Atheros's decision to leverage the Wi-Fi Alliance was a key part of that.

So when we set up the Wi-Fi Alliance, we used the paperwork from the WLANA, which had followed what was originally the Ethernet Alliance, Fast Ethernet Alliance, Token Ring Alliance. So organizationally, the interoperability organizations, tended to be around technologies not about industries. And so if the Wi-Fi industry had followed the pattern of wired networking, 5 gigahertz might have its own industry association. And instead, you chose to stay in the tent and get the seal of approval from the Wi-Fi Alliance. And I remember there was some tension there.

Redelfs: Yeah, it was interesting, because I think the alliance felt it was the right thing to do.

Abramowitz: Yes.

Redelfs: But the individual members were like, well, we're not ready to ship it yet. So we want to drag our feet and slow this down.

Abramowitz: Yes.

Redelfs: So they embraced us, but with a foot-dragging approach.

Abramowitz: Right. And now, at that point, I'm not on the alliance board, but I'm tied into it, because I was with Intersil, which was a founding member. And so the thought was, well, it's IEEE. And we do want to do it. And then, I remember there was a fear. Well, we don't want Atheros or Intel to take 5 gigahertz elsewhere.

But the fact that it stayed within the tent, I think, really is what helped move the industry forward. And so there are the conversations about how to do-- and it was a little bit of a challenge. "b" and "a", I think, were a little bit less of an issue than adding "g". OK, how are we going to create these interoperable logos so that people can look at the box and figure out this product works with this product? And should we have "a" only? No, we can't have "a" only. Everything has to be backwards compatible, et cetera, et cetera.

Redelfs: One of the things I remember is that with 802.11a, the alliance came back and said, well, to do interoperability, we really should have at least two chip vendors and multiple system vendors. And so we were actually hoping Broadcom would ship that 11a--

Abramowitz: Oh, the "a". [LAUGHS]

Redelfs: --we knew you guys were working on, but you never ended up shipping it until much later when you did the "a/b/g".

Abramowitz: That's right. It was a total head fake.

Redelfs: Right, because it really held up our ability to get official certification for interoperability.

Weber: But with the two different bands, how did you do backward compatible then?

Abramowitz: So you had to have both. You had to have a radio and a chipset that did both.

Redelfs: But the logo-- there was a logo design from the Wi-Fi Alliance that showed "b" and "a". And so they distinguished which things you were interoperable with. And that became important with "a" and "g" as well.

Abramowitz: Right. And they were different colors.

Redelfs: There was a lot of effort on that.

Abramowitz: A lot of effort-- what the colors were, and what the logo was going to look like.

Redelfs: Because you didn't want the consumer to just see "Wi-Fi"--

Abramowitz: And get confused

Redelfs: "interoperability," and then have it not be.

Abramowitz: Right

Redelfs: And 802.11a-only products didn't ship for very long.

Abramowitz: No.

Redelfs: So everything was backward compatible to "b".

Abramowitz: That's right.

Redelfs: And in fact, the alliance never certified an a-only.

Abramowitz: No.

Redelfs: It had to be at least "b" compatible.

Abramowitz: Correct.

Redelfs: So they never certified until there was "a/b" combo.

Weber: And then it was "g", was always "a" and "b".

Abramowitz: Well, "g" was always "b" and "g."

Redelfs: Because if you did "g", you kind of got "b" for free.

Abramowitz: Yes.

Weber: True.

Abramowitz: That was our line. Get "g", "b" [comes] for free. The thing, by the way, the transition to 802.11g, what made it so palatable was because of the transition in technology, the "g" products were five times as fast. But the cost was basically the same. And vendors could actually introduce them at higher prices. They could pay the same cost for the chipset, introduce them at higher prices, market them more heavily, and so it was a huge profit motivator for Linksys, Netgear.

I mean, Linksys basically built their business on that launch of 802.11g. They ultimately sold for half a million dollars-- sorry, half a billion dollars-- to Cisco, based on the growth in that 802.11g business.

Redelfs: But talk about the chips a little bit. Because one of the challenges for the old guys, the 11b the guys and before, was getting their MACs to operates at 54 megabits, because the ARM processor and the code didn't run fast enough. And this was--

Abramowitz: Well, that's why Intersil bought No Wires Needed. They ultimately-- I think, and I don't actually have the details, because then I left Intersil, and I went to Broadcom. And I didn't really pay attention to Intersil's inability to keep up, but it became very clear that they were challenged.

Redelfs: And both Broadcom and Atheros went to state machine MACs, rather than software on an ARM--

Abramowitz: That's exactly right.

Redelfs: --which really eliminated that performance.

Abramowitz: Yeah, is the CHOICE MAC was actually a state machine MAC but had some of its own performance limitations, which I'm not quite sure what they were.

