Oral History of Edmund Cheng

Interviewed by:
Douglas Fairbairn

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Doug Fairbairn: We're here at the Computer History Museum. It is March 10, 2014. My name is Doug Fairbairn. And I'm here talking with Ed Cheng. Welcome Ed. Thank you for joining us.

Edmund Cheng: Thank you.

Fairbairn: OK so Ed, as we were talking before, we'd like to go back and talk a little bit about your early family life, where you were born, where you grew up, what was the influence of your parents, did you have brothers and sisters who might have influenced? So let's just start with that. Where were you born and where did you grow up?

Cheng: I was born in Hong Kong. And I grew up in Hong Kong. I was in Hong Kong until after high school. And I came over to the US to pursue college.

Fairbairn: So what was your early family life? What kind of living situation? Did you have brothers and sisters? What were your parents engaged in, and did that influence you significantly?

Cheng: So a little background. I was born in the year-- well, my parents left Shanghai to move to Hong Kong basically as refugees, war refugees, because the year I was born, there was civil war going on. And the city was under war conditions, and in fact the control did change hands right about that time, and you know this.

Fairbairn: So what year did they leave Shanghai?

Cheng: '49. And because I was born right around that time, my mother was-- need to not be in a war zone, as you can imagine. So it was that. So Hong Kong was a rapidly growing, almost like bloating type of refugee city at the time, because there was a huge influx of-- It's a British colony, and so it was a little bit of a haven from the Civil War, because it's a little bit shielded from that. And so it attracted a lot of people.

Fairbairn: It was chaotic, I presume.

Cheng: I suppose, yes. I was too small to know. So I suppose it was similar situation like in Taiwan right about that time. And it's just the luck of the draw that my parents ended up in Hong Kong. And because of my timing, seems like everything I hit in my growing up life, we were at the sort of-- I guess in the US, you call it the baby boom, right-- so we were at the way front of a lot of things.

So the demand for resources, always very difficult, very tight. Things like school, and so forth. However, my parents instilled a lot of value to all of us. We have four kids in the family. And as far as academics and subjects go, something you would expect from Asian parents, I suppose.

Fairbairn: What did your father and mother do before they immigrated? And what did they end up doing one they got to Hong Kong?

Cheng: Both my parents' college education was disrupted by events in the World War II. So they were kind of-- and eventually, my dad had a job with Pan Am-- Pan American World Airways. So it turned out to give me a lot of exposure into the United States. It's an American airline, right, so I got some exposure into the United States through that.

And when I was small, I think typically like a future engineer, I was curious about mechanical things. And then in a city like that, I had a lot of opportunity to just stand around and watch how people pour concrete, for example. It's very fascinating, look at how they did the rebars and so forth. And also, these auto mechanic shops-- space is very tight, so people actually do work lots of places that you would not expect kids to be, but I had the opportunity to observe how people take apart engines and put them back together and so forth.

And eventually, I started to discover electrical things. And I had the chance of to learn about-- basically from reading a lot of books, used books. I happened to come across some used books on World War II era type of radio constructions. So I went through that route, and started to get up to become quite proficient with building tube-type radios.

Fairbairn: So you actually built electronic radios and so forth?

Cheng: Yeah.

Fairbairn: And did your parents have any knowledge in that area, or they just encouraged you to do whatever you were doing?

Cheng: No, they did not have any knowledge in that area. But they did not stop me. We did not have a lot of resources. But they thought it was not a bad thing. And so, in high school I became-- I started the electronics club, volunteered to help with taking care of electronic issues at the school, like simple things, you know. This is just a high school, right? But they still needed PAMs and so forth. So I ended up doing a lot of what you might call technician-type duties, running around backstage.

That eventually opened a door for me. When I was in between the junior and senior year in high school, I had the opportunity to-- this is 1967 now. And Fairchild [Semiconductor] has already set up a fairly large assembly plant in Hong Kong. And there was a new company called Sylvania, which was at that time part of GTE, also followed their footsteps to start up a new transistor assembly plant. I didn't know anything about that stuff. I had no idea what company-- what all those names meant. And so I picked the one that was closer to my home.

And I worked at Sylvania in the summertime. And they needed some help, because they were just starting new. And they found that I could actually do-- maintain their curve tracers, and all that kind of stuff, do calibration work and so forth. Bonders. There was a lot of calibration stuff going on in these factories, because the thermocouples constantly need to be calibrated.

Fairbairn: So you had learned English in school? As a British colony did they teach English as sort of standard--

Cheng: As a foreign language. So it's a second language. So I know some grammar and so forth, but it was far from being proficient, as you can imagine.

Fairbairn: So when you went to work at Sylvania, was that in English or in Chinese?

Cheng: I would say it's 99% in Chinese. There were only a very small number of expats. They came from Boston area. The mother plant was in-- somewhere. Woburn, I think.

Fairbairn: All right, go ahead. So you ended up working there as a summer job, or also during the school year as well?

Cheng: No, just summer job. And then, that's in my senior year, I start thinking about what to do afterwards. And I kind of like electronics, and I was pretty good at it. But the University of Hong Kong has very limited room, basically.

So somehow, again, just by random chance, I learned about quite a few universities in the US. And one of them that I applied to actually offered me a scholarship, and that was Ohio University. So that's how I ended up there. They also offer and electrical engineering program. Very naive back then, at that time.

And I have no clue-- it turns out that it was a kind of-- the school offered a lot of emphasis on the motors, generators, stuff like that, because power industry is important in that area. I found out that, in fact, there was a lot of strip mining going on. There's a lot of power plants. But they also were starting to move into offering electronic classes in transistors based type of circuitry, and so forth. So it worked out to be pretty good.

Fairbairn: So what was it like? Had you ever left Hong Kong before? And what was it like going up the United States and Ohio? And tell me about that experience.

Cheng: It's a huge cultural shock. Never left Hong Kong, even a step. Hong Kong is kind of landlocked, because it was sort of like an island.

Fairbairn: Incredibly dense population.

Cheng: Incredibly dense population. And then I was kind of like parachuted into a semi-rural environment. So it was a big shock in every which way.

Fairbairn: And was that sort of a happy experience? Were you depressed? What was exciting? What was the--

Cheng: No. I was very, very happy during the college years. So I hit it off very well with my teachers, professors. And so they took care of me pretty well.

Fairbairn: Your English had gotten significantly better by this time, or you sort of learned it is you went?

Cheng: So one of the fortuitous things that happened with me is-- you remember that I mentioned that I came on a scholarship, which meant that I get to stay in a dorm. A lot of foreign students find lower cost housing than the dorms. They tend to live together in apartments and then they then talk to each other in their mother tongue again, whereas I was truly parachuted into a very American environment.

