Oral History of Avadis Tevanian

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Markoff: So we're here for oral history of Avie Tevanian, and it is...

Tevanian: Tevanian.

Markoff: Tevanian. I'll restart.

Tevanian: Thank you.

Markoff: Avie Tevanian, and it's February 21 and I'm John Markoff and Hansen Hsu is to my left and David Brock is to my right, and on we go. So can we start by having you tell us where and when you were born?

Tevanian: Sure. I was born in Portland, Maine, back east in 1961.

Markoff: Okay. Can you tell us something about your family and how your family came to Maine and a little bit of their origin?

Tevanian: So I'm 100% Armenian. Both of my parents are Armenian and both of their parents, all of my grandparents came over in the early 1900s from Armenia as part of the war with the Turks. I should know more about that than I actually do, certainly heard a lot of stories about that when I was younger and mostly forgotten them. So anyway, my grandparents came across literally on the boat. They had children. My dad's family went to Portland, Maine. My mom's family went to Worcester, Massachusetts. Somewhere along the way, they met each other. Don't know how that happened. They got married, and I was their oldest son.

Markoff: And was Armenian spoken in the household when you were growing up?

Tevanian: It was, a little bit. My parents were both fluent in Armenian. They would usually use it when they didn't want us kids to know what they were saying, but we knew a few of the words ourselves, not enough to converse with them, but we could usually figure out what they were saying.

Markoff: Yes, yes. And what did your parents do?

Tevanian: So my mom was some kind of bookkeeper before she was married. When she got married, I think she gave up that career and just became a full-time mom. I came pretty early on after they got married, and she had four boys so we kept her busy.

Tevanian: My dad started out basically when he was very young, like 10, 11, 12--very poor family obviously coming from Armenia in Portland, and he worked when he was very young and tried to also go to school. So he would--in Portland, he would go down to the wharf in the morning, like 3:00 AM to 4:00 AM when the fishing boats were coming in. He'd buy the fish from them, take them to the supermarkets and try to make some money doing that. Then he'd go do a paper route and just anything that he could while still going to school. He then went into the Army for WWII. He was a machinist. He was always good with his hands. He was literally in the action, not on the front lines but right behind. As a machinist, he would go in and fix tanks when they broke down or whatever else. Then he came back, and he was basically, you know, he did jobs where he could use his hands for a while working in machine shops. Worked in a Christmas ornament factory for a while if I recall correctly, and then he basically became an entrepreneur. In the late '50s, which of course is before I was born, he saw an opportunity or he saw a movement of drive-in theaters and so he bought some land just outside of Portland and built a drive-in theater which exists today and is still a family business.

Markoff: Oh wow.

Tevanian: He then, in the '60s while also operating the drive-in theater, bought a bowling alley out of bankruptcy and rebuilt that business and turned it around. I spent many hours working in that bowling alley myself, and then as my younger brothers were getting to the age where they would go out and get jobs and stuff, he built a business beside the bowling alley which was at that time a retail boat business which then got morphed into other fun toys like snowmobiles, motorcycles, things like that which a couple of my brothers still run.

Markoff: Your dad's sort of entrepreneurial gene, it's interesting. He started [as] sort of this blue-collar worker, but going back do you know if there was an entrepreneurial history in the family in Armenia? What pushed him toward business?

Tevanian: I really don't know. It was so long ago, and we lost him about 30 years ago so it's been a while since I've heard any of the stories. He grew up in the age himself where you had to work hard just to put food on the table, and he was helping put food on his family's table by doing that and so I think he learned a lot from being in the Army, especially in WWII. He was just always looking for ways to better his family's life, and so I think when he got to a certain point of affluence, if you will--by the time I was born and growing up we were definitely middle class. By working hard for many years, earning a salary and I'm sure saving it like crazy, I think he thought he could take a little more risk which was building the drive-in theater to get beyond just having the regular 9-to-5-type job. But he was not just a typical--even though he started out as a blue-collar worker, he was not typical. I remember when I was younger, he

taught me about how the stock market worked, which I thought was--even back then not many people even invested in the stock market. You had the Wall Street Journal with the quotes in the back of the paper every single day. It was the only way you got stock quotes, but he was into that. He'd show it to me, so he was interested in these other things beyond just the blue-collar-type stuff.

Markoff: Could you say a little bit about your brothers and what--did they go in a technical direction just sort of generally?

Tevanian: So I'm completely different than my brothers. They all went into the hands-on-type businesses themselves. In fact, I have three younger brothers. They all went into the family business focusing on what, again, started out as the boat business. Now, my father actually died shortly after that was set up and operating, and he had always intended that that was something they could do with their lives and they ended up doing that because he wasn't there to run it anymore. So they kind of learned trial by fire on some of that. I had one brother who worked building yachts for a while up at a place in Maine and doing some other things like that, but two of them still do that today.

Markoff: And sort of characterize what the household was like, you know, your home was like growing up where dinner table conversation is lively. Sort of stylistically, what was the family like?

Tevanian: You know, it was kind of crazy with four of us boys, in retrospect. In some sense, it was a traditional Armenian family in that my mom was just a great cook making traditional Armenian foods and so nothing I would have appreciated at the time, of course. It was just dinner, right? But it was something that I think was just really good for our upbringing. We always saw our dad as a hard worker going in early in the morning, coming back late at night. When we were old enough to know it was when he was rebuilding the bowling alley. My brothers and I were all close. We'd do things together all the time. We lived in a neighborhood that was friendly. The doors were always unlocked. We knew all the neighborhood kids. We'd go outside on the street and play kickball. We'd go down the street and find a big field and play baseball, all those kinds of things, but this was typical of the '60s and early '70s. Many evenings we'd all stay home and watch TV around the one family TV, again, like everybody did and sometimes with our TV dinners. I became a huge Star Trek fan then, right when it came out.

Markoff: And so if your brothers went into the family business, was there something--why did you go in a different direction?

Tevanian: I was always the different one, so when I was very young they knew that I had an aptitude for math, is what it turned out to be. So we'd all be in our station wagon driving along, six of us, two parents and four kids, and my dad would be shouting out math problems for me to solve. It would be multiplication tables or things like that, but I was always the one that got good grades in school and

homework was easy and it was more challenging for my brothers. It was always informally known that I was kind of going to be the one to go off and do something different.

Markoff: Did you say you were the first?

Tevanian: I was the oldest, yes.

Markoff: Okay.

Markoff: Any idea where the aptitude for math came from?

Tevanian: I think both of my parents were pretty smart. I can't say that either one of them was particularly good at math, and I'm pretty sure that by the time I got to high school I was doing more advanced math than they knew about because they never helped me with homework and I'm not sure they could have at the time. It's just I got that gene from somewhere and I had a love for it, and I think maybe that's part of the genetics, too.

Markoff: And in that period in the '60s when you were growing up, religion and politics in your household, were there...

Tevanian: The religion was minimal. My mom was somewhat religious, from Massachusetts. She was a regular churchgoer, but we had all worn her down and the extent of her religion at that point was to try to get us to go to church for Christmas or Easter or something like that. Minimal politics. My dad leaned Republican as a businessman. He did run once for some city alderman position, and he didn't know what he was doing and he didn't win, but he only did that once.

Markoff: Once, yes.

Hsu: Was your mother Orthodox?

Tevanian: So I don't even know. My mother--I don't know.

Markoff: There was an Armenian church, though.

Tevanian: There was an Armenian church. That was a big deal in Worcester where she came from. In Portland, there was an Armenian community, which I think went to an Armenian church or an Armenian-dominated church. I'm not sure because that was not my thing.

Markoff: Yes. And Portland, Maine, in the '60s and '70s, it was big enough that you wouldn't call it a small town, right? How would you describe Portland, you know, your community in Portland when you were growing up? Was it suburban or urban or?

Tevanian: So I grew up--we lived in Portland when I was born and we moved from Portland to a neighboring town, Westbrook, when I was in second grade. So I was maybe six or seven years old. Westbrook was definitely the suburbs even though it was only four miles away, so I consider myself as growing up in the suburbs. And when we got old enough we had dirt bikes and we literally drove the dirt bikes a quarter of a mile down the road to where the trails were and there were trails there.

Tevanian: It's probably worth mentioning. I mean, my brothers and I--me being more of an academic-type person--had this exposure to all these things that academics normally don't get exposed to, like we'd go dirt bike riding all the time over huge jumps doing crazy things that we look back, we don't know how we possibly survived. With my brothers, we literally built a boat and it was a high-speed boat that went 90 to 100 miles per hour. It was called a drag boat, quarter-mile drag boat, for the time it would have been called “mail ordered” a small, fiberglass hull from somewhere in California that got shipped out. Actually, that was our second boat, our first boat we literally got plywood, we bought frames, plywood-ed it and fiberglass-ed it ourselves. That boat probably went 70 miles an hour, and my brother and I were driving it one time. And I looked over the side and I see this blue flap, and it was fiberglass starting to come off. I motioned to him, said we'd better go back quickly. When we got back, it had all ripped off from the bottom just to plywood. So it was interesting growing up in a family like that because of all these other experiences that I think most of the people I know today never had anything like it. Somehow we all survived it.

Markoff: In your school, in Westbrook, science and technology, did you get exposed to--besides sort of math, was there--I guess I would call it fallout from Sputnik? Did you have a science education?

Tevanian: Yes, we had a science education and a math education. We're talking rural Maine now, not way out in the boonies but we're near Portland so we've got good teachers. We've got money for the schools. We've got good schools, and to me it was a good exposure. Westbrook had a very good school system, and today you go to a lot of schools and there's all these different lanes and different tracks and you're on the advanced lane where you're learning Calculus as a junior or even earlier sometimes and the low lanes where you're kind of struggling to get algebra done. We had one lane with some honors classes and that was it, and that was only in math. We had that in some science, too, but I feel I got good, solid exposure to the sciences which I liked and to math which I liked, and I think maybe more importantly, I think I was lucky in that the school--when I went to high school, in eighth grade, as I was

preparing to go to high school, the school knew that I had some good math aptitude, and so they kind of singled me out maybe along with a few other kids to show us a few extra things and give us extra stuff. So I remember so vividly when I was in eighth grade at the high school orientation, they pulled me in and they said, "And we have a computer." And I didn't know what a computer was. Okay? I didn't know what a calculator was, nothing like that, but they had a PDP-8/E. I didn't know what it did. It was just this box that had some flashing lights, and I just fell in love with it. I'm like, high school is going to be so cool, and it was. I had a teacher. I had the same math teacher for three years, Mr. Small, sophomore, junior and senior years. He had an advanced honors math class which I was in, and he would do other things after school that would enrich us even more so while we did most of our PDP-8/E programming after school--kind of come in and use it, right, for as much as you want, and only a handful of us have ever wanted to. But he would do other things like offer a special class to learn programming. We had an Olivetti cash register that could be programmed in some way I can't even remember now, and so I would get access to all these sort of extracurricular things.