Redelfs: So let's jump back at another sort of thread through all this was security. And you touched on it a little bit. So take us back to the beginning of the original Wi-Fi. And if you remember, everybody had some proprietary. And then WEP came along. And WEP was obviously broken.

Abramowitz: Well, WEP was-- so I actually remember the conversations in the IEEE meeting, the original IEEE meetings. I remember Dave Bagby was the chair of the security committee.

Redelfs: And WEP stood for?

Abramowitz: Wired equivalent privacy. So the notion was you could actually tap a wired line and figure out what was going on. And so clearly the ultimate security was not what was required [for networking]. And we needed to get something to market and so that phraseology became adopted. As long as the security was good enough, there was this expectation that better security would come later. And it did. 802.11i was formed to do that. And AES encryption wound up getting built into 802.11i.

In the meantime, there was this [time] -- when Wi-Fi was not mainstream -- people didn't have any incentive to go figure out if WEP could be broken. And I'm not to remember the exact timing. But somebody broke WEP shortly after Wi-Fi [Alliance] started certifying products.

Redelfs: If I remember correctly, the weakness in it was known. But because people were doing it on an ARM processor, it was kind of the best they could do without changing their fundamental architecture as well.

Abramowitz: That may be true. Well, I think there would have been a political challenge in changing something within 802.11. And then there may have been an implementation challenge as well. But just getting standards through 802.11 was nontrivial. So what wound up happening was, by recollection, WEP got broken. The Wi-Fi Alliance actually-- and David Cohen who I mentioned earlier wound up being the security chair, after he was president, so he went from vice president to president, left 3Com, and then wound up, oh, with me, at Broadcom. I hired him at Broadcom as the security chair.

I skipped the step in between, and the Band-Aid was TKIP, where you would change the keys fast enough that it was tough to break the code. So that's one-- and I think the industry's just lucky that it didn't blow up into a bigger deal in the timeframe between when the original WEP products existed, and when first the Band-Aid fix, and then the real fix came out.

But I'm sure Atheros did this-- I know Broadcom did-- is that our first "g" chipset actually had AES built in, which was called-- so what happened was the original standard had just this WEP, wired equivalent privacy. The Wi-Fi Alliance pushed on TKIP, which was rotating keys and called it WPA, Wi-Fi Protected Access. And then once you added the AES encryption, then it became WPA2. And that was really what was advocated, if you will, for enterprise solutions. And that helped the technology move into mainstream as well.

Redelfs: Lots of moving parts going on.

Abramowitz: Many moving parts with lots of different players. The semiconductor vendors said, at this point, kind of settling out right, where you now have a Broadcom, Atheros, Marvell world with Intersil and TI kind of getting left out, and Proxim who had proposed all the technology for first OpenAir then HomeRF, getting completely sidelined. In fact, I think they went under.

So the bets were big bets. And those who bet right did well, and those who bet wrong, I mean, you could bet wrong and lose everything.

Redelfs: And Lucent ended up acquired by Proxim, who were the old HomeRF guys.

Abramowitz: That's exactly right. Before they went--

Redelfs: Before they went bankrupt.

Abramowitz: --bankrupt, they bought Lucent. So that was unfortunate. I mean, the industry just started changing so much that it's sometimes hard. I think that's a lesson in industry evolution, where you have the folks who really built the foundation and understand the technology. And then things start to move so fast that it's not-- that part's not what's relevant. It's, well, what can you do on top of it?

Redelfs: So you talked a little bit about Cisco, one of the really big companies getting into it. You've talked about Apple a little bit too. The other 800-pound gorilla that got into this was Intel and their Centrino which was a bundle of, originally, the graphics chip, and the processor, and Wi-Fi.

Abramowitz: Yeah.

Redelfs: And I remember talking with one editor who said, you know, now that the Wi-Fi is built into the processor? I said, it's not built in. But they're marketing was so strong that people thought it was all in a

single die, rather than being separate die which they originally bought from TI and doing it as a marketing bundle. They really misled the press on that.

Talk how you think Centrino and Apple and some of these other players influenced the industry. I mean, I've talked to people who felt like without Centrino it would have happened much, much slower. Other people give Apple the credit for making it happen quickly. What's your perspective on sort of the accelerators?

Abramowitz: I think Intel was absolutely positively an accelerator. They invested a lot of money in a variety of different areas. I mean, they did some harm by also investing in HomeRF, and in Bluetooth, and--

Redelfs: They had given it up by Centrino.

Abramowitz: I think some of the Bluetooth stuff was still out there when they were doing Centrino. What was good for the industry as a whole about Intel was they were spending dollars in a Wi-Fi direction, whether that was investing. I forgot what hotspot company they invested. Intel capital was investing in different players and building out the ecosystem. And they certainly caused a lot of consternation, obviously, at 3Com, thinking about, well, how are we going to compete with them longer term? Broadcom, in terms of, well, how are we going to sell to the PC vendors, Atheros, the same thing, right? It forced us to be on a very aggressive technology development cycle.