And so I was in the dorms. And dorm life was very eye-opening. For one, I get to practice this English language, or the American flavor of the English language 24/7. So I picked up an American accent, if you haven't noticed. And I also got to-- I think the professors kind of took a liking to me, and they trusted me with a lot of things. So I got to do a lot of things in the EE department fairly early on.

Fairbairn: They figured out quickly that you were pretty bright.

Cheng: I guess.

Fairbairn: So how did you-- you started out in electrical engineering, and you got a bachelor's. Any significant projects, or programs, or professors who influenced your direction while there?

Cheng: So looking back, I tried to take a lot-- I took a lot of courses in math and physics in addition to EE. Because for me, EE classes were pretty easy, because I already had very good understanding, but without the math. I knew about radios and so forth. So when I started to connect to the math, and I was able to catch on to like a lot of these, like for example, frequency domain type of concept and so forth, came very quickly to me.

But looking back, we had at that time, a brand new IBM System/360 Model 44 computer, which by today's standards is a very minimal machine. But the important thing was that it had the FORTRAN IV Level G, I believe, compiler. And that's the only thing that I actually got to use, because I would never touch that JCL stuff.

The way that-- well, they did not have the problem of students overusing the computer. Most students would not go near there. So I was sort of the outlier. So I never hit any bounds on what I can and cannot do there. So I would be there a lot. And I started to just experiment or play around. It became a big toy.

Fairbairn: So you weren't taking classes. It was just your own initiative. And what kinds of programs were you writing?

Cheng: Whatever that struck my fancy, because I would just look at some books, and look at some things that they were doing, and I would say, hmm, I wonder how they did that. And I'd just try it, and kept-- so I ended up, I think, spending a lot of time on-- it was very beneficial to me later on. Because I started to get a flavor for how stubborn these programs can be, and how unforgiving, all the brute force type of debugging was--

Fairbairn: Just punch cards and--

Cheng: Oh, absolutely. Back then it was just nothing but punch cards, yes. So in my senior year-- well, one thing that was just very nice at Ohio University was that it was one of the Center of Excellence that FAA uses to do some of their avionics development and research.

So there was a project going on at the time. Well, the C-5A was already deployed. And Instrument landing systems. I don't know, ILS and the localizer. They were all antennas, arrays, and systems that you put around the runway. And the frequency range of those systems were such that if you have large metal surfaces near there, there was some concern about whether the antenna profiles would be significantly affected, which would not be good, because if you have a plane parked next to the antennas, what happens to another plane coming in?

So there was somebody else doing-- it was a grad student that was doing his thesis on the instrument landing system. So one of the professors said, hey since you-- since I noticed that you have all-- I've logged a lot of time on the computer. Apparently the professors do notice that, unbeknownst to me. And he said, why don't you see if you can extend that and get the localizer.

And so then I had a real bona fide reason to do things, which also allowed me to have a much bigger account, which means that I can run bigger jobs. That was very good, because that was my first real experience in building a piece of code that was useful to that electromagnetic fuse [INAUDIBLE].

Fairbairn: So you had to apply your math skills as well as everything else you'd learned, it sounds like.

Cheng: Yeah. That was-- looking back, it was a very important, and fortuitous point in my life, I think.

Fairbairn: Did you come to any conclusions about the potential impact of the problem you were investigating?

Cheng: Oh, yes. The conclusion, of course, was that the impact is very minimal. And unbeknownst to me, at that time-- I had no visibility to the outside world, what's going on. The reason why FAA was so interested in the C-5A which is a military transport and so forth, was that there was a twin version of this thing coming out. I say it in jest, but it's actually made by Boeing, called a 747, which is amazingly similar profile of the C-5A. And that was going to be everywhere in any number of these large airports. So it was actually a very useful problem to know the answer to.

Fairbairn: So you-- were there any particular professors who became sort of your close advisor, or helped influence your direction on leaving Ohio?

Cheng: Actually I was very close to almost all the professors that I had. It's very small department compared to some of the programs out here that I know. It's tiny compared to that. So I knew most of the people very well. And it was a very nice, cordial environment.

Fairbairn: So during your time in Ohio, did you go back to Hong Kong frequently, or once a year--

Cheng: No.

Fairbairn: Or what was--

Cheng: Not even.

Fairbairn: Not even once a year.

Cheng: Maybe I went back once during the four years, or something. You have to understand, during back then, we did not have Internet. We can't do Facebook. Even long distance calls were prohibitive, and so. And at that time, the cost of living discrepancy between the US and the rest of the-- well in, places like Hong Kong, it's so large, that it's unthinkable to do a lot.

Fairbairn: So did you-- you had three other siblings. Did they stay in Hong Kong, or what--

Cheng: Oh, as it turns out, they eventually all came to the U.S. for college. And today, they're all living in the US. And eventually, my parents came over too, and joined us, because the center of gravity is moving

Fairbairn: Right. So they came to you, rather than you going back to them. All right, so you're about to graduate, or you're in your senior year. What were you thinking in terms of your future? Did you think about going to work immediately? Did you know you wanted to go to graduate school? And how did you end up at Caltech.

Cheng: Well I wanted to go to graduate school. And the professors there all encouraged me to apply. And they had some connections with-- well, one of the professors got his PhD from Cornell. You know, we have connections in the Midwest and that area. So I ended up with an offer to go to places like Cornell. And applying to Caltech was again a fortuitous, but random event. So I just-- the only school on the West Coast that I applied to was Caltech. But I actually, my first choice school was MIT, I mean, frankly. However, MIT's professor gave me only a provisional, what do you call it--

Fairbairn: Acceptance?

Cheng: They accepted me, but they say, well can you hold on a bit before we offer you the research assistantship? I think that they waited for somebody else to turn it down, so something like that. I didn't know. So I was just looking at the-- OK, so they all have the same deadlines. It's a nicely uniform system. So I say, hey, you know, I have this offer from Caltech. I call the guy, and he said, well, you know, just wait on it. And it was off by one week, basically. So I said I have to accept the Caltech one. And I went-- and so I did. So I did not go to my first choice school. But as it turns out, I was very happy at Caltech.

Fairbairn: So you had never left Hong Kong before you came to Ohio. Had you ever left Ohio before you went to California?

Cheng: No. I had no clue what I was doing. I just walked. You know, nowadays when my kids apply to schools, we visit the campus, we talk to the professor, we talk to admissions. Nothing like that back then. The best thing that I could get was to get their catalog, and just read it from cover to cover. So I did a lot more reading now.

Fairbairn: So, Southern California-- another big shock moving from Ohio, right?

Cheng: I had no idea that Pasadena was actually like LA, and that close to Hollywood. But it was very exciting. I got to learn a bunch of things that was again very foreign to me, coming from a school that was still teaching me about AC motors, and stuff like that. Suddenly, I was taking classes in semiconductor physics, which was very difficult, just because I had no prior exposure. So I had to work real hard to get up to speed.