Markoff: So this is--by now we're in the early '70s or is this...

Tevanian: Well, now you're in mid- to late '70s.

Markoff: Mid- to late '70s, okay.

Tevanian: Yes.

Markoff: So was the PDP-8 connected to the outside world with a modem or anything, or was it just a standalone...

Tevanian: It was a standalone computer with two ASR-33 teletypes, which is where the normal--the quote, computer science class--there was no computer science class. There was a math class where you learned a little bit about programming it, and you always used just the ASR-33s but again, they would let me go after school and load up different things into the computer, so everyone is using BASIC. I would learn FOCAL. I would learn how to program from the switches on the front, and I would write, obviously, my regular BASIC programs but I could just do all these other things just to learn extra stuff that wasn't even being taught in class.

Markoff: FOCAL was lower level or what kind of a programming language?

Tevanian: It was another programming language. I can't even remember any details, but it was BASIC-like, I think. What really excited me was programming at the switches. You select the address. You select the data and "load," and that was it and then "run" when you're done.

Markoff: Is that machine or assembler? Where would you...

Tevanian: Machine code.

Markoff: Machine code.

Tevanian: Yes, you wrote out the bits.

Markoff: [inaudible] the way you could go.

Tevanian: Each switch was a bit. I think that was the best.

Markoff: That's great. That's great. And so would you call--Mr. Small, what did you think of him as a mentor? Did he take you under his wing, kind of?

Tevanian: I think he did. It was the computer stuff. He sponsored our math team. I became the captain of the math team, had tremendous fun with that. He'd give us all this extra stuff to do outside of class, and interestingly, through all this, I thought I was going to become a statistician because I was told by--they would have career people come in for career advice--and they said, "All you guys that are really good in math, you're going become statisticians."

Markoff: And now that would be a perfect career choice because you could have gone right into machine learning and you'd be set.

Tevanian: Yes, yes. Actually what happened was I think it was either my junior year or senior year we got some new-fangled Data General computer that had memory and our programs could be stored on it. This was a whole new paradigm for us programming, and it had much more advanced BASIC, and it had other ways to interact with it and you could write real games and stuff on it. I remember when I got to the school the PDP-8/E was already installed, up and running, but for the Data General, it took a week for some technicians to come in and set it up and test it and do whatever they did. At that point, I said that's what I'm going to be. That's going to be my job, one of those people.

Markoff: When you talk about--did it come with games? Was Adventure on it or were there--and were you taken with games at all or were you more interested just in...

Tevanian: This was before Adventure. There was some game on it. I think it was a very basic game that would have been a teletype-type game. I don't remember what it was, but I did love it. I did love it.

Markoff: And did math take over your life? Were you a math geek or were you--were there other subjects in school that caught your interest?

Tevanian: So I guess I was probably a math geek then because the computer science part of it was very minor, although I liked working with the computers much more. I also enjoyed some of the sciences. I really liked physics, for some reason. Something about that really, really resonated with me. But when I went to college, then it wasn't about math. It was about computers, and I went to University of Rochester which didn't offer a computer science program, knowing I wanted to do computers. So I was still sort of a quote-unquote "math geek" because I had to get a degree in math. That's all they offered. There was no computer science degree, but I spent all my time working on computers.

Markoff: And before we leave high school, outside pursuits like sports and reading? Were you a jock at all or...

Tevanian: So that's an interesting question because in middle school, of all things, it was all intramural sports and I literally played every intramural sport that you could play and I won an award for that in my eighth grade, most intramural sports played, something like that. By the time I got to high school, I wasn't good enough at any of the sports except for bowling because we owned the bowling alley. Very good bowler, probably could have become a professional candlepin bowler, but I wasn't really good enough at the other sports. I think it was more I wasn't big enough to play the other sports, so I didn't do them in high school other than recreationally occasionally with friends. I then got bigger in college for some reason. I had a big growth spurt in college, and I'm actually much more athletic now than I was in high school. So never got into sports per se. That having been said, my family spent every summer on a lake nearby where we had a summer place and so I became a very good water skier. To some people, riding dirt bikes and things like that is very much a sport in that it takes a lot out of you. When you're out on trails and it's bouncing around and you're hitting jumps and doing corners and everything else, so there was that aspect of it.

Markoff: Did your dad's background as a machinist carry over? Did you get into tinkering, or was there a machine shop at the house?

Tevanian: He had a machine shop at the bowling alley. We'd always joke it was behind the machines. You had the front of the house and then you've got behind the machines, and usually the only time you go behind the machines is to fix them. He would go behind the machines to build things, and so he would buy equipment, lathes or massive drill presses, whatever, and during the day when he's supposed to be working up front he would have someone else work up front and go in back and just build things. On the

weekends, he'd sometimes bring us in and show us how to do things but I personally had no aptitude for that. That was my brothers. We built that boat. We built an engine from scratch. We went down to a Chevrolet dealer and ordered a bare block, and they're like, "What? Yeah. Okay, we'll order it for you." They shipped it to our house, and we bought all the other parts, and built the motor. That was all my brothers because they had much more aptitude for that than I did, but I got to see it all happen.

Markoff: And in high school, did you have any--did you work in the family business or did you have jobs?

Tevanian: Good question. In high school, on weekends, definitely worked at the bowling alley, help out in the morning on Saturdays and Sundays when it would get busy, sometimes help out during the week in the evening when there is a big league night but not too much because we had school to worry about. The first real paying job I had was after my senior year, just before college, at a paper mill called S.D. Warren. And I won--if you can win a job, I won this job. They gave this job to a couple students in recognition of some academic whatever. They were the local company in Westbrook, and so they gave a couple jobs and the job was “outside crew.” You may ask, well, what's outside crew? Let me just say when we didn't have our normal job to do, we would go and we would sweep parking lots. So we would do things like you'd go on the daily run around the paper mill to empty the trash cans. You would be called, on occasion, to clean out a sewer which meant taking these massive hoses with these water jets that shot backwards, sticking them into the sewer and firing it up and just having it bore through the sewer. It was a paper mill. These things would get plugged a lot, and you just do all these crazy things throughout the mill. So that was my first real job. It was just interesting because the next summer I worked at the paper mill again, but I worked in the Research Department programming their computers.

<laughter>

Markoff: And what kind of machines did you have? That was still in high school.

Tevanian: No that was after one year of college, after my freshman year.

Markoff: And the corporate computers of that era, what did you--do you remember what they--were they DEC minicomputers or...

Tevanian: So this was interesting because it was in the research lab, and it wasn't really programming the corporate computers. We got to do research projects where, for example, so they would make paper and they would coat it. And there's all these different coatings you could do. In the research lab, they had a small-scale prototype coder where they'd run experiments, and they had a control system on it that was unlike what was in the mill because in the mill it just did one thing. But we could fully program it to control the coder and mostly get readings off it to figure out temperatures and all kinds of other things, and I got to do the programming on that which I think was probably controlled by Digital Equipment, probably PDP-

type stuff, and I loved that because I got to work on all these programs to control equipment, I mean control real equipment. I could control digesters that would cook the pulp as it was being prepared to turn into paper to control the temperatures and heat and everything else, and I could control the computers to basically run and monitor this coater. It was very cool stuff.

Markoff: And so in that period through high school, so personal computers were starting to show up in the world. Microcomputers were starting to show up in the world in '75, but it sounds like you sort of grew up on minicomputers. When you were high school, did PCs show up at all in your--you didn't see that issue of Popular Computing that had the MITS Altair on the--it wasn't Popular Computing. It was Popular Electronics. It had MITS Altair on the cover or have your own computer kind of thing.

Tevanian: That was not even on our radar screen. The closest thing that we had to that was I had the top-of-the-line TI handheld pocket--not pocket, the big TI calculators back then.

Markoff: Yes, which were programmable.

Tevanian: They were programmable, yes.

Markoff: And then in terms of going to school, what determined where you went to college?

Tevanian: Almost accidental. Obviously, neither of my parents had gone to college. They were not--they were smart. They were not highly educated, which was not uncommon back then. I had—I mean I was literally going—high school for me was day to day, whatever. Right? I'm having fun on the math team. I'm having fun programming computers and no long-term planning. Someone's telling me I'm going to be a statistician, but I'm thinking I'm going to be a computer technician installing computers, whatever. And I realized at some point that I was going to go to college, but I knew nothing about college. I knew nothing even about the application process, and then I started hearing in the fall of my senior year about some of my friends who had been getting some early acceptances at colleges. I'm like, really? I didn't even know you were supposed to apply now. Right? And so somehow I figured out--and I think my parents started helping me a little bit, probably mostly high school counselors--yes, you need to apply to college. I had won this award called the Bausch & Lomb Science Award, which was awarded by Bausch & Lomb in Rochester, New York, back in the day. They gave this award to an outstanding science student in every high school in the country. One of the benefits of that was you got a free application to the University of Rochester. This is a really kind of a sad but funny story. I had heard of Rochester Institute of Technology, being a technology person, and I figured that was one of the schools I would apply to. So I'm given this free application from the University of Rochester. I think they're basically the same thing. It never occurred to me they were different. I'm like, this is great. I get to save 50 bucks, enough to pay them for the admission fee. so I sent it in, and I sent in a couple others. The ones I remember I applied to were Rochester, Princeton, MIT, and Tufts. Both Princeton and MIT said no. MIT

said no because they didn't like my essay, and I remember at the time I made a mistake of not having anyone help with my essay. I'm sure it was a disaster, which in retrospect I should have done differently. Both Tufts and Rochester accepted me, and so we figured I'd just go to Tufts because it's pretty close. We drove down there one day and it seemed like a fine school, and so we went. That was a fine trip, but then a friend of our family said, "You know, you should look at Rochester before you make the final decision." So my dad and I got on a plane, first time ever getting on a plane. We had to take a connection to get to Rochester, New York. I remember going there, and they said, "You know we don't have a computer science program." I think Tufts might have had a minimal computer science program. It was pretty rare. But they took me in, they had graduate students, graduate computer science students. They took me into the lab where the graduate students were and they had a Xerox Alto, and I didn't know what a Xerox Alto was. But they showed me this computer with a spinning globe on it, so here I am coming from a PDP-8 and I see a computer with a graphical display with spinning color earth graphics. I was just blown away. I didn't see anything like that at Tufts, and I'm like “okay.” Even though these are graduate students and they said, "By the way, you know we can probably get you in here and give you some access." I'm like, I have to come here, so I decided to go there.