Redelfs: Because they were basically giving the Wi-Fi away for free.

Abramowitz: They were giving the Wi-Fi away for free. That's exactly--

Redelfs: So how did you and Broadcom compete with that?

Abramowitz: Well, the same way Atheros competed, staying a step ahead technology-wise. So what happened was Intel bet big on 802.11a. When they finally introduced Centrino-- remember this. They introduced Centrino about the same time we introduced 802.11g. So you have Intel putting the brakes on.

The big huge message from the industry was, geez, not certified yet so don't go there. Don't go there. And part of that was that Intel had finally gotten their wireless chipset out. And it was 802.11b. And here we were going to all the PC vendors. Then you were going to the PC vendors saying, hey, "you get this next generation technology. But you've got to buy it from us."

And Intel's saying, well, you could have it from us in a year's time. So it really created this technology war, which at the end of the day is good for the industry. But that's really what we did. We tried to stay ahead. We tried to stay ahead with the core technology then we added range extensions. You guys added-- I'll get into 108, the Super g, -- that was brilliant, that strategy. We countered with our 125 high speed mode. And Intel's just sitting there--

Redelfs: With b.

Abramowitz: With b.

Redelfs: When it was free. And free's hard to compete with.

Abramowitz: It was hard to compete with, I think, on the low end. But for folks that wanted to differentiate on performance, for folks that wanted to keep up with Apple, right? You needed "g", or you needed "a". And then people did look at, well, what's the performance of the solution that's embedded in the laptop? And competition-- and the other thing that happens with Wi-Fi that didn't happen in the ethernet space is it's not just about the chipset -- now you have worry about, well, what's the antenna that's embedded in the laptop? And how do you differentiate based on that? So there were multiple levers, if you will, for vendors to potentially differentiate on.

Weber: And what percent of the market was laptops in this era?

Abramowitz: At that point in time-- well, so I haven't defined a point in time. The industry, it's kind of interesting, because in the 1999-2000 timeframe, people are still putting in infrastructure. It's the executives that have Wi-Fi. It's not all the laptops that have Wi-Fi. Home routers really started to happen-- they started to happen in 2000 to some degree. That some of the 1M to 5M growth. But they break out, again, was with "g" in 2003, is when home Wi-Fi really started to happen.

So I think Centrino was the switch where people said, I can't have a laptop without Wi-Fi or at least without a Wi-Fi option. And that's probably when Wi-Fi in laptops started to become prevalent.

Redelfs: And it started as PCMCIA cards, which were those credit card sized things that slid in the side of laptops at the time. And you had a little flip up antenna, which often got broken off. And actually back at 3Com, we had developed something called mini-PCI, which was an internal standard daughter card for laptops. And the interesting thing is originally that was for modems and ethernet. But very quickly we had to figure out how you put an antenna on that. And the laptop guys didn't know RF. So one of the things I think Atheros and Broadcom did well is educate them on RF and how to put an antenna in a laptop.

Abramowitz: Yeah. Yeah but, that too was-- the notion of "anything for the customer", which was part of the culture at Broadcom and part of the culture at Atheros. Intersil was a spin off of Harris, which was a defense subcontractor. So there was kind of a different [approach]—"wait, you want us to help you with your antenna?"

Redelfs: We'll do a study then charge you for it, right?

Abramowitz: It wasn't quite the same. So again, the industry had shifted. And what Broadcom did particularly well was say, OK, these are the applications that are going to be large. These are the customers that we think can reach those large applications. And we're going to do everything we can to make those customers successful. So at that point, mid-2000s, it's cards. It's increasingly the routers. And it's starting to be phones.

So in 2003, we did the first single chip Wi-Fi at Broadcom, which seemed like, oh wow, this is going to be great. And we actually put it in the Sony version of the Palm Pilot. It was going to be the first Palm Pilot with Wi-Fi connectivity. And unfortunately, I don't think that product ever came to market. And so what looked like it was going to be—well it was the harbinger of things to come -- but it actually wasn't successful.

Weber: The Palm Treo, right?

Abramowitz: No, the Palm--

Weber: Oh, with a real Pilot, OK.

Abramowitz: The real Pilot, yeah.

Redelfs: They did an ODM deal with Sony--

Weber: OK.

Redelfs: --which also was at 3Com back in the day.

Abramowitz: That's true.

Redelfs: Great. So fill us in. So you left Broadcom then. And what caused that change?

Abramowitz: Well, the biggest issue was that-- again, this is a family issue. I'm from the East coast, my wife's from the East coast and my wife's father was not doing well. So she wanted to move East. But I actually sat down with you and had breakfast, and told you I was thinking about leaving Broadcom. We wanted to move to the East coast. And you said, well, I'm on the board of [Azimuth],a [test equipment] company in Boston.