Fairbairn: So you had not had any semiconductor classes at Ohio?

Cheng: Only whatever that's touched on by the electronics circuits classes. But they always give you a very cartoon version of what the holes and electrons are like.

Fairbairn: No real theory and mathematical basis, and so forth.

Cheng: Yeah. So I very quickly found out my depth in that. So it was hard work. So that was one. And then the year was '72.

Fairbairn: You entered in '72?

Cheng: Yeah. And at Caltech, the thing that affected my time at Caltech the most was that I bumped into Carver Mead, who had just finished teaching a class, which I think it was called EE 281. It's like a multi-project wafer type of a class.

Fairbairn: Must have been one of his original VLSI design classes.

Cheng: Yeah. And it was-- well he had a good personal relationship with people at Intel, from Gordon Moore on down. And he had a few former students, like Gerry Parker and Ted Jenkins were the two people that I interacted with a bit at that time. And they would simply process some of our student project wafers like it was an engineering lot. With the sponsorship of Gordon Moore, you can get a lot of--

Fairbairn: A lot can happen.

Cheng: --Students' projects go through. So I did that, and then by--

Fairbairn: So you sort of, quote unquote, bumped into him and then took his design class?

Cheng: Yeah, yeah, yeah. So he seems to take a liking to my project, because by just before Christmastime, he pulled me into his office and say that, hey you know-- pull something out of this bottom drawer and say that, this is something that I've been working on. I don't really have time to finish it. So can you take a look at this?

So it turns out that it was a-- so let me think about how to say this. It was an analog read-only memory, but it's a sequentially accessed analog read-only memory. And the only application that I can't think of was that we use that to generate the x and y and z vectors, incremental vectors, for moving a-- to generate a cursive character on a beam--

Fairbairn: Vector display?

Cheng: Yes, vector display. Which back then-- this was just before random access memory got real cheap. So compared to core memory, this is very good. And a lot of-- well, all the radars were built like that, and a lot of high end graphics were all done like that. Tektronix built a lot of big terminals and things like that. And I think most of the Calma, Computervision, and those machines were all done with vector. So I actually built a-- the first version was a PMOS 8 micron-- 8 micron I think, yes. And then I did an improved version on an NMOS 6 micron.

Fairbairn: So you did this as one of the projects that was fabbed at Intel?

Cheng: Yes. And I was able to store all 32 characters of the ASCII set. I remember the first time when Carver was talking about these things, he used the word font, and I have to stop and say, can you spell that for me? You know, first of all, it's a second, foreign language, and second of all, I never had the chance to use the word, that word, font.

Fairbairn: Yeah, no, it was largely unknown to the general population before the world of computers and so forth.

Cheng: Now it seems like six-year-old kids would say, that's not a good font.

Fairbairn: No only graphics and typesetting people knew about fonts. So, was all this happen during pursuit of your master's degree, or later in your PhD?

Cheng: So Caltech actually has no thesis or research requirement for master's degree. So I guess to answer your question, it is for the PhD then.

Fairbairn: So you went there with the goal of getting a PhD. It was never an option to just get a master's. OK.

Cheng: And I was also having too much fun. It was just exciting and fun to do. And then, after I got the chip, that's when the real fun started, because we also had to-- I had to build video amps and somehow interface them into some kind of a graphic display. None of these things was-- well, it turns out that high frequency analog is-- precision analog, high frequency precision analog, is not as easy as just making it happen.

So it was a lot of debugging and-- actually, between Carver and me, neither one of us had that type of experience. But he-- I think-- I see this in the Bay Area too, the university professors have a lot of relationships with the industry, especially back in the '70s. And in the case of Carver, he just had so many former students. Caltech put out a lot of very smart people, and working in the area.

He would just call up somebody and bring them in to give a talk, tell us about-- you know, they are building-- the aerospace industry is all done in LA back then. So these people, their professional job is to do microwave radars type of work. So they would say, well, you should think about doing this, try that. That turns out to be immensely helpful. Beats learning that stuff from grinding through math in a lecture class, let me tell you.

Fairbairn: So you got some help from the professors and Carver, but mainly from just outside consultants that came in through his connections.

Cheng: Pro bono consultants.

Fairbairn: Just visiting.

Cheng: Just through his personal relationships. So that was very good. And I think I start to appreciate the sense of community, because growing up doing electronics, it was always a loner type of thing.

Cheng: So what did you eventually do your thesis on at Caltech?

Cheng: So that was contributed to a big chunk of it. And I also worked on-- worked on some-- how should I say? Let's see. A serial multiplier that was used for a DSP system. So I was basically moving into-- all these things are kind of reverse signal processing related, right? Analog and digital and so forth.

Fairbairn: Did you end up working significantly with any of the other professors, or was Carver your thesis advisor? How did that--

Cheng: So Carver was my thesis advisor. I get a lot of help from the semiconductor physics professors, because understanding the physics of these seemingly very simple MOS devices turned out to be very crucial in making that type of chips work. The reason is because I was using--

Fairbairn: Doing the circuit design, and--

Cheng: --I was using the transistors that was really designed and built for digital circuitry. The people have no considerations for analog type of designs. So we use what we have, and we just make the best of it. So the thing to do is to understand what it is, and figure it-- rock it out ourselves. And also is before the time of circuit simulation, just a little bit before. Actually SPICE was being developed by right about that time, unbeknownst to me, again. This happening up in Berkeley.

Fairbairn: So you're coming to the end of your time at Caltech. What were the options that you were looking at, and what kind of job were you seeking as a result?

Cheng: So this is 1975. I think the Vietnam War is coming to an end, and economy was-- there was just a lot of not good things happening, because the oil embargo happened two years earlier, like '73. And the semiconductor industry hit a fairly steep recession. So everybody had hiring freeze. Lucky me, again.

Fairbairn: But you ended up going to Intel?

Cheng: That's right. So I ended up with job offers from HP, TI. Both of them are from the research labs in Intel. But Intel was a microprocessor chip design. It was tough choice, because the other places I get to do, you know, signal processing. But Carver said, you know, these microprocessors stuff, might be something there.

Fairbairn: Just might be.

Cheng: Might be. So it was very-- it was, yeah.

Fairbairn: So you went off to Intel. What group did you get hired into? Who was the manager?

Cheng: Bill Lattin hired me. He just joined from Motorola, actually, he started out-- it was a high power group, looking back. Justin Rattner was the logic-- the computer architect, I guess.

Fairbairn: So what was the first project? And did you get to apply any of your analog type of skills, or were you thrown into the world of digital and microprocessors?