Markoff: And so what year did you enter?

Tevanian: '79.

Markoff: '79. Okay, so the Alto was pretty mature at that point. It was...

Tevanian: Relatively. It was rare, but it was relatively mature.

Markoff: Do you know why they ended up--why Rochester? Was there a factory in that area?

Tevanian: Xerox.

Markoff: Of course. Yes, of course.

Tevanian: Xerox was a big supporter of Rochester.

Markoff: That's right. That's right.

Tevanian: So it was all accidental. I thought I was applying to RIT, and I finally get to Rochester. That's actually a different school, but it's okay. It worked out.

Markoff: So before leaving high school, did either video games or computer networks show up on your radar at all? Video games were out in the world.

Tevanian: We had a Pong. Okay, so we had the first Ataris that came out.

Markoff: At the bowling alley?

Tevanian: No, no, no, on our TV at home.

Markoff: Okay.

Tevanian: And I loved those things. Right? The video games in the bowling alleys came a little bit later, but remember you could get Pong and you could get the basic Atari thing. Maybe you could get the video games in the bowling alleys then, too. I don't remember, but it was very cool to have it. You could get Pong. That's right. Pong was first, and so I remember falling in love with all that stuff. To me, the notion of being able to program those things myself was completely foreign. That was something way beyond what I even thought possible, at least for myself.

Markoff: But the family had one of the video game, like an Atari or something they could play?

Tevanian: Yes, yes, yes.

Markoff: But you weren't programming that. You were programming real computers.

Tevanian: I mean you couldn't really--it was an Atari game console, and you bought the preprogrammed games. You couldn't program them yourself. It was a big deal to program them.

Markoff: Yes, yes. Tell us about the University of Rochester and sort of what--showing up as a freshman, what was it like? Were you living in a dorm?

Tevanian: Living in a dorm, I remember it was very hard for me because I'd never been away from home before, completely isolated. No internet to send emails to friends or family, no unlimited cell phone plan to call home. There's one phone in the dorm, and you have to pay long distance charges which I couldn't afford. So I was isolated, and to make matters worse, I go to my first orientation meeting with a bunch of other freshmen, and they're all saying, "What's that weird accent you have?" I had a really thick Maine accent at that time. I'm like oh my God. I didn't even know I had an accent. What are these guys talking

about? They're all from New York and everything else. And so it was very hard, yet by those days standards they had great computing facilities, and again, no undergraduate computer science program as a degree but they did offer some classes. So of course, first semester I signed up for Intro to Programming, whatever it was. We learned PASCAL or Fortran or whatever, and so I got an account on the IBM 370 or whatever it was at the time, the big computer, punch cards and everything else. That was for classwork, and so I started using that. I found another friend in my dorm who was also into computers. He wasn't quite as good a programmer as I, but I would be in my dorm writing my programs and then taking them in to the punch cards. Remember, in those days you had an allocation of computer time, and it was all normalized to dollars. So we had like, say $100 for the semester. I used it all up in two weeks just writing my own programs and experimenting. One of the first programs I wrote, even without any assignments was a program that would print posters because we wanted to put posters on our walls in the hallways of the dorms. We had no way to do that, so I said I can write a program. I designed a font and did it all. I encoded it myself and then wrote a program. You just put in the cards, posters are going to print out, and I got in big trouble for that because I had these huge printouts coming out which some guy would cut it off and bring it to you and start yelling at you, "Why did you do this?" So I got in trouble for huge printouts. I got in trouble for using up all my money, but that was a blessing in disguise because within the first couple weeks of this class I had to go visit my professor because I had no computer time left to do my homework. So I had to explain to him how I'd used up all my computer time, and I was in fear. But in retrospect, I realized he said, "Okay, this guy has self-identified as someone who is really interested in this." So not only did he fix my problem with the computer time, he said, "I want to introduce you to our graduate computer lab."

Markoff: So you got back to the Alto.

Tevanian: So I got back into the Alto. No, not quite into the Alto then, but I started getting jobs working for computer science faculty working side by side with graduate students getting paid a reasonable amount of money. I wasn't expecting to get any money, but they were paying me now so in evenings and weekends I would go in there and I would either do the work I was supposed to do for the professor or teach myself how to program the Alto. A lot of the programming work I was doing was on a VAX at the time, so I got to use all the different systems.

Markoff: So you moved to computing right from the--what was the math scene like? Did you stay in the math program and was it competitive, and how did you stack up against when you got to college? You'd been a math star. Were you still a math star?

Tevanian: Okay, so my ego is usually in check, but there's one thing I have to say, which is at orientation they had us all in a big auditorium, all the freshmen. They said, "Okay you guys, you're all one of the top students at your high school. Now you're just one of the normal people." That scared me, but I still had no trouble there, and in the math stuff I was able to stay ahead of everybody. Computer science stuff, clearly it was still not a problem, so I felt good about that. The math stuff I had to do because it was my

degree. The math was getting pretty abstract and pretty complicated and certainly in the later years with the really advanced classes, I was more in the mode of okay, I'm just going to figure out how to get an A in this class as opposed to really learning it, and that's what would start to happen. I know every once in a while I'll find some old document in the closet. I found one a few years ago which was some old math notes I had, and I looked at them. I didn't even know what they were about. I've lost so much of that knowledge. On the other hand, I remember I was still into sciences, and so I took chemistry and physics and other classes almost for fun, which in retrospect was kind of crazy, but I remember I took a lot of advanced physics classes and I remember even though I was in advanced math, we got to a point in physics where the professor said, "Okay, and so now we're going to do some differential Calculus that you guys haven't got to in math yet, and so just trust me that this is how it works." And that's when I said, "Okay, this physics is getting a little too complicated for me." So particle physics and quantum theory, and I stopped. I'd had enough of that. And then, I just focused on the math but my time was all about the computers, and it wasn't even about the--I took some good classes in compiler theory and other things where I learned how to build compilers and did interesting things there, but it was all about being able to work with faculty and doing actual research with them where they were doing research projects, and I got to contribute to it and doing fun things myself. You asked about games before. I started writing games on Altos.

Markoff: So what were early games that you wrote on? I may have played some of your games.

Tevanian: You probably have. I forget what order I wrote them in. I think the first one I wrote--I did knockoff games because I wasn't creative enough to do original games. The first one was a knockoff of Missile Command. I think that's the first one I did because it was relatively straightforward for the graphics capabilities of the Alto at the time, didn't require too much microcode. Then, the second one that I did was Defender, and Defender was tricky because the graphics on that are very intense, and I had to write most of the game in microcode.

Markoff: Oh, wow. Was there Pascal? Well, there's Smalltalk. Right. Did you learn…

Tevanian: No. Smalltalk was useless for games.

Markoff: Yeah. <laughs>

Tevanian: Okay. I wrote in microcode and BCPL. Didn't spend any time really in Smalltalk. That was too abstract a language for me.

Markoff: Yeah. And how about, I mean, Alto was such a statement about an interface at that point. I mean, you had been in this ASR world and all of a sudden you were in this human-machine interactive world. Did that play a role in shaping your outlook about computing?

Tevanian: Probably. You have to remember, I was still doing a lot of programming on the VAX, too. So I had a normal, was it a VT 50-something or other, screen that I spent probably almost as much time using for, you know, when I'm running my compiler I'm doing that. I was doing some VLSI design work, some design checkers. I was using that with big data. So I spent probably roughly equal amount of times and… But I really loved the graphics part of the Alto and just what I really loved about the Alto also was the fact that you could write microcode and you could get right in there and it was literally the case that your program could break the computer. If you didn't have the right wait states in the right spots, bad things would happen to the computer, and so you had to be really careful about that, and there's something about that. I always liked to be really close to the metal.

Markoff: Did Maze Wars exist?

Tevanian: I think so. I think.

Markoff: And were they networked? Were the Altos connected?

Tevanian: The Altos were networked and my advisor later on at Carnegie Mellon, Rick Rashid, had written with Gene Ball, Trek, which inspired me to do the other games.

Markoff: Okay. Okay.

Markoff: Oh, so you saw it before you met Rick or…

Tevanian: Rick had already left. Rick was a graduate student at Rochester just prior to my arrival there.

Hsu: I see.

Tevanian: And then he went off to be faculty at Carnegie Mellon, and so I was able to see Trek, which of course, I loved.

Markoff: Yeah. Yeah.

Tevanian: Right, and that was clearly one of the, that's probably one of the very first network games.

Markoff: Yeah. Were you already, just in terms of your studies and your interests, was there already an OS direction as an undergraduate?

Tevanian: No. Because people didn't really talk about OSs then. I would say it was an interesting low-level software, so…

Hsu: Close to the mission [ph?].

Tevanian: Was there an OS on the Alto? Yes. Did I care about it? No.

<laughter>

Tevanian: Because I was writing to the bare metal, and as soon as you launched the Defender program, it took over everything. I didn't use any of the UI elements that the OS provided. None.

Markoff: Yeah.

Tevanian: So that never really occurred to me. All the interesting, to me, all the interesting games, Trek, I loved Clint Parker's pinball game. Remember Pinball? That was awesome. These are things that motivated me and they completely took over the whole computer.

Markoff: And did you have a view into PARC? Did PARC show up on your worldview as an undergraduate? Were Alan's group, LRG or any of the other…

Tevanian: Not at all.

Markoff: Yeah. That's interesting that it's so disconnected.

Tevanian: And, you know, well, I should say if it did I don't remember. This was long time ago.

<laughter>

Tevanian: So it's entirely possible that it did, it's just that I've kind of blanked it out.

Markoff: Yeah, yeah. And so at that point had personal computers begun to be accessible at Rochester or were you still a big computer guy?

Tevanian: Personal computers were accessible.

Markoff: I guess the Alto is a personal computer.

Tevanian: There was an undergraduate lab, which fortunately I didn't have to use.

<laughter>

Tevanian: Which had, was it the Commodore PETs?

<laughter>

Tevanian: And then they had some Apple IIs, and so before I got to spend a lot of time in the graduate lab, I did spend some time there, which, again, this was all outside of class. But I would do silly things, like I would create-- so let's say there was eight of these computers. I can't remember whether it's the Commodore or the Apple. I don't remember. I would write a program that would play music and I would have an instance running on each computer simultaneously each playing a different part.

<laughter>

Hsu: Ohhh.

Tevanian: I would do stupid things like that.

<laughter>

Markoff: That's very cool. Yeah.

Markoff: The audience in that case was you?

Tevanian: It was me.

<laughter>

Tevanian: It was me. Just to show that I could do it. You'd have to figure out a way to get them all started at the same time. But that would probably be by bringing in friends or something.