Talk about coincidence, by the way. The CEO of Azimuth, Ray Cronin, and I had sat next to each other on a plane flight just a few months earlier. So he had told me about the company. And I told him I didn't think there was a business in Wi-Fi test equipment. And he had told me why he thought there was. And you told me why they thought there was.

But so it seemed like a good opportunity, for a couple of reasons. Broadcom used their equipment. I knew Atheros used their equipment. I knew Intel used their equipment. And Apple used their equipment. And they were working on getting certified to automate the Wi-Fi Alliance test procedure. And obviously everybody was building Wi-Fi solutions. So automated testing for Wi-Fi seemed like a good idea.

Cisco had their own proprietary technology to allow better performance between Cisco adapters and Cisco approved adapters, [called] CCX adapters, and Cisco infrastructure. And we had automated a test for that – or [I should say] Azimuth was, at the time, I guess working on that. So testing was not something that was really well understood in the wireless space but had good potential.

And I remember one of the observations was, well, the networking industry tests rigorously. The cellular industry tests rigorously. The Wi-Fi industry, as evidenced by what happened with some interoperability testing for 802.11g, well, the system vendors don't necessarily test that much.

Redelfs: Kind of rolling around on a cart in an office to see where you drop the connection.

Abramowitz: And the other thing was there was tremendous reliance on the semiconductor vendors, which gave the semiconductor vendors a lot of power. But it just seemed like that dynamic might shift. So I went to go promote testing -- oh by the way 802.11n was coming, and the dynamics in "n" were you had this one startup company, Airgo, that had their own proprietary MIMO technology out in the market well in advance of when the standard was even close to being completed. Then you had competing standards within [the IEEE for] 802.11n. We can talk a little about that.

But there really was a likelihood that n products were going to have a problem when they first came out. The Wi-Fi Alliance was going to go as fast as they could to get approval of "n" products. But you knew that folks were going to try and jump the gun particularly in the consumer space. And so the idea was Azimuth could be there to help provide equipment to really advance the industry faster.

So ex-post it didn't happen. Vendors continued to rely on the semiconductor vendors to do their testing. I remember that to hedge their bets, Netgear -- who wanted to be first to market because they weren't first to market on "g" -- they bought chips from-- I don't remember whether it was Atheros and Marvell or Broadcom -- but it was two different vendors. And they actually had two different product lines that didn't interoperate with each other. So Netgear had two products on the shelf that originally didn't work together. And we had anticipated that they might have a problem. We tried to sell them test equipment. And they would have none of it. Their story was, well, the semiconductor vendors will figure it out. Or ultimately, the Wi-Fi Alliance will take care of it. But we're not going to get in the business of actually testing our products. [LAUGHS]

Redelfs: That's called the low overhead model. It worked for them.

Abramowitz: Yeah, it does.

Redelfs: That's great.

Abramowitz: And you caught that on tape.

Redelfs: Azimuth is a good example of some of the ecosystem companies that were really popping up around this time as well. You mentioned before some of the point of presence, the Boingos, and stuff like that. Were there others that kind of come to mind that popped up around this time really enabling the industry?

Abramowitz: There were mesh companies. There were, I remember, Instant802 was going to license open source access point code. Well, they changed to Devicescape, and now they're actually successful mobile phone software company. So that was a successful pivot.

Boy, I don't know. The ones that were successful got purchased. So now I'll struggle to think of who--

Redelfs: There were the hotspot guys who did the hotels. There was the metro Wi-Fi kind of guys.

Abramowitz: Yeah.

Redelfs: Quite a bit of explosion of Wi-Fi everywhere.

Abramowitz: Well, once it became clear that Wi-Fi could be everywhere, people tried to [leverage that] -- and it's going on today. I mean, if you look at what's happening now with Wi-Fi, it's just remarkable. I talked about going from 1 million to 5 million chips in 2000. The other benchmark number I have is it was like 50 million chips by 2004, 2005. It's supposed to be 7 billion next year. The market has just truly gone nonlinear.

Redelfs: And I read somewhere the crossover of Wi-Fi with Ethernet happened actually a year or two ago.

Abramowitz: Wow.

Redelfs: There's actually more Wi-Fi chips now than ethernet chips.

Abramowitz: Ubiquity is the name of the game. And I think so that's great for the consumer, because now you have what the original vision was back in the hype days of 1990 to 1995, where wireless is going to be everywhere. It is. And it's cheap. And you can put it in devices in the home. You can put it in devices in the enterprise. You can now farm out the smarts of what needs to happen to the cloud. So you can bring down the cost of the nodes that are part of the infrastructure. And that increases the possibilities.

Redelfs: So that leads to your most recent venture, your own startup company. Why don't you talk a little bit about that, how that got started, and the whole lot intersection of Wi-Fi and the cloud.