Cheng: Yeah, so I started actually solving problems like-- back then the microprocessors that were hitting the market was 8080, and 8085 was still in debugging. It's not come out yet. So I joined Intel in about Christmas time, '75, basically '76. And the question was asked, can we make a 16-bit ALU fast enough for what we want to do? So I turned it into an analog problem. And played--

Fairbairn: For the 8086-- this is for the 8086?

Cheng: So again, 8086 has not been started yet. So I was kind of like coming up with a solution that found a problem. Again, you know, events looking back, it looks very differently from at the time when we were just thinking like, hey, that's a problem that needs to be solved. And once you had a solution, then suddenly a lot of people say, hey, we can use that. I was actually building it for Bill Lattin's project, which many years later became the 432. But the 80-- so 8086 sort of was the first 16-bit microprocessor that was introduced.

Fairbairn: So did you come up with some innovative techniques to speed up the-- were you able to apply your analog skills to speed up the digital problem?

Cheng: Yeah. So the carry chain and so forth, I thought of it as an analog propagation, analog signal. And it turns out it was very-- it worked out very well. And I built a lot of test chips to make sure that I was not-- that it actually does work. Working at Intel, everything is verified and tested. So I get the chance to constantly be doing things and making sure that it works.

Fairbairn: So what was the-- so lead me through your time in Intel. What was the next thing that you--

Cheng: Well, it's a long time ago, so it's kind of fuzzy. But I worked on various circuit design problems, whatever it was that they were throwing at me. And there was an opportunity to put an analog interface into a microcontroller. And, again, it was for an application that seems like a neat thing, but never worked out like that.

So for example, we're doing this microcontroller that they thought-- right about that time, microwave ovens were starting to come out. And they thought that having a-- the cheap interfaces would be like a pot [potentiometer]. And if you just put in an analog voltage into this thing, you can do a lot of settings if you have an A to D converter. So I built a 8-bit A to D converter. Again, this was done on what's known as the HMOS which is approximately 4-- somewhere around 4 micron NMOS. No CMOS, NMOS.

So after that I thought to myself, you know, if we do a few more things, we could probably get a 10-bit A to D converter out of this. And with 10-bit, we have a lot more applications. Because right about that time, Motorola was supplying a lot of microcontrollers to electronic engine control. So they were up to the third generation already, EEC-I, II, III, and IV.

So to make a long story short, I built the A to D converter and proposed an architecture to work with and work for Ford. And we actually got the EEC-IV business at Intel.

Fairbairn: Wow, that must have been a major breakthrough, a huge win for Intel.

Cheng: And we thought that, wow, this would be the huge volumes, right? And of course, in reality, things didn't happen like that, because a little company called IBM came knocking and wanting to do a thing called PC. So that changed Intel's trajectory completely, which was for the better, I would say. And so suddenly, the automotive business looked less important to them.

Fairbairn: So you were at Intel for how long? For six years? '75--

Cheng: Approximately.

Fairbairn: --to '81. And sort of any other major things, and how did you end up leaving Intel? What was the--

Cheng: Well, so, first-- well, Intel was growing fast. And they knew they had to grow outside of the Silicon Valley. Back then, it was not called Silicon Valley yet. Santa Clara valley. So they knew they had to move out. So Bill Lattin took his team up to Oregon. I did not move. You know, I-- those were the few years that I was in the process of getting married, so I just didn't want to move. So for personal reasons, I stayed.

And then I reported to Craig Barrett, who was starting his first general management job, so I reported to him. And he also wanted to move that group out to Chandler, down in Phoenix area. Again, for the same reason, I did not want to move. So after a while, I think I finally got figure out that, hey, you know, this is--it's going to be--

Fairbairn: You're going to have to keep turning down jobs, right?

Cheng: And they were good jobs. So anyway-- so meanwhile, I started to-- we kept talking to Carver, and he said, hey, we're onto something. There was a much bigger problem to be solved, because people need these chips tonight, and if you look at the way things are scaling, it is-- the old way of doing things on pencils and Mylars is just not-- won't get us very far.

Fairbairn: Not sustainable.

Cheng: And I agree. I think that-- again, I thought that it would be a very tough problem. How do you automate something that's very difficult to do by humans already?

Fairbairn: So this is 1981?

Cheng: Yeah.

Fairbairn: But he convinced you that this was worth pursuing?

Cheng: Yeah. Right. So he, along with a few other people, we embarked on a project that, in retrospect, looks like it was too ambitious at that time, because I think that in terms of the hardware technology and software technology, it was very difficult to do all the things that we envisaged to do. Too much.

Fairbairn: Who was the founding team? This is for Silicon Compilers, right?

Cheng: Yes. So Carver had me, Dave Johannsen, Ron Aires, who's passed away since, I think, and John Doerr.

Fairbairn: So John Doerr was at that time still at Intel, is that right?

Cheng: No, he has just left Intel to join a VC firm called Kleiner Perkins.

Fairbairn: Kleiner Perkins, OK. So he provided the financing, or Kleiner Perkins provided the financing?

Cheng: Yes.

Fairbairn: And so was John on the board? Did he have a management role? What was his--

Cheng: Yes, he actually took on this project under his wings. And he was essentially like a part-time CEO.

Fairbairn: So Dave and Ron were both working at Caltech. Did they move to Silicon Valley, or how did this all come together?

Cheng: No, they didn't. So it was tale of two cities. It was a little difficult.

Fairbairn: What was your role in the early days of Silicon Compilers?

Cheng: So I started with essentially like an engineering role, that involved both software and hardware. But very quickly, I started to focus more on the actual chips, the silicon side of things. Out of necessity, I think, because I think that I was the person that had the knowledge and experience in that area. And so because of the fact that I was still living up here, and some of the other guys were down there--

Fairbairn: Down in Pasadena?

Cheng: Pasadena. This was long before the-- well, ARPANET was around, but it was still very early days for that. And we were outside of the ARPANET. But it was a big motivation for me to work out a lot of the networking communications and so forth between the two sides. And I actually-- I think I was one of the earlier people in the business that had actually email addresses and so forth for the company. So it motivated me to understand that stuff, and get into it.

Fairbairn: So how did they-- sort of briefly, how did the company evolve? What was its focus? And I guess Phil Kaufman later became CEO, right?

Cheng: Right.

Fairbairn: How and when did that happen? And just take us through the evolution of the company.

Cheng: So the first year, we were trying to do something that was very ambitious, like I said. We want to automate a lot of things. So we thought that it would be good for us to do some feasibility demonstrations, and build something with such a system. So I went and built something that people would take notice of it, which was at that time-- it's the Ethernet data link controller chip. And at the time, we knew that that stuff was coming up. Actually, I also-- if I'm not mistaken, you were at Xerox PARC at the time?