Markoff: Yeah, yeah. That's a classic hacker behavior**.** Yeah. I mean, you were pushing the machine to its limits just to--

Tevanian: Yeah. I would just try to think about what could I possibly make this thing do that it's never done before?

Markoff: Interesting, and how much of your life was computing during college? I mean, were you just sort of swept into the computing world and…

Tevanian: I was swept into it. All my spare time. Okay. So today it would be worse because today you're always connected, so, you know, at least then when I went home I was disconnected. But I would be connected a lot in the office or in the lab for many, many hours.

Markoff: Yeah. Was Rochester an ARPA site? Did you have connection to the ARPANET, or was it something that you were aware of?

Tevanian: I don't think we were an ARPA site at the time because we did all of our external e-mail with UUCP and Usenet. So we probably were not an ARPA site at the time or may have just been barely coming in.

Markoff: Yeah. Yeah. And in terms of the people who were influential, do you remember any of the computer scientists at Rochester as being very influential on your development as a young computer scientist?

Tevanian: This, again, this is a long time. I remember… First of all I remember a lot of them were tall.

<laughter>

Tevanian: And I'm tall. I wonder if there's some correlation between tall and computer science. I was thinking that at the time. This is interesting. They're all six feet and above and I'm like 6'2", 6'3". So that was the first thing that I thought was an interesting correlation. There were a bunch of guys that I have a hard time remembering their names, who are very influential. One was I already mentioned Clint Parker, who--he wasn't that active when I-- he was officially a graduate student but he wasn't that active. I think he'd been there for a while. He had done the pinball game and he had done a lot of really low-level,

groundbreaking Alto stuff. I know I leveraged some of his stuff in some of my games. He would do, like, he wrote the classic, super-fast multiply/divide for the Alto and I lifted that and put it in, and there're a few other things that he had done that I would just kind of take from. I was inspired by the work Rick and Gene had done on Trek even though I'd never met them. There were some people there who were starting to do some experimenting with networking, which I was just kind of learning about. I don't remember who they were. But it's so long ago. I definitely had good relations with faculty. You know, the person I was working for for most of the time was a VLSI design person, and at that point in time the design tools for VLSI were very primitive and he hired me to write a design rule checker program, which had never been done before. Where you make sure it's actually probably going to work and not, you know, short-circuit immediately. I did some computer vision work, very early computer vision where the hard-- I mean, you had to, like, figure out how to do an edge detector, right? And now that's all given, right?

Markoff: <laughs> Yeah.

Tevanian: Well I think his name was Chris Brown, who was doing some early work in computer vision, which now seems so basic, and then I got, I had a good relationship, with-- his name escapes me. It'll come to me. Jerry-- it'll come to me later. He was the department head who helped me get into grad school, as it turns out.

Markoff: And questions about your games. First of all, Defender was graphic intensive. One of the innovations of Alto as I remember it was BitBlt, and I wonder if BitBlt was something that was what you used or that you knew about in terms of its graphics capabilities?

Tevanian: I knew about BitBlt, and BitBlt was important for the games, but Defender had a unique sort of challenge, which is it drew a landscape in real-time at the bottom of the screen that was basically random. Not random but it was, oh, it was like a squiggly line. Okay. It wasn't just a line from one point to another, it was thousands of points, okay, and it had to be drawn in real-time, and BitBlt was useless for that, and so I had to code that by hand. There was, I coded one instruction which would draw the landscape, and another instruction which would erase the landscape.

<laughter>

Tevanian: And so as fast as it could, basically 60 times a second, it would erase, then redraw, erase, then redraw, and try and get display sync just right.

Markoff: That's good. Yeah.

Tevanian: That was only way to do it.

Markoff: And did these games give you a reputation? Was there already a community of people who would value?

Tevanian: I never thought about that at the time but probably. There weren't a lot of things like that for the Alto, right, and I do know these games spread to the other--

Hsu: That's what I was thinking.

Tevanian: --sites that-- as everything did. Everything good got spread out, so it did spread to other Alto sites. I can't say that I can look back and say that caused me to meet more people or whatever. I just, I just don't know.

Markoff: Yeah, okay, and so were you always, at this point, you were always-- so I'm just wondering about high-level languages and what the gestalt was or the sort of, at Rochester at that point, was it a Pascal world? What was the, sort of the high-level language that was fashionable, and did you have to spend time with it?

Tevanian: So from an academic perspective teaching the masses of undergrads, it was Pascal. They offered some more advanced classes where you could do more, you could learn more languages, and in particular I remember there was a language class, part of which-- well, I think there was a language class and then there was a compiler class and in the language class we learned a lot of languages. I remember doing homework; there was one homework where you had to write a text editor in SNOBOL, of all things. So I do remember learning a lot of languages, at least at a peripheral level. Enough to do a command line-based text editor back at that time.

Markoff: But when you graduated, you still graduated with a math-- not an applied math degree, a math degree?

Tevanian: I had graduated with a BA in Math.

Hsu: Math. Yeah, yes.

Markoff: And tell us about the sort of the path from Rochester to CMU and the help that you got from the chair.

Tevanian: It's Jerry, and his name is Jerry Feldman.

Markoff: Oh, my God. Okay.

Tevanian: Yeah, and you know Jerry Feldman.

Markoff: I do know Jerry. Yeah, yeah.

Tevanian: Lot of people know Jerry Feldman. So Jerry was the chair of the department at the time, and I got to work with him a little bit. He got to know me. So if you think back to what I said about high school, I was going to be a statistician, right? Well, so I'm thinking as an undergraduate in college now, I'm a pretty good programmer. I've done a lot of work for the faculty, writing code. Not research, per se, but, you know, some good work under their direction. Okay. Well, I'm going to go get a reasonably good paying job at Microsoft who does all the professional software, right? So that was my thinking certainly at least through junior year. But Jerry and others said, "You know, Avie, you should take a look at graduate school." They thought I'd be a good candidate for graduate school. I'm like, "What are you talking about?" It never even occurred to me. I'm lucky to be even-- I'm going to finish college. This is totally cool. First one in my family. But I was working with researchers now, so I saw what they did, and somewhere along the way what I did was this work I'd been doing on the VLSI design, design rule checker, I had built a interesting piece of technology which would do, using the C language, which would-- it was a dynamic mark and sweep type garbage collector to automatically manage data structures without having to write any code. That no one had ever done before and it's kind of interesting. I pre-processed the header files and I added to them and recompiled them and did all this other magic with a run-time library and could garbage collect in real-time. It was pretty cool for what it was, especially for an undergrad, and I wrote a paper on it, and I didn't even submit it for publication or anything but I figured, "This will just be a cool thing," and the faculty I knew was helping me with it, and so it's a bit of unusual research for an undergraduate to do, and so the faculty said, "Look. You should at least look at a graduate program before you go off and get a job." I said, "Okay. I love working with you guys. I love this research stuff. Why not?" and so I said, "But I'm only going to do that if I can go to either Carnegie Mellon, Stanford or MIT."

<laughter>

Tevanian: Okay? "And if I can't get into one of those then--" and they kind of agreed with me. They're like, "Yeah, absolutely."

<laughter>

Tevanian: And so I applied to all three and Jerry wrote me letters of recommendation. I had a research paper that I had written. Lo and behold, I got accepted at all three.

Markoff: Three. <laughs>

Tevanian: Okay. And so I'm like, "I guess destiny is that I go to grad school."

<laughter>

Tevanian: So that's how that happened.

Markoff: And how'd you choose which of the three? That's really interesting.

Tevanian: Okay. So the way I choose these things seems strange. I mean, you go back to the Rochester thing. So here's the way that works. So I get letters of acceptance from all three, and Carnegie Mellon, in their letter of acceptance or maybe in a quick follow-up, says, and, you know, "We'd love to--" they're all saying, "We'd love to see you come," right? Because they don't accept everybody. There're 15 maybe a year at those places at the time, and they're like, "Come visit us. Call us up. Tell us when you can come down. We'll schedule meetings and everything. We'll take care of everything." So I called them up and I went down. It wasn't too far of a trip. Easy drive down to Pittsburgh, and loved it, and so I then tried to talk to both. Like, I talked to both Stanford and MIT to try to do something similar, and so I called MIT and they said, "Oh, we don't do that."

<laughter>

Tevanian: "We expect people that we accept to come here." I say, "Okay. Well, you turned me down once; I'm going to turn you down this time."

<laughter>

Tevanian: And then Stanford said, "Yeah, we can host you. We don't always do that. We'd love to see you come out, but, you know, no, we can't pay for a plane ticket and no, we can't give you a hotel or anything." I'm like, "Mm, screw that. If I want to go to the West Coast, I'll go there for a job after I graduate from Carnegie Mellon." So Carnegie Mellon was very good about this and they weren't real, I mean, they weren't the name brand school, right? So I would talk to my uncles back in Maine who had heard of Stanford and MIT but had never heard of Carnegie Mellon, and they're like, "Wait a minute." Especially MIT. If you're in Maine, MIT is, like, it. "You've been accepted to MIT and you're not going?"

<laughter>

Tevanian: I'm like, "Trust me. This is the right thing." But when I visited Carnegie Mellon it was just, you know, I loved it, just like I loved Rochester when I went there, and they were very welcoming and they had a, from what I could tell, a great program. It was a great program.

Markoff: Yeah. Go ahead.

Hsu: So you applied to those three because they were the three top programs or they were the ones that the faculty recommended?

Tevanian: Those were the three top programs.

Markoff: Yeah, yeah, yeah. And just--

Tevanian: There were some people that said, "Why didn't you apply to Berkeley?"

<laughter>

Tevanian: And I said, "Because Berkeley was number four."

<laughter>

Hsu: Oooh.

Tevanian: Sorry, Berkeley fans.

<laughter>

Markoff: Yeah. And before we leave college, outside of computing, social life, sports, what was, what did you do besides compute while you were…

Tevanian: So what did I do besides compute? Nothing of interest that I remember.

<laughter>

Tevanian: So, you know, I still had, you know, interesting summer jobs but that's just all around computing, although when I was in, as an undergrad I would still go back and we'd go to our summer place on the lake and so that was a nine-to-five computing job. You left it there because there was no way to compute remotely and everybody left at five. The place was shut down and then I'd come back to the lake and go waterskiing with my brothers or boating or whatever, and we'd go dirt bike riding, you know, all of those kinds of things. But there wasn't that much else.

Hsu: Yeah, hm, yeah. Before we get into the--

Tevanian: Yeah.

Hsu: --CMU section, could you tell us more about the other research projects that you were working on at Rochester and some of the other programs that you wrote?