Abramowitz: Yeah, so, this was another one [where someone found me due to an industry event]. I guess I have to talk at [industry] events more often. I was at an event for Azimuth talking about Voice-Over-IP and I was already on my way out [of Azimuth] but they asked me to do the talk. And I wound up meeting the director of business development for Xerox PARC. And they had some technology-- it was mesh networking technology-- that they thought might be valuable enough to start a company around. And they had a program called Startups at PARC.

So he told me a little bit about it [their plan for a startup]. And I said, I don't think it's going to work. He said, well, he wasn't actually asking me whether I thought it was going to work. He was asking me if I knew a vice president of engineering that they could hire. [LAUGHS] But he listened to me. And he said, can you come in and talk about why you think it won't work?

So we had lunch and they wound up hiring me first as a contractor to figure out, well - if our idea is not going to work, what might work? And we came up with a bunch of ideas. I wrote a business plan for the one that seemed to be the best one.

And it involved taking the technology that PARC had developed in mesh, taking the technology that they'd done with regard to security and ease of use. They'd had a program called network in a box that had patents back from 2004 to make it possible to ship a small business-- this will sound familiar, because it's one of the dreams at 3Com -- just ship the small business a kit. They can unload it and everything works. The PCs work. the networks work, et cetera and then they obviously had some ease of use, because PARC is known for that.

So they liked the business plan I wrote. They hired me as an entrepreneur-in-residence. I hire a team. I went out to VCs like Foundation Capital. The original plan for the company that became PowerCloud was to do a full end-to-end hardware plus cloud solution to manage those infrastructure devices from the cloud. And it probably would have been successful save for timing. We tried to get funding in October of 2008, just before the market crashed but then after the market crash, there was not a lot of money to be had. We wound up doing a pilot with a major service provider, coming back out, trying to get funding. That didn't work. And so I tried to sell this cloud managed network technology to vendors in the space. And you can imagine--

Redelfs: As a licensing--

Abramowitz: As a licensing-- no, no, no. Actually sell what we'd done.

Redelfs: Sell the company.

Abramowitz: Sell the company. And people said cloud managed networking, mmm. Sounds really interesting. If you guys decide to license the technology, we're interested. But I don't think we want to buy the company.

I took that feedback and rewrote the business plan to basically sell software to hardware vendors. I struck a deal with D-Link, then Zyxel, then a small company out of Canada and got funded as an OEM software company to do cloud managed networking to small business.

Now ultimately, Meraki, which had started as a mesh networking company, added cloud, did the cloud managed networking, you know, and got bought by Cisco for $1.2 billion. So we should come back and talk a little bit about Cisco and the market, because they've done an admirable job of--

Redelfs: Acquiring.

Abramowitz: Of acquiring, strategic acquiring, in the direction that they thought the market was going and calling it right. And I think they did that with Meraki and it's worked out well for them.

For PowerCloud, so we did cloud managed networking for business. We were looking for larger [OEM vendors/] customers but larger customers by and large want to do things themselves. So we pivoted. We wound up taking our [cloud managed networking] solution-- this is actually interesting in terms of where the market is headed -- and we built a consumer router that allowed visibility control in the home, better than anybody out there. We did a Kickstarter project to prove to our investors that this was a product that people wanted.

Redelfs: This was the Skydog product.

Abramowitz: So Skydog was successful -- top 1% of Kickstarter ventures. And then we launched it on Amazon and wound up -- out of 3600 routers you could buy on Amazon -- the highest rated dual-band and the second highest rated router overall, before Comcast bought the company with the goal of taking the features and functionality in Skydog and taking the platform and being able to deliver that to their larger customer base.

Redelfs: Interesting, because Comcast originally said, look, we're going to bring the cable to your home. And we're drawing the line there. We're not getting into the home distribution side. I remember having meetings with the Cable Labs folks, and the whole industry said--

Abramowitz: Not going there.

Redelfs: Hard line here. We're not going there. We're not going to be responsible for RF interference in somebody's home and trying to support that. It sounds like Comcast has really changed their mind on that. Could you talk about that?

Abramowitz: Sure, I think the whole-- I mean, the industry's changed its mind. The recognition is that wireless connectivity is what the end customer wants. We can go all the way back to the studies in 1994. People would prefer to be-- wired versus unwired, people preferred to be unwired. In some places, there's no other way to do it. Your mobile phone's not going to have a cable connector.

And they're looking for ways to provide features and functionality to their customers. They're going to make them sticky. And Wi-Fi increasingly is a way to do that. And then it becomes a little less about the core technology and little bit more about what sits on top of that technology, the software to make things easier to use for the end customer, the software that makes it easier for the guys back at the head end to manage the whole system. And so again, back to this ecosystem notion, where now it's not just the chip

vendors that are making money. But it's the software vendors that are selling management solutions or cloud management solutions to make the products better and more effective.