Fairbairn: Right. I was there from '72 to 1980. And then I went to VLSI Technology, also the encouragement and guidance of Carver Mead. So I was at PARC when the Ethernet was developed. And I think Bob Metcalfe spun off to form 3Com in '81 or something like that.

Cheng: So I was a little exposed to-- I think maybe Dick Lyon was at PARC also, right?

Fairbairn: Yes. Dick Lyon was there. And so he, and Lynn Conway, and Carver and I and few others working close together. Carver had come up and taught his VLSI design class in 1976. And then subsequently, we designed some chips, and subsequently in '78 and '79, he and Lynn collaborated on the development of the book. So in parallel with the time that you were at Intel.

Cheng: Right. So I went off and built the Ethernet data link chip. It was just a controller chip, and--

Fairbairn: Now, did you do that using the tools that were being developed by Dave and Ron, or did you--

Cheng: Yes.

Fairbairn: --sort of a combination of old technique and new technique?

Cheng: I think looking back the way-- to characterize it-- was that I put it together. And I told them, your software needs to do this, to automate this. Essentially, that's kind of-- you understand what I'm saying?

Fairbairn: Yeah. So were you doing layout? How did you actually create the layouts?

Cheng: Yeah, I did some layouts. But some of it-- I did very simple things, because most of the things, most of the circuitry was just piecing these simple things together.

Fairbairn: So you developed the chip, and you were able to fab it. Where did you get it fabbed?

Cheng: So at the time, John Doerr also had funded a company called SEEQ, S-E-E-Q. And so they were set up to do EEPROMs. But somehow he convinced them to build a non E-squared version, I suppose. So this is long before commercial foundry was available.

Fairbairn: So you developed this chip. The chip worked, or did you have to--

Cheng: I think so. SEEQ actually sold that product for years, actually.

Fairbairn: And did you collect royalties or something on it?

Cheng: Yes, we collected some royalties.

Fairbairn: And then how did the rest-- how did the story itself-- Compilers evolve, and--

Cheng: After that, we went and I think the next big project that we were engaged in was to do a version of the VAX architecture, the MicroVAX. Hudson, Massachusetts already has a MicroVAX chipset ongoing. But we were doing, essentially, another version. So I think-- I don't exactly know which was the nomenclature. But we went and we actually did one, built the MicroVAX chip for them. And that was a big help, because DEC actually updated our machine, the computer hardware by a lot, because we were using some old PDP-10s and so forth. And so we suddenly had VAX 780. And ultimately our product was shipped on VAX 750s.

Fairbairn: And so you developed this chip. Did that chip-- was it operational the first time? What was your-- do you remember any--

Cheng: Yeah, that was fabbed by Hudson. And we worked together with a design team. Digital has a design team. I think the people we worked with were up in Seattle-- Bellevue. So I was the main interaction with them as well. Together we made the chip happen.

Fairbairn: So when did Phil Kaufman join the company? Do you remember?

Cheng: Maybe '82? He was one of the business unit general managers at Intel before that.

Fairbairn: At what point did you realize that maybe Silicon Compilers was a too little too early for its time, or-- how did that evolve and, I guess it eventually was bought by Mentor, is that correct?

Cheng: Yes, Mentor Graphics bought-- and before that, we also merged with SDL. And then the combined company was acquired by Mentor Graphics in '89, I would say.

Fairbairn: So how was that overall experience? What had you learned from the Silicon Compilers experience? How did it turn out relative to your expectations?

Cheng: So I would say we focused mostly on the physical side of things, putting the circuitry together. We focused much less on the front end design, how do you describe the hardware. And as it turns out, later on VHDL was proposed by DoD. And then Verilog became-- ultimately becomes the lingua franca of TA in hardware description. So that's a missing piece.

We also-- we actually worked very-- our design system contains timing analysis in addition to logic simulation, which was very early for that type of technology at that time. So we did a few things right. But looking back, I would say each of these areas that we worked very hard to do eventually turned out to be a very large, large-- how should I say-- a large product area. Like timing is a big product.

Fairbairn: Whole companies did just timing, right?

Cheng: And whole companies just did Verilog for example. And looking back, we were spread very thin like peanut butter. So it's difficult to compete favorably in that environment, I would say.

Fairbairn: Before the merger with SDL, what was the size of the company? How large did Silicon Compilers Inc. become, do you remember?

Cheng: Well, in terms of-- well, I don't know how you measure.

Fairbairn: Well, just in terms of employees, or-- just get some measure of the size of the operation.

Cheng: It was something like maybe 50, 60 people.

Fairbairn: So do you know what eventually drove the merger with SDL? What was the--

Cheng: Well, I think both sides felt that we were under critical mass. And in terms of philosophy, it's also a little-- quite compatible. We both were trying to do design automation. You know, looking around at that time, other companies that-- for example, ECAD was just doing DRC. The DMV side, the Daisy, Mentor, Valid, were just doing layouts. They were mostly doing logic schematic capture. Nobody had the-- nobody even was thinking about how to really automate the-- right. And the word synthesis is not even in our lexicon at that time. So it's different times.

Fairbairn: So eventually, what finally drove the acquisition by Mentor? How did that come to be?

Cheng: Mentor wanted to move into the IC space. And I think that we fit that part of their vision to move into-- you know. But Mentor was having some product launch struggles at the time, which I didn't know that until later on.

Fairbairn: Their famous version 8 problem, right?

Cheng: Yeah. And again, also, they just reached a little bit further than they should. So it's difficult. But this is sort of the nature of our high tech industry, that you need to constantly be challenging yourself to do ambitious things. But only history can judge whether you were just about right, or too ambitious, or not enough ambition. But you have to sort of pay your money and take your chances.

Fairbairn: So you went with the acquisition? You stayed at Mentor Graphics for a few years after the company was acquired?

Cheng: Yes. And so I basically focused on mixed signal, mixed analog-digital and simulation and analysis. And we had some clientele in that area. So some big--

Fairbairn: While at Mentor?

Cheng: Yeah.

Fairbairn: Using the Silicon Compiler technology?

Cheng: Yes. So I continued to push that, and keep developing the product line, and so forth.

Fairbairn: And by this time, was all the operation in Silicon Valley, or was there anything left in Pasadena, or did that--

Cheng: Oh, no.

Fairbairn: That went away a long time ago.

Cheng: Long time ago.

Fairbairn: So you continued on with Mentor for how long, three or four years?

Cheng: Something like that.

Fairbairn: And then what happened? What was the next step in your career, and how did that come to be?

Cheng: So I joined up with a few other people to do a company called Anagram. And at that time circuit simulation has become one of these-- again, a 0.2 becomes a big company now. I think HSPICE was quite successful. PSPICE was also not bad. And there was quite a few products out there. So we started a new area which I think I called Fast SPICE. And there were some attempts at doing relaxation and other approaches. And there were not any widely used productized type of software out there. So we thought it would be good for us to do something.