Tevanian: So the two research projects I remember at Rochester were the VLSI design tool and the computer vision work. I don't remember the details of the computer vision work. Those were the only ones that I really remember and frankly those are probably the two major ones that I did. If there was anything else, I don't really remember what it was, and then everything else was all my personal programming projects, and I always took some kind of computer science class every semester. There was plenty that were offered. I took them all. But probably the most time was spent on my own projects and then the big ones I think were definitely Missile Command and Defender. Those took a lot of time.

Markoff: Go ahead.

Hsu: And VLSI design, was that because Rochester had that connection to Xerox? Was that coming straight out of Xerox PARC?

Tevanian: We had someone on faculty whose area was VLSI design, and I don't know why we did but we had a diverse set of faculty.

Markoff: Did Conway & Mead exist by that time? That text about VLSI design, or were you--

Tevanian: I think so. I think so.

Markoff: Yeah. But that was a graduate level text probably, not for…

Tevanian: You know, I remember taking a VLSI undergraduate class. We built a basic circuit, sent it on for fab.

Markoff: Oh, so there's…

Tevanian: But it was very basic, and I think as I recollect, that helped me a little bit to at least understand what I was working on on the design rule checker.

Markoff: Yeah, yeah. And while you were there, did the IBM PC emerge and did there become a culture of the IBM PC-style computing, DOS, did that all happen while you were an undergraduate?

Tevanian: Gee. You can look at the calendar. Yeah. It would've happened when I was an undergraduate just based on the calendar, but it--

Markoff: Didn't say--

Tevanian: --never-- I was always doing much more interesting things. I mean, programming on a VAX was way more interesting and programming on an Alto was way more interesting yet again. So why would you ever use an IBM computer? And again, if I wanted to do anything, I could always go use the Apple II or the Commodore PET, which in many respects was even more interesting than the IBM.

Markoff: And did computing ever, did you live in a dormitory the entire time you were at school or did you move off campus or…

Tevanian: So it was different every year, so my freshman year I was in the dorm, sophomore year I was in an off-campus school-managed, two-bedroom apartment with a friend. Junior year I was back on campus in a suite with five friends, and then senior year I was in an off-campus apartment with a couple friends that was on the school shuttle.

Markoff: Yeah, yeah, and did you ever have a, not a home computer but a computer that, you know, that was not a work computer? So did that transition happen while you were in school, like, in your dorm room or in your bedroom?

Tevanian: So the first computer I had that was in my room was probably-- think about this for a second. That was probably when I bought a Mac for myself at Carnegie Mellon in 1984.

Markoff: Yeah, yeah. So the Mac happened after you left [Rochester].

Tevanian: Yeah, that's right. Yeah, I was at Carnegie Mellon then.

Markoff: Yeah, yeah. Was it a big deal to buy a Mac at that point, like--

Tevanian: Oh, yeah.

Markoff: --$2400, whatever it was. It was like, was a commitment.

Tevanian: Student discount.

<laughter>

Markoff: That's right. So you were around when, you know, the Mac team was on their tour. Do you remember the Mac, like, did Steve come through while you were a graduate student?

Tevanian: If he did on a Mac tour, I don't remember it.

Markoff: Yeah. Do you remember the 3M machine? That--

Tevanian: The concept of a 3M? Absolutely.

Markoff: Yeah, yeah. Yeah. Because it was--

Tevanian: Absolutely, yeah.

Markoff: But it was bubbling while you were a graduate student, didn't it? Or maybe it was too early. When did it start, '85, '86?

Tevanian: Well, so, you know, I mean, different people have different views of when the first 3M machine was but like the PERQ. What was the name of the company?

Markoff: Yeah, yeah.

Tevanian: PERQ Systems or something like that?

Markoff: Yeah. It was--

Tevanian: Yeah, PERQ. They sort of had one of the first 3M machines.

Markoff: I remember that.

Tevanian: Which, of course, that was a Carnegie Mellon spinout.

Markoff: And it was mouse-driven, I remember.

Tevanian: It was mouse-driven. Yeah, yeah.

Markoff: Yeah. Yeah. I had forgotten PERQ entirely until…

Tevanian: Yeah.

Markoff: So tell us about coming to Carnegie Mellon, entering the program and what it was like.

Tevanian: Yeah. So very different than being an undergrad. I was almost like a kid in a candy store. I mean, they had everything. They had Altos, of course. They had the IBM machines, which I could care less about. They had a DEC-20, which was super-hot, right? And, I don't mean, hot in temperature, it *was* hot in temperature, but super-hot as a computer, right?

<laughter>

Markoff: Yeah, yeah, yeah.

Tevanian: And I could get on that if I wanted to. They had PERQs all over the place, which was totally cool, because not only was it like an Alto in the lab but you could actually get a PERQ in your office, which was, I mean, that was really cool.

Markoff: Yeah.

Tevanian: So from that perspective I was like a kid in a candy store. It was also different in that there were some academic requirements, but they were very minimal, you know. Minimal theory class, minimal-- I probably took four classes. The whole time there. It was-- it was one of the things I liked about it, it was applied research. Everybody there, almost everybody, was doing things that was tangible, that you could see was going to have some real impact in 3 to 5 to 10 years.

Markoff: So what was the process of pairing up with the project or the faculty or, you know, so was it a recruiting scene or did you volunteer? How did you find your way to the project you ended up, and was it more than one?

Tevanian: You know, I don't know the way it exactly happened, but I think there was, first of all, I think Rick may have sponsored my visit to go see the place, because they knew there was a connection there with him being a Rochester grad, and I think I'd expressed some interest in OS level stuff by then. I'd certainly taken some OS classes by then, and so I don't know that they assigned us together. They probably didn't. Other than maybe an informal temporary advisor. But we were sort of naturally drawn together because his area of expertise and research was OSs and he was working on the PERQ systems with the Accent operating system, and operating systems were an area of interest to me and we had the connection with Rochester. So he became my advisor, and most other students who took on Rick as an advisor or he took on as a student, prior to me, would go work on some aspect of Accent, and there were plenty of things, plenty of research to do there, and I looked and I said, "I don't want to do that," and I wanted to do something new, and Accent was fairly mature. It was, they were selling it through PERQ, and I wanted to do something completely new, and I think it was Rick told me, said, "You know, we've got this other thing that we're looking at getting a DARPA grant for. Why don't you take a look at that?" Either he told me that or someone else told me that or I, somehow I discovered that, and I looked into it and it was this project to build parallel computing, if you will. It'd been done a little bit at the time but not really. They wanted to do, they were putting in a grant for it, and so I decided I wanted to do that, and so that was a clean-slate project, which I could basically start with Rick from scratch, and he was very supportive and that's how it all started.

Markoff: Yeah. And so parallel computing was on the horizon. What were the hot-- RISC was a very hot topic there but that was probably more architectural. Like, in the software world, what else was-- there was--

Tevanian: I think RISC came a little bit after, just a little bit after that. Soon after that though. Robotics was starting to get hot.

Markoff: Yeah.

Tevanian: Not like it is today, right? Very different levels. There was a lot going on in theory. A.I. was very hot. Okay. A.I. was sort of one of the newer things. People didn't know it didn't work then. At least they couldn't get it to work then with the resources they had then, but they really were trying to make it work. That was a big one. There was still stuff going on in computer vision, there was stuff going on with transaction technologies, database and transactions. Those are the ones that I remember off the top of my head.

Markoff: Wasn't there a file system project at--

Tevanian: That was later. File systems came a little bit later.

Markoff: Later. Yeah. Okay. And so there was a community of people. Were there other faculty who were sort of alternative universe ways for you to go that you, you know, paths not taken? Because there was…

Tevanian: Well, I'm sure there was but I never really considered them. I mean, I could've gone to work on A.I. I mean, Carnegie Mellon was really leading that then with some of the people that were there. Or robotics. They were leading a lot of the robotics. There were a whole separate robotics area, and no, maybe robotics could've interested me a little because I like doing that kind of stuff. But it just didn't, it didn't click. I just, I think Rick and I hit it off, hit it off pretty well, and I just loved this. It was a ground floor thing that no one was working on at all. It was a whole new project, which got me really excited too.

Markoff: Do you remember the name Red Whittaker? He was the hot roboticist when you were there. You didn't end up doing anything with him?

Tevanian: I remember the name; that's about it.

Markoff: Yeah. And there was, you're right, the A.I. stuff they had there was formidable. I mean, it was--

Tevanian: Herb Simon, Allen Newell.

Markoff: Yeah, yeah. They were the guys, yeah. Yeah.

Tevanian: They were the guys. They were all there doing that.

Markoff: Yeah. Yeah. So the challenge-- talk about getting into parallel computing and the challenges of, I mean, did you-- I mean, I remember that time as parallelization was not working very well. I mean, people didn't think parallel. There were all kinds of sort of threads but it wasn't really, things were not parallelized at that point in the world.

Tevanian: Well, as far as I was concerned, and sometimes I have tunnel vision. This may have been one of the times. As far as I was concerned, we're the first ones doing it and it was an unsolved problem. We're going to make it work. Okay, and it wasn't really going to be-- I never thought of it as a hard problem. It's like, "Oh, you've got--" instead of one computer, you've got four. You just got to coordinate things, right. And people knew some of the basic things like semaphores. Those were known concepts, right, and so to me it was, "Okay. We just got to do some hard work." So we got the grant. Digital had been tapped to build the computer. They were going to take a 780 and turn it into a 784, which was four 780s all hooked in with an inter-connected shared memory, to turn into a 784, which I loved. I loved the 780. I get to use four of them?

<laughter>

Tevanian: This is totally cool and it's all mine?

<laughter>

Tevanian: I get to build the OS for it? There's no OS for it. It was just beautiful, and as part of that they had just come out with the MicroVAX. They gave me a MicroVAX, which I got to put in my office. I had, like, the best computer in anyone's office in the whole school.

<laughter>

Tevanian: And it was interesting, because I got to write the OS for it.

Markoff: Yeah, and it was not-- so sort of the architectural direction was not parallelizing UNIX, it was much more fundamental than that?

Tevanian: I want to say yes, but it's not that simple. There was a very fundamental aspect of it, which was to start with, what are the concepts we need to build a parallel, an OS for a parallel computer? And so from that perspective, we did look at important subsystems that hadn't really been done in a way that we thought needed to be done. Excuse me. At the OS level for threading, scheduling, virtual memory management, some things like that. But as we got into it, very early on, mostly I think at Rick's urging, we also integrated UNIX, and the reason for that was building an OS that's useful is hard, right. There are many, many different layers that you need to build, and what we figured was there were a bunch of layers that we didn't care about some of these issues, that we wanted to have access to. Like you remember the programs awk and sed and grep?

Markoff: Yeah.

Tevanian: We just want those, right?

Markoff: Yeah.