Redelfs: So big changes there.

Abramowitz: Yeah.

Redelfs: So you mention the 7 billion number. That's probably a good question to close on. The changes happening in the industry today with Comcast getting into the business now and trying to put it in everybody's home whether they want it or not, because it's going to be bundled with the cable modem, and the 7 billion number that's in all our cellphone handsets, where do you see it going? I mean, Internet of Things gets you excited?

Abramowitz: Absolutely. No, I think--

Redelfs: Specific areas there, because that's sort of a catch all phrase?

Abramowitz: It is a catch all-- right, anything that's connected to the internet is an internet of things, which is really true. But that is where it's headed, and Wi-Fi as a true connectivity standard that has been driven down in cost and, by the way, people have come up with low power versions of Wi-Fi as well. It's still interoperable. So what you now have is this technology that can be embedded in everything from refrigerators, to cars, to coffee machines, to obviously Nest thermostats.

And people can, to the extent that they want to, control different aspects of their life by having the connectivity in their home, outside the home, and then you have it all visible on their cell phone.

Redelfs: So the Internet of Things, though, can be, like you said, anything connected to the internet. It could be connected cellular. It can be connected Bluetooth. ZigBee's another one that sort of has associated themselves with Internet of Things, particularly in the home. Who's the big winner? Is it Wi-Fi? Is it all of the above? Is it going to fragment by different types of applications?

Abramowitz: So I think the main winner's actually Wi-Fi. I think that the infrastructure's there. The big players are there. The key problem is-- power would be the key dilemma. If you can't get truly low power in the device, then maybe an alternate technology winds up having its own niche in the market. But people aren't going to put anything other than Wi-Fi-- well, Bluetooth for the headset, obviously-- but Wi-Fi in cars, as an example, or in a refrigerator, or in a coffee maker, it just makes too much sense to build that in.

And again, there's so much infrastructure to support that, whether it's the vendors who can show these guys how to make it happen, or the taking of the information all way back to the cloud and being able to tie that in with other information, with other devices that are in the house. I think the Wi-Fi industry really was poised to take the maximum advantage of it.

Redelfs: And any wireless protocol has its trade offs. Wi-Fi tends to get picked on by its competitors. It's too high power. People always want it faster. There are trade offs between range, and distance, and power. But power, it tends to be where it gets hammered most there, some with ease of use, the whole BSSID thing is not real user friendly. And security, I think, has been an issue. It's less of an issue now, but it still comes up. Any of these that you see as real limiting or you think--

Abramowitz: No, I think they are--

Redelfs: --the IEEE and all will fix these?

Abramowitz: Not necessarily the IEEE. But I'm now independent. I'm talking to companies. I know you talk to companies too. And I see folks understand where the gaps are. And there's enough of a market, enough of an opportunity for folks to figure out technical solutions or business solutions to fill those gaps. So I'm confident that that will happen. It may take time. I may take longer time than you or I would like. But I think ease of use issues can be dealt with. I think security issues can be dealt with. I think the speed at this point is adequate for just about anything people can come up with. And so I think it's still the golden age of the Wi-Fi.

Redelfs: Great. You know, it's interesting, a few years ago, one of the things you would hear is mobile first for applications. Because initially applications were developed for PCs, and then the mobile application was an afterthought porting. And then there was this big trend to mobile first, where people would develop the mobile application, and then maybe later do the PC version.

We're starting to hear this phrase, "Wi-Fi first," that your cellular phone will be Wi-Fi connected first and cellular second. Any thoughts? Is that really going to happen? Or is Wi-FI going to be so ubiquitous that cellular becomes less important or less necessary?

Abramowitz: Well, for a cable provider-- for some service providers, the answer is an absolute yes. For the guys with mobile infrastructure, they probably want the Wi-Fi for offloading. But they don't necessarily want Wi-Fi to be first. So I'm not sure who wins in that big war, but there's no question that every phone has Wi-Fi or needs to have Wi-Fi in this day and age.

Redelfs: And that's a lot of phones.

Abramowitz: That's an awful lot of phones.

Redelfs: Close to half your 7 billion.

Abramowitz: Yeah.

Redelfs: Great.

Weber: Ad hoc networking has sort of been in the wings for many years. And I know that's possible with Wi-Fi, correct?

Abramowitz: Yes.

Weber: But where do see that going, if anywhere?

Abramowitz: So I've actually done it. It's not something that I necessarily track into much detail. Because I think that it's an application that folks will figure out how to do based on the silicon that's out there. I think it's a user issue that can get solved over time, based on the application people want to do.

Weber: Great.