Fairbairn: Whose idea was that? Who was the motivating factor and say, hey, let's form a company? How did you get involved?

Cheng: So I would say there's a professor up in the University of Washington, Seattle. His name is Andrew Yang. And he and a few of his PhD students were already moving in that direction.

Fairbairn: And how did they find you or get you involved?

Cheng: Again, just random events. I met up with them over some kind of a research gathering, I think. And it seemed like a good thing to do. And we got kind of lucky at the time, because we did find some applications that grew very fast at the time.

Fairbairn: So who furnished the money for Anagram?

Cheng: We did not actually go out for VC funding. So it was basically self-funded.

Fairbairn: And what was your role in the company?

Cheng: I was the CEO, president/CEO.

Fairbairn: So that was your first CEO experience?

Cheng: Yeah, that's right.

Fairbairn: Did you feel you were fully prepared at that point? How did you feel moving into that role? Were you comfortable? Was it different or harder or surprising than you expected?

Cheng: It was not easy. It was hard. And I also had to travel a lot at the time. A big part of our business was coming from both Japan and Korea, and Taiwan, too. So those were the years when the industry was-- well, Japan was very strong. And Taiwan was coming up rapidly.

Fairbairn: What year was it?

Cheng: I would say '94 to the '96, that time frame. '93 to '96 time frame, yeah. Maybe '97 or something like that, I forgot.

Fairbairn: Was the product successful? Did it realize the goals that you set out? And then what became of the company?

Cheng: I think it was quite successful, by our criteria. And eventually Avanti acquired us, somewhere between '96 and '97.

Fairbairn: And does that product continue in some form at this point?

Cheng: Yes, yes. So that got absorbed into Avanti. And Avanti eventually got acquired by Synopsys later on.

Fairbairn: And does this product still live, in some form, in Synopsys?

Cheng: Yeah, actually, I think Fast SPICE is still a fairly important product line for-- you know. So if you trace the genealogy of today's Fast SPICE, it comes from several different roots. But what we did was still quite useful.

Fairbairn: What was the-- I presume from the name that this was-- its major advantage was that it was a lot faster than the traditional SPICE. And can you explain just very briefly what the source of that speed advantage was, and what compromise, in terms of accuracy or whatever, if any that took place as a result.

Cheng: So we basically looked at-- by then, it was all CMOS. So we looked at CMOS circuitry, and say, hey, for the circuit simulator, there's what type of-- where are the spots where the circuit simulator spends a lot of time on, and how can we speed them up? So it was very targeted engineering-- software engineering, if you like-- on speeding things up.

But it also involved doing things differently. For example, the nature or the way that the transistor models were calculated required a lot of time. And so, is there a better way to do these things, and knowing basically what regime you're in, and for the transistor, can we make much better, much faster calculations without compromising much accuracy? So it's really a piece of engineering work, basically.

Fairbairn: It wasn't fancy mathematical algorithms. It was just looking at just doing a good job of engineering, and figuring out where the problems were, and where the hold ups were, and how to optimize those.

Cheng: But I think we make sure that the mathematics was sound. But it was not mathematics driven thing. Not like the [INAUDIBLE].

Fairbairn: And the accuracy was essentially the same as more traditional SPICE algorithms?

Cheng: So when we introduce a product like that, customers have ready-made evaluation vehicles. They already have circuits and the results from SPICE. So they throw us in into the lion's den every time. So that's--

Fairbairn: And what kind of performance improvement did you see with the Fast SPICE.

Cheng: Depending on-- sometimes we see several x. Sometimes we see 10s of x. It depends on--yeah. So it was enough for people to take note.

Fairbairn: So Avanti acquired the company. Did you then become part of Avanti? Or what was the next step in your career?

Cheng: No, I was with Avanti a very short time. And then I departed. It's typically what happens. Acquired CEO.

Fairbairn: And what was the next step in your career? What-- how did you--

Cheng: So I sat out for a year, because some contractual requirements. And then Synopsys was looking for somebody to-- they acquired also another kind of a rival Fast SPICE company called EPIC And so they were looking for somebody to head it up. And I joined Synopsys I believe it was in '78 or so?

Fairbairn: To-- '90?

Cheng: I mean, '98, I'm sorry. Sorry.

Fairbairn: So then you ended up staying at Synopsys for quite a long period of time? How long--

Cheng: Yeah. 'Til about 2006, I'd say.

Fairbairn: And were there any major developments, things-- was it an engineering management positions that you held? Or what was the--

Cheng: Yeah.

Fairbairn: What do you feel the most important contributions or events during your Synopsys career were?

Cheng: So we went through the Avanti acquisition in the early 2000s. So we brought in a bunch of products that affected my area at the time.

Fairbairn: Were there some of your ex-employees still with--

Cheng: Yeah, there was. Actually, there was. So the acquisition was a very big event.

Fairbairn: So you had to combine the Anagram operation, or what was left there, with the EPIC operation, and sort out the issues there, and so forth?

Cheng: Yeah.

Fairbairn: So you stayed in Synopsys 'til 2006?

Cheng: Yeah. And I think in somewhere along that time, I also moved over to take on a marketing role. And the operation also changed and morphed into something-- because by then, we also were bringing in a lot of DFM type of product lines. There was a lot of growth by acquisition during that period.

Fairbairn: So Synopsys eventually became the leading company in EDA. During that time, or--

Cheng: I think yes. I would say so. And you may recall that Cadence was having some stumbles about that time.

Fairbairn: So what would you attribute Synopsys's success-- you know, it's been a very longtime player, growth through acquisition, as many EDA companies have. But they've managed to kind of keep moving forward without any major setbacks. Is there any observations you would have, having been within the company for six or eight years as to what management style or approach or whatever helped account for that success?

Cheng: I think Aart is a very effective CEO. I think he's-- yeah. And also Chi-Foon is also very effective. I guess now Chi-Foon is the co-CEO. And the two of them work very well as a team. I think the leadership sets the tone. And so in terms of how the standard at which businesses is to be done, they set a very high standard. They are very open, and very no-nonsense. I think there is reason why their top management has been so stable. They did a very good job. They're very effective.

Fairbairn: I was at Cadence for a few years myself. And I would say Cadence had a very outwardly focus, very heavily focused on sales and marketing. And I always perceived that Synopsys was more of an engineering company, that at its heart, it was an engineering company. The leaders were engineers. Is that a fair assessment? Do you think that-- internally, was engineering sort of held up to be the core of the company? Or is that not an accurate observation?

Cheng: So first of all, I think it's accurate. Most, if not all, of the top management are technical people. But make no mistakes, they are very business-focused. They also pay very close attention to the customers' needs and what the customers are doing. And so sales and marketing is also a very important discipline there. I think they have found a very good balance, actually, I would say.