Tevanian: We don't want to build those from scratch for a parallel world. We just want them, and so we figured we could leverage UNIX, which was getting pretty popular in colleges. Not only to get those things but to also have a way to get others to use our research, and so we pursued the strategy of building a whole new core OS, which was Mach, the Mach kernel, and then grafting onto it BSD UNIX. The whole thing people generally refer to as Mach.

Markoff: Now, it occurs to me to ask. Maybe I know the answer to this. Where did the name Mach come from? How did you come to name this, the project?

Tevanian: Okay. It's one of the things I remember.

Markoff: <laughs>

Tevanian: So there are bunch of us working on the project, and it didn't have a name, and one of the things about Rochester is it rained a lot. Or, I mean, Pittsburgh is it rained a lot, and a bunch of us would go to lunch over at Pitt, which was right next door to Carnegie Mellon and there are lots of good restaurants there. So we go to lunch over at Pitt, almost every day, and so Rick and me and a couple other grad students. Maybe a couple other faculty members. We're trying to figure out what name we should pick for this thing, and the best we had come up with is-- I can't remember what the best we came up with, but we're all walking along and we're trying to find acronyms that have multi-processor in them and computing in them and things like that, and we're failing and as we're walking over one of the

bridges, huge puddles of mud everywhere, and we're like walking. It was, "Look at all this muck," and so it's, "Muck. That should be the name."

<laughter>

Tevanian: Right. Multi-user communicating kernel. Something like that, and we're all just joking about it, and so we get back after lunch and we're joking with one of the other faculty members who I believe was Italian, and we're like, "The best we've come up with so far is Muck," and he heard it as Mach. He's, "Ah, that's a great name. Mach."

Markoff: <laughs>

Tevanian: And so it stuck.

<laughter>

Markoff: There was no Star Wars, I mean, Star Trek. No. That's right. <laughs> Because it's, I thought that was the answer.

Tevanian: No, no, no.

Markoff: So did the idea of a microkernel exist at that point or where were you guys in the sort of architectural approach that was based on separating things in that way?

Tevanian: I think the answer to that is yes, if only because Accent had already had an architecture sort of like that, and I don't remember if it was a similar time frame but there was other work going on. I think there's some work at Stanford going on or would go on soon with the V kernel, and there may have been other work going on a little bit later. So it wasn't brand-new but it wasn't old either.

Markoff: Right. Right. And were you thinking, I'm trying to remember, at a certain point, parallel languages began to emerge. The one I'm thinking of right now is Linda, but I think that was maybe in the late '80s. Were you ahead of all the parallel-- were there any parallel languages to design to?

Tevanian: As far as I can recall we were ahead of the parallel languages, and again, we were operating at a level below that anyway, and if anything we were trying to provide something that people doing parallel language development could take use of.

Markoff: Yeah, yeah. And I guess one of the things we wanted to ask for is sort of a definition for a general audience of what a microkernel is or how you thought about separating function in design.

Tevanian: The simplest way to describe how I think about the separation is you have only the minimal functionality that you require in the kernel in the kernel. Everything else is out, and so what that basically means is the basic functions to control the computer itself, which is resource management for the protected resources, the scheduling of the resources, which is both scheduling of processors and scheduling of memory, which is the virtual memory part, and that's it. From a conceptual perspective. Now then reality sets in, right, and you look at things from a performance perspective, and so there's all these things that are now conceptually outside of the microkernel. File system, networking, even device drivers that have logic in them. But what you do is you co-locate them with the kernel for performance reasons, and that's what exists today.

Markoff: Okay. Yeah, yeah. I don't know. We had talked about this at lunch and the performance issue in particular. Did you have…

Hsu: Oh. I was, actually I was just going to ask sort of what was Mach's major advance over Accent?

Tevanian: So Accent had focused on what I would say is two-- one idea that's almost the same thing. Two things but almost one idea. Message passing and virtual memory, and so Accent did message passing in a certain style that allowed you to decompose problems into multiple processes that communicate with each other and also introduce this notion of what's called copy-on-write virtual memory where you can send, you can send-- this is important when you have things sharing, two processes sharing a lot of data but don't actually have to use it all. You could send, like, 10 megabytes of data in one message without actually sending it and it goes copy-on-write, so it only actually copies when the other process writes it, and so that and the message passing, and they kind of go hand-in-hand, and we actually did a paper about the duality of virtual memory and message passing at one point. That was sort of one of the key things behind Accent other than powering a 3M machine, and so we kept that paradigm. But the newer things that we added were the notion of the scheduling of multiple processors and how you do that, and we learned a lot over the years on how to do that officially based on different architectures, and how do you do a virtual memory system that supports this copy-on-write notion in a multi-processor system, which is much more difficult than a non-multi-processor system, and then we also did some work with more formalized the notion of having services that aren't in the kernel itself, even though for optimization reasons they are. Those were the, the big things. You know, in the grand scheme of things it doesn't seem like a lot but it's pretty profound stuff and important stuff. Yeah.

Hsu: And also to follow up on sort of this, the performance issue. So Mach 2.5 was sort of a hybrid microkernel so some things were still in kernel space, not everything was in user space, and then Mach 3 tried to move everything into user space. But then you mentioned that later on things kind of moved back towards the hybrid model.

Tevanian: Yeah. So that's a good memory of the version numbers. I wouldn't have remembered that until you mentioned it. So 2.5, up until 2.5, we had built everything into a monolithic kernel for performance reasons, and then the 3.0 effort was an effort which I think actually that happened after I left Carnegie Mellon and was done in part by OSF. That was an effort to formally have a micro-kernel and have services outside. To me that was more of just a research effort and I don't know that that code base ever made it in any product anywhere.

Markoff: Tell us about the creating the team. How big was the team and what your role was in the Mach group?

Tevanian: Okay. So, that's one of those areas where my recollection differs from other people because other people have told me what they thought the team was and how it worked. And so--

Markoff: This is your oral history.

Tevanian: This is my oral history. And I'll annotate it with what others have told me that seem plausible. So, I started the team being the first person on the project because I wanted something new. And Rick suggested, because we had this grant potential-- and, of course, Rick was involved as my advisor. But initially, he was still mostly involved with Accent. And then as other students started coming in, they started just joining the team. I think initially, I was probably spending a little bit of my time on some of the classes I had to get done and just kind of poking around on this and doing a little bit of investigative work such that we could get the grant to have the money and working with DEC on getting the actual hardware, things like that. I know I was working on the MicroVAX doing a lot of prototyping before we even had a 784. So, we had a few other students join the project, I think just because they thought it was interesting. Being the person that started it, I sort of controlled the codebase. Now, I've been told I was a benevolent dictator when it came to controlling the codebase and would send things back saying it wasn't good enough or all kinds of evil things like that. I have no recollection of that. So, I can neither confirm nor deny. It's partially believable. But a few years in, we had-- the project was getting large. And a few years in, we were hiring research staff, not even students, to work on it, to do a lot of things. It was turning in to a big project. And I don't know the numbers. It's too long ago. But we quickly had probably a dozen people on it. And then we started deploying it internally to the department where we had people in the department using the software.

Markoff: And do you remember what part of-- so, money came from DARPA the first year you were around? You were up and running as a funded project pretty quickly?

Tevanian: I don't know that the money came in the first year. I don't remember when it came in. But it came in relatively early.

Markoff: And from IPTO? Do you remember what part of DARPA, by any chance?

Tevanian: I do not remember which part of DARPA it came in from.

Markoff: Or the-- was there a program manager who showed up, or it was you just had money?

Tevanian: I remember we went to a meeting where there were ARPA people there. There may have been some military people there as well, maybe even someone in a uniform. But it was too long ago. I don't remember the details of it.

Markoff: So, the thing about Mach is it got-- out on the West Coast as a BYTE editor, I knew about Mach. Mach sort of established itself as a sort of future-of-computing kind of idea early on. Do you have any idea how that happened, how it sort of got out into the broader world?

Tevanian: So, a couple reasons, the first reason is because we adopted BSD UNIX as our interface. And everybody wanted to use BSD UNIX already, at least in academia. And we had a better BSD UNIX because we took out some of the pieces of BSD UNIX they didn't like and put in parts that they now liked. And that's true even today. If you use FreeBSD, it's basically the version that we did. We grafted Mach stuff in to it. And so, it was easy for people to use it. It was-- they could use awk, and sed, and grep. It all worked just like they're used to. And the other thing that we did was we wrote research papers and went to USENIX conferences and other conferences and talked about it. And not only did we talk about it in a research paper, we said, "And oh by the way, here's where you can get a copy of it." And everybody else with a research paper had the research paper. And oh, by the way, that's all we have. So, that was a pretty big difference. And it gets back to the whole Carnegie Mellon, at that time, doing everything that was very applied. We thought we were failing if we weren't doing something that other people could actually, not just read about, but use.

Markoff: That's an interesting culture. So, maybe-- we're about an hour and a half in. So, maybe one last question, and then we could take a little break. Does that-- does that--?

Tevanian: Sure.

Markoff: So, your view of the significance and the legacy of Mach, sort of take it the next step. And how did it change the world?

Tevanian: Well, boy that's a complicated question. I think it changed the world in-- this is laws of unintended consequences perhaps in a good way, which is it's not even about the technology. It's about

the relationships that came. So, as we were presenting at USENIX one time, Steve Jobs sent some NeXT employees. And they loved what they heard. And they found they could play with it. And they did. And so, they called us up and said, “We want to make this part of the NeXT computer.”

Markoff: So, that would have been circa eighty--

Tevanian: ’87/’86, ’86/’87, right after they formed NeXT. I don’t remember which conference they saw us at precisely. But they told us in ’87.

Markoff: Yeah.

Tevanian: And then-- so then that caused me and Steve to have a great relationship. We did everything with NeXT. That led to Apple. And I mean the rest is all history. So, it’s almost a non-technical story in that regard.

Markoff: So, clearly-- I mean, we’ll get to that, but there is that thread going into NeXT and Apple. Did Rick take stuff of Mach philosophy and architecture into Microsoft? Did it also have an impact in that direction?

Tevanian: I don’t think so. I think it went more-- the directions it went-- obviously, there was the NeXT direction. There was the OSF direction, which was pretty significant. There was the BSD direction, where they took a little piece of it, and then it kind of stagnated. Those were probably the primary directions. There were other companies that used the OSF version a little bit, never in any kind of meaningful volumes. And I think what Rick took to Microsoft was more his research philosophy just in general. And he wasn’t even necessarily doing OS research. He was doing research.

Markoff: Okay.

Hsu: So, then in terms of the microkernel-- so, all the major OSs that use the Mach or a version of the microkernel still use the hybrid model that you developed and not sort of the whole theoretical absolute separation between user space and kernel space programs, at least practically. Like practically, it’s not performant enough?