Redelfs: Any other thoughts for where Wi-Fi goes in the future? Anything that you--

Abramowitz: Well, I think you're going to see, obviously-- I started a cloud managed networking company – so I think you're going to see more and more leveraging the cloud. Not that you won't still have to have device on premise. So enterprises will still likely have a hybrid. And you'll always have something in the home. But increasingly, you're going to take advantage of the processing power of the cloud, the ease of use, the ability to be mobile in your knowledge what's going on with whatever devices connected. So I just see more and more clever uses and applications of Wi-Fi in the future.

Redelfs: Great, so do you-- go ahead.

Abramowitz: Well, I was going to say, the other thing, it's just really remarkable, the industry as a whole has just grown tremendously. As I was thinking about this interview, you look back over time and say, wow. How did we get here? And it's fascinating.

We wouldn't be here without the standard, obviously. We wouldn't be here without the Wi-Fi Alliance, because you really needed that interoperability testing. But then it's not just about organizations.

It's actually about the people that really made things happen in those organizations. And you look back and you say, you know, it's interesting that a lot of people in the Wi-Fi industry have recirculated over time. And they are smart people. They are good people. They tend to be quirky -- particularly early on. But it's been a great industry from the standpoint of people seeing the vision, grabbing onto it, and wanting to be part of it, wanting to advance the industry.

So you really have just, in retrospect, kind of an ideal mix of the standards bodies-- by the way, even the FCC-- you have the standards bodies, the government organizations, the marketing or business organizations, the people pushing it, and then good old fashioned capitalism thrown on top, where people realize that maybe at the end of the day, expanding the pie and getting a bigger piece of that pie is better than trying to own our own smaller pie. And I think if you think back in the early days, everybody wanted their own little chunk. And what's actually wound up happening is probably the best possible outcome where you do have this industry standard. You do have folks all working towards that that common goal and great things have resulted.

Redelfs: Any other-- you mentioned FCC and futures, anything like 60 gigahertz get you excited? New unlicensed spectrum that Wi-Fi Alliance is adopting?

Abramowitz: I have not had the time and to spend energy there yet.

Redelfs: Yeah, great. So how about for Jeff Abramowitz? What's next for you? You've been a Wi-Fi guy since the early days. You going to try to stay in that?

Abramowitz: Hard to believe that I wouldn't stay connected. In the near term, I am working with the Center for Entrepreneurial Studies at Stanford and actually lecturing back at my original alma mater, Penn in the entrepreneurship course there. But then I'm working with, boy at this point, it's probably eight to 10 different companies that are in various stages and just trying to figure out, well, what's the next big thing? And how can I potentially help?

Redelfs: Great.

So Jeff, let's talk a little bit about the applications over time. In the early days of Wi-Fi, you know, when it was Symbol, and--

Abramowitz: Proxim, Intermec --

Redelfs: And some of these guys.

Abramowitz: Yes.

Redelfs: What were the applications? Who were the customers for this? What were they doing?

Abramowitz: Mostly vertical market opportunities.

Redelfs: Like what kind of vertical market?

Abramowitz: Everything-- inventory management, trying to put something in a warehouse and having some basic tracking capability. Or I remember NCR was actually wireless cash registers, I think, was where they were headed. And manufacturing floor was trying to figure out with things that were high value and wanted to stay connected to what the devices were or some information from those devices. I think it was much more, again, vertical market. It was completely vertical market driven.

I know early on, NCR tried to do or maybe did a deployment at Carnegie Mellon as part of a push in education, kind of how could this be mainstream? But the adapters, most of the adapters were desktop adapters. And the mobile adaptors would have this big device. So you had big, bulky laptops. And you'd have to attach not just a PCMCIA card, but a PCMCIA card to an external radio. So really early stuff was mostly fixed like the manufacturing floor.

And then as you could build those antennas, et cetera, into the bar code scanners, then Symbol was able to take advantage of that. Or Proxim or Intermec were able to take advantage of that. So that was the '93, '94, '95 timeframe.

Redelfs: And Proxim got into the using Wi-Fi and proprietary radios across the street. Was sort of a--

Abramowitz: There was a--

Redelfs: A campus connectivity, more of a router type of thing than--

Abramowitz: Really a point to point wireless. I didn't go into this, but that was the bulk of No Wires Needed's business, was actually point to point, basically taking an access point, pointing at another

access point in order to connect to a different building. It's never really been a huge business. It's always been large enough to make money and cheap enough to be worthwhile. But it's not really considered Wi-Fi, because it's not really point to multipoint. People to use Wi-Fi because that's the cheapest technology available.

So then in the late '90s, laptop computers [use] rose significantly. The application really became connectivity to corporate infrastructure primarily for business purposes. But then as you mentioned, as broadband came to the home, and they came to a specific part in the home, how do you share that internet access with everybody in the home, whether it's a mobile or fixed device. And that's really where I think the first wave of large growth, or second wave of large growth, happened.