Fairbairn: So, come 2006, time to move on again. Serial entrepreneur. Tell me about that, and--

Cheng: OK, so this is actually my current project. So we're doing something that's not even in electrical engineering discipline proper. This is more like a mechanical engineering issue. So it's thermal analysis. But the main issue here is that the power densities for these modern electronics is getting very high. So high that you can have very, very steep slopes if you look at the temperature profiles, which means that you can have--

Fairbairn: Is this a gradient over the chip?

Cheng: Right, yeah. Within-- inside. If you just look at--

Fairbairn: You have very hot spots and then--

Cheng: Yeah. And the gradient of the slopes is directly proportional to the power density ratio. So we can develop very narrow peaks. They could look like needles, actually, on the profile pictures. So you may have reasonable average temperature, but quite onerous-- quite ominous type of spot temperatures. And as you know, all it takes is one bad thing, and your chip is toast.

Fairbairn: Literally, in this case. So this is 2006 when you decided to move to this company. Tell me about that. How did you find it, or it find you? Why did you decide that that was the time to make a change?

Cheng: Actually, while at Synopsys, one of the several responsibilities I had was also related to the gate level power analysis tools, as well as the power compiler. Back in the early days when we couldn't even give those tools away-- back in the early 2000s, people-- design engineers did not want to pay attention to that.

Fairbairn: Didn't care.

Cheng: Didn't care. But we could see the wave coming. And at that time, Intel was already showing pictures of the power densities, like kitchen stove cook tops, to the rocket nozzles, and a nuclear reactor core, and the surface of the sun. They were all like orders of magnitude, right. So we're on track to-- so they've been preaching it for many years. And they caused Intel-- well, the whole industry-- to change direction to go into a multi-core instead of cranking up the clock rate. There's a lot of actions that was taken to mitigate the problem. And still it is a problem.

Fairbairn: And so in 2006, what-- had somebody else sort of identified a tool or a company? Or was this your idea? Or how did this all come to--

Cheng: Oh, this company has been formed. It was already in operation at that time.

Fairbairn: So they asked you to join as CEO?

Cheng: Yes.

Fairbairn: And did you think that this was something that was an immediate problem? What's your experience, again, in terms of the solution versus the demand, and especially in regard to timing?

Cheng: Well, I think that it's also like many things I've done in my life, it is ahead of its time. And so the demand is still catching up. I think we have the technology to do these things. And so what we're doing is essentially a missionary marketing project to show people that, hey, if you have this type of problems, or if your designs fit this type of a profile, you should-- this will benefit you.

Fairbairn: And is the impact of these very hot spots, if you will, or temperature gradients-- does it actually lead to poor operation, or out of spec operation? Or does it actually destroy the physical chip? What is the consequence? And what's the evidence that you have this problem if you've got an operating chip.

Cheng: OK. So let's start with the more ominous ones. How it destroys the chip usually is because of some sort of a wear-out mechanism. And everybody knows about electromigration. And actually the semiconductor devices suffer from high temperature as well, especially around the oxides. There's more-- there's quite a bit of both negative bias and positive bias at high temperature-- makes the device essentially drift out of spec, potentially. So there's a lot of concerns in that area.

But for the things that attracts the attention of design engineers are that some temperature variations, both in space and in time, actually impacts the circuit operation. So for analog circuits, [INAUDIBLE] components, this is very easy to understand. What's a little less obvious is-- for example, we know of an issue for these mobile RF power amps where because of the modulation, how you modulate the RF signal to get your carrier has sidebands, and the interaction causes the power to vary at a rate that's about the same time constants as your thermal time constants. And so the device actually-- they've noticed that on the up part of the signal, the behavior is different from the down.

And then the net effect of it is that it stresses their adjacent channel, how much power they're allowed to leak into their adjacent channel. And as you know, they're also trying to pack a lot of channels into the spectrum, because so many people use cell phones and such now. And so all these things are contributing to a design issue that they need to address. And we happen to be a solution for them, that they can show them what the issues are, and help them mitigate them.

Fairbairn: While they're in the design process?

Cheng: Yes.

Fairbairn: So are there any-- so you indicated that sometimes people don't immediately understand the depth or breadth of this problem. So perhaps you've-- can you tell any anecdotes or stories about companies that have ended up with this problem, that caused a major issue or company crisis that you were able to come in and solve? Or are all such stories still proprietary?

Cheng: It is difficult. The reason is because I don't think that any of our customers would like publicity drawn to them having a wearout, or IE reliability issue. So, no. However--

Fairbairn: Can you say that there are-- based on your knowledge, there are chips out there that do have a reliability or wearout issue that--

Cheng: Just think about the trends. In the last decade, we've made the metal lines narrower and thinner. So the cross-sectional area is smaller and smaller. And we wrap them in low-K dialectirc the low-K meaning porosity, means holes. Means kind of like wrap them in a blanket. And then we put a current through them, that are switching pretty fast. I mean, you know, I think the clock rate has stabilized now. But it's still fast enough. We're still in the gigahertz. So if you just look at the amount of current going through them--

Fairbairn: So are these mainly--

Cheng: Even for signal lines. These are just for signal lines, which is a--

Fairbairn: Right. So these are mainly wiring wearout issues, metal migration or whatever.

Cheng: Yes.

Fairbairn: What about actual device-- transistor device failure. Is that also possible?

Cheng: Yes.

Fairbairn: So it's good that we recycle our products-- consumer products every couple of years?

Cheng: Yes, I know. I mean, just looking at-- a lot of people seems to replace a cell phone as quickly as the battery dies out. So in that case then, yeah. But-- so, the expected life time-- when I started my career, telephones were made to last 25 years. So we certainly live in a different world. However, the wearout mechanisms today are much faster, too. So you basically-- if I was a designer, I would have to balance this against the warranty requirements, basically.

Fairbairn: Now, an area where there maybe are longer lifetimes expected-- military projects. So are those particularly important customers for you, perhaps, that have long term life requirements?

Cheng: Certainly. Certainly a lot of the-- for example, the RF and microwave applications are in mil-aero related, areas.

Fairbairn: So, how big is your company now? This is Gradient Design Automation?

Cheng: Yeah. We're still very small. We're still operating like a start-up.

Fairbairn: How many people?

Cheng: We're small. Just around-- under 10.

Fairbairn: Under 10, I see. And has it been venture funded? Or what--

Cheng: Yes. It's venture funded.

Fairbairn: Who are the investors, or investor?

Cheng: So the lead investor is Alloy ventures, and Lanza techVentures, also.

Fairbairn: Is Lucio Lanza on your board?

Cheng: Yes, he is.