Tevanian: Right. So, as far as I know today, the only commercial uses are what Apple has today, which is still what I would call the monolithic kernel. Although, it is partitioned a little bit. And then the other example would be like FreeBSD a little bit. But I’m not really aware of anything that uses the Mach 3.0 pure microkernel structure today.

Markoff: Interesting. Okay.

Tevanian: I think that was more just a research project that proved it could be done. And today, people opt for performance.

Brock: If I could just ask one quick question to make sure that I'm understanding the story correctly. It seems like at first the Mach project was very tied to this new kind of experimental machine, this ganging the four computers together with the shared memory. But then it sounds like very quickly the operating system becomes not particularly tuned to that parallel experimental machine but could be used much more widely. Is that correct? Did it lose its particularity, or--?

Tevanian: So, that is a really good point.

Brock: Okay.

Tevanian: And let me clarify. So, initially, the project was targeting the VAX 784, this cluster of four 780s. But before they could build that, they sent me a MicroVAX, which was just a VAX. It was a 780. It was a small one. It was a little deskt-- it was, not a desktop, but it was small. And so, I started programming that. It only had one processor in it. So, I started building an OS for one-- for N processors where N equaled one.

<laughter>

Tevanian: Okay? And did work on the 784 later on, worked on other multi-processors. But what we discovered was that-- what we quickly discovered, and this was a problem for BSD at the time, was BSD wasn't portable. And so, we built something that was portable. And so, other companies were using other instruction sets. So, Encore was using the MIPS instruction set, I believe. Sequent was using maybe the Intel instruction set. I can't remember exactly. IBM wanted to do things with the RT, which was the-- was that the PA-RISC instruction? No. Yeah, it was PA-RISC. Yeah, no that was Dell-- HP.

Markoff: No, PA-RISC was HP.

Hsu: IBM was--

Markoff: What was the IBM RISC-- attribute--

Hsu: POWER?

Markoff: POWER.

Tevanian: POWER, yeah, POWER. And so, we started building a portable OS in addition to a multiprocessor OS. And I remember in really early days, I was thinking I'm a graduate student, been there a couple of years. I'm thinking where are all the places we can take this quote unquote "microkernel" where we're not going to need all of this heavy functionality you see in an OS today. And I'm thinking like maybe someday we can put this in a refrigerator, okay? This is back in mid '80s. I'm thinking to myself okay, is this interesting enough where we can sell it for fifty cents a unit. I'm thinking no, we're never going to sell that many copies. But that was the thinking back then. We were tuned for the 784 initially. But we knew we were building something beyond that. We were porting to these other systems. We were porting to the RT. That was a single processor system, but it had an inverted page table, which no one had ever seen before. But our VM architecture made it easy to support. We ran on Encores. We ran on Sequents. We discovered they had different memory architectures where there were twenty, thirty processors in them. And you had to know where the caches were to make things efficient. And so, we were doing all of the above at that point in time. And we didn't just focus on the one thing. And maybe this is in part why we had so many people that started to work on it.

Markoff: That was the era of mini-supers, wasn't it?

Tevanian: Yes.

Markoff: Did you become sort of the-- I mean they needed-- they were all parallel kinds of machines. And did they all pick up Mach?

Tevanian: You know, I think they all had projects with us going on. They generally shipped their own OS to their customers. But they were all working with us. And they would have people porting-- I don't know that any of them-- some of them probably went commercial with it. But I'm not really sure which ones or if there were any meaningful volumes. But a lot was learned in those years.

Markoff: Yeah, can we start-- tell us a little bit about your dissertation, what you focused on and where.

Tevanian: Okay, let me remember. Oh yes, okay.

Markoff: A long time ago.

Tevanian: So, for my dissertation, I remember my plan was to do a dissertation on Mach. It seemed to make perfect sense to me. Rick said, “No, you can’t do that. That’s way too broad.”

<laughter>

Tevanian: But I was one that was happy being broad. So, he said, “No, you’ve got to focus more.” So, what I did was I focused on the virtual memory system of the OS. And I focused on-- what we had done was we had built the first both portable and parallel virtual memory system. So, that was the focus.

Markoff: Yeah, okay. And how does that work? Did-- in terms of when you left and when you got your dissertation, did you get your dissertation before you decamped, or did it come after you were at--?

Tevanian: Well, you mean the chronology related to when I left Carnegie Mellon?

Markoff: Yeah.

Tevanian: So, you have to have your dissertation done before you can leave.

Markoff: Okay.

Tevanian: And so, the order of events was you pick your topic, of course, well in advance of this. And then you do the research specific to it. Then you write it up. It’s a massive document. And then you defend it with your thesis committee. And then there’s more work to do. They say, “Great, good job. Now make these changes.” It takes you a few months. You do those tweaks, and you’re done.

Markoff: Besides Rick, was there anybody else of note or you remember on your committee?

Tevanian: Yes, so Rick was on my committee. Al Spector was on my committee. Al was another faculty member. And Dennis Ritchie was on my committee.

Markoff: Oh, that’s gold standard. That’s good. Yeah, and then there’s a question here, but maybe in the sort of-- flip it. You continued to work on big systems. There was this massive explosion of the personal computing world in the first half of the ’80s. But I get the sense that, aside from you having a Macintosh, that you were in a different world. You remained sort of in a high-performance computing world as opposed to the PC world while you were in graduate school, or--?

Tevanian: From a research perspective, I think that's fair. Remember, I did have the MicroVAX, which was-- it wasn't as low-end as the Macintosh. But it was essentially a personal computer, a personal workstation. It's hard to say why we didn't focus on even the lower level, more personal computer type stuff. Maybe the hardware wasn't quite ready for what we were trying to do is one of the answers. But I'm not a hundred percent sure about that.

Markoff: And then one more question. So, while you were there-- a generation earlier, DARPA used to have these annual meetings at Snowbird in which they'd have the faculty who were the researchers. And then the students would come, too. And it really was a community building exercise. Had those stopped by the time you were on a DARPA track?

Tevanian: Well, if they hadn't, I never got invited to Snowbird. Maybe Rick went. So, I don't know. I do remember going to DARPA meetings in Washington to talk about what we were doing every once in awhile.

Hsu: One question also. So, why did you decide to get a Macintosh rather than an IBM clone? Was it because of the Alto? And how did you like the Mac compared to your Alto or compared to your experiences with the Alto?

Tevanian: So, that's a good question. Let me think about why that might have been the case. I think it's simply that the Macintosh was-- we talked about the 3M machine before. And the Macintosh was sort of in the vein of the 3M machine. And the PC was not. And so, this was now a 3M machine that, with a student discount, I could afford. And so, it seemed to make sense to buy it.

Markoff: And while you were doing this research on-- were you aware of the other projects that were going on at other campuses at the time? MIPS-X had started up at Stanford. There was-- Sun originally started with Bechtolsheim and Baskett at Stanford. Were those on your radar at all before they got out into the commercial world?

Tevanian: I don't know that those were on our radar screen before they became commercial that much. We were being funded to use the DEC stuff. Other people who were doing things, like IBM for example, were coming in and showing us their stuff for the RT. I don't recall which of the others had come in. Some of them may or may not. We were definitely getting a lot more interest and focusing more on the bigger guys. The Encores and Sequents were the bigger iron.

Markoff: And then I was thinking West Coast. And then and there were also-- so, you had PERQ right there. And then what was the name of the Sun competitor in Cambridge that I'm forgetting? In Boston--

Tevanian: Apollo.

Markoff: Apollo, did they have much contact with you guys?

Tevanian: No, I don't-- I mean we were aware of Apollo. But we never interacted with them. I'm trying to think. We probably had a meeting or two with them. I remember visiting their place maybe once. But nothing really happened all that much.

Markoff: Was Data General still alive at that time? I'm trying to remember when they got in trouble.

Tevanian: I think they were irrelevant if they were alive.

Markoff: Yeah, go ahead.

Hsu: Were the Mac ports of Missile Command and Defender fairly straightforward and just something fun you did at home?

Tevanian: The Mac ports of those games were mostly fun. The Mac had reasonable computing power compared to the Alto except when you programmed the Alto in microcode. That was hard to be comparable to the Mac. So, the ports were relatively straightforward, but I couldn't get around using the OS. And I remember the one big problem I had was I wanted to have sound effects and music in the games. And in the Mac in those days, when you turned on the sound processor, it consumed like fifty percent or more of the cycles of the computer. And so, that put me over the edge where the games didn't work. So, I had to override the Mac sound driver with my own. And then I got it to work.

<laughter>

Markoff: Were these freeware projects? I can't remember.

Tevanian: I had visions of selling both the Mac and Defender games. And in fact, this was sort of the beginnings of people selling software. And I had a contract with a company in L.A. that was a software publisher. And they asked me to put some copy protection in, which basically read bad sectors of the disk. And then they were going to ship it. And for some r-- I think they went out of business before they shipped it. Something like that. So, I gave it away as freeware. I had a little message, "If you like this, send a check to whatever." A few checks came in. I think I got-- I think I almost paid for the Mac. Maybe not quite, not quite. They'd come in, you know, five dollars, ten dollars at a time.

Markoff: Yeah. But it didn't seduce you into an open source-- I mean a cottage programming lifestyle?

Hsu: Shareware.

Markoff: Shareware?

Tevanian: No.

Markoff: Yeah.

Tevanian: No, no.

Markoff: Yeah. So, now here you are at your next juncture. What was your thought process, while you were sort of in the second half of your graduate student career, about what you would do after graduate school?

Tevanian: Okay so, let's set the stage. I'm a happy camper, happy graduate student at Carnegie Mellon, loving what I'm doing. I mean I've got all these computers to myself. Because I'm writing the OS, no one else can use them. I've got control over this OS. People come to me to check in things and whatever. They look to me for advice on what to do. And we're getting-- people are following what we're doing. Lots of companies want to use our stuff. And I'm just having a grand old time. And I'm almost falling into the trap of what happened to a lot of Carnegie Mellon grad students, which is they can take six, seven, eight years to graduate. And so, I'm probably-- let's see, it's probably '87 now, so I'm in my fourth year. And Rick and I come out to the West Coast for a meeting at Berkeley because we're-- it's the Berkeley UNIX Conference. And we find out that Steve Jobs wants to meet with us on our trip. This is probably-- this might be '86 actually. So, we come in. We fly in, my first time ever to San Francisco. We fly into San Francisco. Rick and I are staying in a not-so-good hotel just off the airport. And we're going to meet Steve for dinner. So, we go over to the NeXT offices on Deer Creek Road. And we're sitting down in the lobby waiting for Steve. And so, Steve comes down all excited, "Hi, guys. How are you doing?" We shake his hand. "Oh, I've met you before." That's what he says to me. I'm like, "No-- you haven't met me before." "Yeah, I've met you before." I'm like, "No, you haven't met me before." I'm like, "Steve, I'd know if we met before." He's like, "No, I know we've met before." Whatever. So, we go have dinner with some of his team. And they tell us-- we had no understanding why they wanted to meet with us other than we knew they were building a computer for education. We thought they might be interested in what we're doing a little bit and want to learn about what we're doing. And he's like, "Well, we want to put your OS on our computer." I'm like, "What? Really? Are you kidding?" So, he then leaves. And we still have more dinner with the other guys. And then we go off to our meeting at Berkeley. And I'm thinking, "Oh my god, I better finish up because these guys want to use this stuff. They're going to fail. I'm going to have to help them," etc., etc., etc. And it's like the corporate world now needs me is the way I'm thinking. So, I get things in

order. I finish up the dissertation. I have my thesis defense with Rick and Al and Dennis. And I start interviewing in the meantime. And so, one thing kind of led to the other. And I ended up going to work for NeXT.