And then actually we didn't talk about this previously, but in the 2003, 2004 timeframe, [at Broadcom] we did a specific chipset with the USB interface, so that we could go in all printers and opened up that market. And they were the single chips and the desire to build into phones, which is why Qualcomm bought Atheros. And that's obviously, given another huge boost to Wi-Fi connectivity.

Now that you have incredibly low cost mobile Wi-Fi, it can go in anything from a thermostat to an automobile. And so there are a fair number of cars that now have Wi-Fi built in. And folks I think they have it built in but haven't necessarily turned it on, because they haven't figured out what they're going to do with it. But I would expect, like in the next year or two, you're going to hear all about Wi-Fi in automobiles. So there's just application after application where things that make sense to get connected to the internet are going to use Wi-Fi to do that.

Redelfs: That's great. It reminds me back in 2001 at Atheros we did a promotional video with Mercedes on future connectivity. And it actually showed a Wi-Fi connected car back in 2001. So it's now happening.

Abramowitz: Oh, it's definitely-- my car has Wi-Fi.

Weber: And in the late '90s when business users were on Wi-Fi, there would be executives or technical people with a need.

Abramowitz: Well, so I think-- it's tough to know exactly. Companies like Microsoft would go full campus. Or a Cisco would go whole campus.

Weber: But it was laptops.

Abramowitz: It was laptops. People had to have laptops.

Redelfs: So conference rooms is where it started.

Abramowitz: That's correct.

Redelfs: And then people realized, geez, I'm moving cubicles around all the time. And why do I have somebody re-string the Ethernet when I move my cubicle configuration? Let's just put access points in ceilings, and everybody can connect wirelessly everywhere.

Abramowitz: Yeah.

Weber: And then the Apple's Airport, obviously, was named after airports. But how public shared spaces, where those important, or is that still a tiny part of the market?

Abramowitz: That actually-- so interestingly, it's finally becoming a bigger part of the market. It really was a huge push with part of the Centrino campaign was hotspots back in 2003, 2004. I remember when Centrino had a two part logo that had Centrino and Wi-Fi hotspot -- and arguing at the Wi-Fi Alliance meeting that that was a misuse of the Wi-Fi logo. Because it was really a Centrino promotion, but the alliance was so excited about having Wi-Fi logos everywhere they were thinking about what the actual marketing message was.

Redelfs: And if I remember, they spend $1 billion on promoting Centrino. That number sticks in my head. So it was significant.

Abramowitz: It was--

Redelfs: A significant budget.

Abramowitz: But the hope was-- and there was a company called Wayport that got bought by AT&T. There were some other folks that were doing public access Wi-Fi. The economics just didn't quite work. And now it does because whether it's cable companies looking to create stickiness for their home users or cellular providers looking to have mobile offload, or there's just a variety of reasons to have public hotspots. They really make economic sense.

Redelfs: Right, and the Starbucks coffee was a big deal too, they did it with AT&T, if I remember.

Abramowitz: They originally did it with AT&T. That's absolutely true.

Redelfs: And that was another one of the big breakthroughs of making free public Wi-Fi available.

Weber: And hotels were huge early on.

Redelfs: Yeah, but the hotels started charging an arm and a leg initially for it. It was $20 a night. And when you're staying at $100 a night hotel that seemed a bit of a ripoff.

Abramowitz: Yeah, the whole hotel-- we focus at PowerCloud, we wound up doing some studies on hospitality. Because what you wound up with is hotels either would put in enterprise infrastructure to guarantee high performance for their users but then have to charge customers for it. Or they'd put in consumer access points and give it for free. [LAUGHS] And so you wind up with this-- and by the way, it was the same opportunity that we saw in small business, where small businesses either pay for enterprise infrastructure or they go with the consumer solution. Mostly they'd go with the consumer solution.

And what we saw at PowerCloud was the opportunity to leverage what was pretty powerful consumer hardware, give it features and functionality from the cloud, so you had the same cost point. But now you can actually do some of the more interesting things and do it at an attractive price. So there is this fill in the middle, which I think there's still a gap for small business going to Wi-Fi that's rapidly getting filled with lower cost infrastructure solutions, cloud managed solutions, that are built on these low cost chipsets that were originally destined for a consumer.

Redelfs: It's interesting too, because Wi-Fi in laptops went from zero attach rate to 99% in a very short amount of time. And part of it was driven by the desire for thinner laptops and the Ethernet physical connector forced some restrictions on the "z" thickness of the laptop. And in fact, most laptops today have no wired Ethernet at all.

Abramowitz: Yes. Which is--

Redelfs: It's fascinating.

Abramowitz: It is.

Redelfs: Great. Well, thanks again, Jeff.

Abramowitz: Thank you.

Weber: Thank you both.

Redelfs: Sure.

Weber: It was really wonderful.

Redelfs: Yeah.

END OF INTERVIEW