Fairbairn: So, what's your vision? How long do you think this company stays in this mode? When do you expect it to grow to a-- you know, does reach sort of a knee, and grow bigger? Or what's your vision as to the timing of this now?

Cheng: That's hard to say. It's very-- it's difficult to predict the future. However, we're working with customers on addressing issues with respect to these FinFET devices, that are-- these 14 nanometer devices are very strong in terms of what-- as a switch performance. So they can also put out a lot of-- do a lot of things in a very small volume.

Fairbairn: Good opportunities for you.

Cheng: Yeah. And those devices are also all wrapped around in thermally challenged materials, because they tend to be floating in oxides all the way around. So all those are our growth areas.

Fairbairn: So let's just look forward. You're right in the midst of some of the leading edge problems with the leading edge semiconductors. What's your view of roadblocks and opportunities for continued migration in terms of semiconductor evolution? Is power the major problem at this point? Just tell me sort of what your view of semiconductor technology is over the next five or 10 years, in terms of what the major roadblocks are.

Cheng: So from a designer perspective, I think even if you don't call it a problem, per se, power is a major design consideration. It's definitely not a "don't care" anymore. The reason why they're not a problem is because of the diligence of some design engineers. Let me put it that way, right. So it is something that requires a lot of attention and care and feeding to make sure that everything stays well.

I think from-- you asked about the-- from a EDA software perspective, you know, the number of leading edge customers are getting to be fewer and fewer, because there's just not that many people-- not that many companies that is investing in these 14 nanometer FinFET devices-- the future generations. As long as we are still measuring our revenue opportunities by how many copies of software we license and so forth, that is a-- what did I call power, a constraint? That's a business constraint for us, right?

So all these things-- we need to innovate around many of these things. Because I think, at the end-- I think EDA is a key, if not contributor-- it's definitely a contributor. Personally, I would even call it an enabler to all these electronic developments. And we all know that that development curve has been spectacular. Call it Moore's Law, if you will. Call it whatever. But we had an incredible run in our career time.

Fairbairn: Yeah, absolutely.

Cheng: And the business is such that-- just recent current event-- I know that this will go into history, so later on, it may not make so much sense. But just within the last month, business news had Facebook acquiring a company that most of us have not heard of, WhatsApp for something like--

Fairbairn: $16 or $19 billion.

Cheng: Just south of $20 billion, right? Which is a sum that's larger than our whole industry put together, in terms of market value-- market cap valuations. And so it's kind of a-- makes you wonder. Some food for soul searching.

Fairbairn: So what do you-- as you said, you and I have shared a spectacular run. We were both sort of born in about the time the transistor was born, and have been able to ride that curve from sort of very large devices to spectacularly small devices, and everything that's come with that. How long is that-- is Moore's Law coming to an end? Is it going to be limited by physics, power, money, need-- what do you see as sort of the evolution of semiconductor technology over the next five or 10 years, or as far as you can see it? What do you-- is it EDA? Is it power? What's the--

Cheng: So first of all, I think it will definitely end. The reason is a nanometer is 10 angstroms. And angstrom is the atomic dimension, basically. And so we're not going to-- people are talking about quantum gates, and switches, and so forth. OK. Got it. There's a lot more work needs to be done to figure out how to get in and out of those logic states.

And so, OK. Fine. Maybe we'll get there someday. Maybe not-- not in our career, for sure. However, there is still a finite point. You're not going to get-- I doubt that we'll get smaller than that. And maybe we don't need to. Because I think, as you mentioned, the financial barrier to-- I think Moore's Law-- ultimately, Gordon Moore himself would explain that it's ultimately an economic impetus. I think that's better way to say it than law. You know, you do that, and you'll be more cost effective, and then you win. And if you don't, somebody else does that, and you lose.

Right, so it's very simple. But if the next node is so expensive, prohibitively expensive, that it no longer provides the economic impetus, then the party sort of--

Fairbairn: Party's over.

Cheng: Poops out, right. So, yes. But then it becomes less of a production and economic driven issue, and more of a research driven issue, research and development. So that will be much more like how high tech-- how technology was generally done. But I would say that today-- I'll make two comments.

One of them is that, hey, you know, for a while, every generation of airplane got bigger, faster, and whatever. And then, suddenly, it said, we're good enough. And stayed pretty much like that. And then it'd make improvements, incremental improvements, in other dimensions. And you can produce a very healthy industry like that. It's not feeding off of an exponential curve, necessarily. But what's wrong with that? So let's just leave that alone, as a philosophical point.

But if you look at what we are already capable of doing, how we can apply the technology-- we don't have to just keep making computers, server boxes, or smartphone boxes. There are so many things that we can apply to in the medical field especially. I think the ability to miniaturize and just use the access to the data processing and data storage-- and it's so beneficial to so many fields, that will have a very positive impact to our quality of life.

Fairbairn: All right, well, that was actually sort of what I wanted to conclude with, was sort of where you thought that the next exciting developments were, and where things might evolve. And so it sounds like the focus on making much better and broader use of this technology, which we're really just scratching the surface of, is high on your list.

Cheng: Yeah.

Fairbairn: So just the-- your feedback and thoughts on use of this technology as we move forward.

Cheng: So if I may quickly recap the last several decades. What I experienced was that there was a very symbiotic growth or development between the computer industry and the software tool industries that I participated in. And then let me explain. So in every generation, we use the best hardware available. And we were stretched a little bit, because we were always-- we were a leading edge software, technical software is a--

Fairbairn: Specifically in EDA software.

Cheng: Yes. EDA software is technical software. And we are insatiable when it comes to computer resources, both in space and performance. And you know what? Every generation, every couple years, Moore's Law is ticking for the computer makers too, as well as the disc makers. And that whole industry is floated up by this general improvement in technology. And just in time for us to go to the next gen-- so in order to design the next generation of chips, whether it's going into the disc drive, or the servers, or whatever-- it requires so much more resources. So it was a very symbiotic and positively feedback system that kept going up and up, higher and higher.

So in a way, it's kind of-- we are very inward looking. And the biggest opportunities in terms of software licensing sales and so forth is to sell to other people just like us, engineers doing … and guys like Intel, AMD. People that we all know, and so forth.

However, if we just take some of the branching, and go into neighboring areas, like chemical and medical fields-- so on and so forth. There's so many other areas that can seriously benefit from the availability of this compute power, storage technology, and communications access, networking capabilities. I think that's it's a-- the opportunity for us to better understanding the world that we live in, and also make it a better place for us to live in. And so just very, very encouraging.

Fairbairn: Well great. I think that is a great a point on which to conclude. And so thank you very much for spending time with us, Ed. And congratulations on a fascinating and successful career.

Cheng: Well, thank you very much for the opportunity to speak to you.

Fairbairn: Thank you.

END OF INTERVIEW