Markoff: When did Rick go to Microsoft?

Tevanian: That was several years after I had left.

Markoff: Oh, he stayed. I see.

Tevanian: Yeah, he was at Carnegie Mellon for several more years.

Markoff: Did they try to recruit him as well as you?

Tevanian: Rick expressed no interest in a corporate job. I think they wanted to hire him as a consultant. But he wanted to stay independent.

Markoff: Yeah, okay. And do you remember who had-- in the first dinner, do you remember who was-- like Bud--?

Tevanian: Bud [Tribble] was there.

Markoff: Who else was doing software at that point, in terms--?

Tevanian: Bud was doing software. Bud was doing software. Bud was there. And I'm not sure who the other guys were that were there. I mean I could guess. But I'd probably be-- fifty percent chance of being right in terms of who was actually there.

Markoff: Yeah. When did Joanna show up on your radar?

Tevanian: I don't think I ever met Joanna.

Markoff: Really?

Tevanian: If I did, I don't remember.

Markoff: Was she gone by the time--?

Tevanian: I think so.

Markoff: Wow. By the time you came? Yeah.

Tevanian: I never met her that I know of.

Markoff: But she was there-- wasn't she there in the early days?

Tevanian: I don't know. I don't think so. Maybe the very early days.

Hsu: I think there-- some of those retreats, she shows up on those videos.

Markoff: Okay, yeah I--

Tevanian: That all pre-dated me.

Markoff: Yeah, I may be confusing things.

Tevanian: I got there at '88.

Markoff: Yeah, okay. Yeah. Was Michael Hawley still around?

Tevanian: Mi-- yeah, Mike was there. Well, he was kind of in and out. He was always in and out.

Markoff: Yeah. And were there other companies on your radar?

Tevanian: Yeah so, obviously they're saying-- NeXT is saying they want to use our OS. So, obviously, they're going to offer me a job if I want it, right? But I knew I had to do a little more diligence. So, I interviewed with Microsoft. I interviewed with Sun. And I think that's about it. If there are other interviews, they might have just been phone calls from people who knew I was looking for a job. Like I think Apple

tried to contact me, but I wasn't interested in interviewing there. So, those were the three places that I considered. Sun was kind of confused. I mean I knew some of the people there. Like James Gosling was there. We talked and stuff like that. But they never kind of got their act together about what they wanted me to do or anything. Microsoft was very organized. They wanted to hire me. And NeXT wanted to hire me. So, I had to decide between those two.

Markoff: And if you'd gone to Microsoft, would it have been-- where was NT at that point? Had NT emerged in the world already?

Tevanian: If I had gone to Microsoft, NT probably would not have existed, or it would have been something different because they basically hired Cutler instead when I didn't go there. Cutler came after I interviewed there.

Markoff: Interesting.

Tevanian: And my view of Microsoft was it was interesting. It was-- I had a great time talking with Bill Gates about technology and stuff. He was really into that. And it was [a] non-traditional interview where he just wanted to know the work that I had done and the design decisions. And he was giving his inputs and stuff like that, which I found very refreshing. Then I talked to Steve Ballmer who was a little more salesy, didn't really know what I did, just knew that other people thought they should hire me.

<laughter>

Tevanian: And then I talked to Nathan, Nathan Myhrvold, who had all these visions of what was going to happen. And I talked to people who worked on DOS. And I talked to people on OS/2. And one of the things that I learned as part of the interview process was there were kind of some warring factions. And it wasn't clear if they were really committed to OS/2. It wasn't clear if they wanted me to go fix OS/2 or do something different. There were a lot of these things going on. And it didn't quite gel with me.

Markoff: So, was this before Allchin had showed up there, too? Was-- I can't remember whether--

Tevanian: I don't remember. I don't remember.

Markoff: So, it just-- it didn't feel-- I mean NeXT had a clear sort of path to putting your software out into the world. Was that kind of the sort of-- if you had to-- when you came down to making a decision--

Tevanian: Why I made the decision?

Markoff: Yeah.

Tevanian: A couple of things, one is this was a chance, from the technology perspective, to take what I had worked on and make it successful. And it wasn't clear to me that that was going to be possible at Microsoft. At Microsoft, it's more you're a good OS guy, come help us to build OSs, okay, maybe something new, or fix OS/2, or whatever, kind of TBD. There was the classic big company versus startup. It's like Microsoft was a, let's say, one or two-billion-dollar market cap company then. How big could it possibly get, right? Who knew? Whereas, NeXT was a startup, right? It's going to grow from where it is, no question. And then, I really enjoyed both Bill and Steve in interviewing with them. But they're very different kinds of people. And at the time, I kind of was more excited to work with someone like Steve because he had, not only the technology passion, but also, you could see he's thinking about how you drive things into markets and stuff like that. Whereas, I loved the conversation with Bill. But there was very little about the markets and that kind of stuff. Not that it's bad. I mean that's who he was. But of all those factors, I mean the fact that they were using my technology really made a big difference. And then, I guess, one last point is, and this was something easier for NeXT to do than Microsoft, NeXT being a small company, Steve made it a point to personally try to recruit me. And he would do the follow up calls, go over the offer letter. And, "I just can't decide." He said, "Well, let me offer you this." You know what I mean? Whereas, Bill couldn't do that. The company was too big for Bill to do that.

Markoff: And there are sort of legendary stories about Steve walk-- taking people on recruiting walks. Did you guys--? What was the sort of the dance with Steve? Did you ever go on a walk with Steve while he was--?

Tevanian: We did not do a recruiting walk, but that's because just I was in Pittsburgh. And he was in Palo Alto.

Markoff: Yeah.

Tevanian: But Steve-- what Steve did was somehow I think that part of oh, we've met before is part of the whole thing. I don't think that was quite-- I think he thought I was someone else. But for example, one of the things that he did was when I think he identified me as someone he wanted to hire and someone that he knew, subsequent to our first meeting in Palo Alto, he had-- he was on a visit at Carnegie Mellon with, again, some of his team. And he and his team took a bunch of us grad students out for dinner. And he was just being real nice to me and joking. And I remember at the end of the dinner, he said, "Send that guy the bill," pointing at me. And he would just do things like that to be a little more familiar and a little more earthy, if you will.

Markoff: Yeah. So, had-- by the time you joined, had NeXT left Deer Creek and gone over to Redwood City?

Tevanian: No.

Markoff: So, you got there while it was still at--

Tevanian: We were still at Deer Creek. We didn't leave for, I think, at least a year after that, maybe even longer. We launched the NeXT product in October of '88 while we were in Deer Creek.

Markoff: Okay. And so, that launch is a famous event. What was your role, and did you develop software for the launch demo in itself?

Tevanian: Okay, so well, there's the version in the Jobs movie, which is not true.

<laughter>

Tevanian: And I tried to explain the truth to Aaron Sorkin, but he obviously didn't listen. So, the-- I have a vivid memory of the lead up-- of a part of the lead up to that, which is two or three days before the launch, we were working on the optical drive. And so, I was part of the OS team. I was chief operating system scientist, something. They gave me this fancy title as a way to entice me to go work there, smart. So, I wasn't responsible for the optical driver. I was responsible for more of the core of the OS. And it was working pretty well. But the optical driver was unreliable. And I remember the guy working on it, outstanding engineer. His name is John Seamons. He was burning the midnight oil just trying to get this thing working in about three days before the intro. And this has got to work. I'm like okay, I've got to roll up my sleeves and help John. So, I dive in with John, fresh eyes on the problem. And it was just unreliable. And I said, "Okay, we've got to do something. We've got to start building reliability tests for the file system, so we can figure out, is it a driver problem, is it the file system, whatever." And so, I built a very simple UNIX level test to read and write files in a slightly random way and ran it. And it failed immediately. And I built in logging and stuff, so we could then figure out what was going on. We went, and we tested. And we looked at logs. We figured out the bug. Great, we fixed it. Good, we're all set to launch. Let's take-- but before we do that, let's take the testing to the next level. And so, he and I kept iterating on these test programs to the point where we finally had a test program, which was basically issuing random file system instructions to the OS, completely random, no program would ever do this, just to get to it to fail. And we would see these failure modes. Oh yeah, that's a bug. And oh yeah, that's a bug because even though it's random, it should still work, right? And so, we finally got it all to work. And we-- I think the two of us worked almost continuously for forty-eight hours to make that work.

Markoff: Was it stressful? Was that your--

Tevanian: I don't remember it being stressful. I just remember being, "Wow, this is so cool." It's like-- I mean it's like it's so hard, but I mean these are the hardest kinds of bugs to find. I mean I remember before I'd been trying to find bugs in the virtual memory system where suddenly, your memory isn't right. And that's all you know is the memory isn't right. And this could be five seconds after it went bad that you discover this. And how do you discover those bugs? And we were working on hard problems like that which was extremely satisfying. But we finally got it to work. And I remember I learned a lesson from that, which is all of us engineers think we can write code that works. But what you've really got to do to test your code is throw garbage at it and then see what happens. When you throw things at it that is what you expect, yes, it works. But a lot of times, developers throw things at it that you didn't expect. But that-- so, that was the lead up to the intro from my perspective, just getting the basic stuff to work. There was a lot of other stuff going on that I was still helping others with, all the demos. You were there, I assume.

Markoff: I was, yeah.

Tevanian: And the demos were incredible. And they all worked.

Markoff: At the actual event at Davies Hall, itself, were you in the audience? Or were you backstage?

Tevanian: I was in the audience.

Markoff: Now, there's a bit of legend that you can help me with, apocryphal. I heard that-- it was the intermission. It was such an event. I heard that the machine crashed during the intermission. And it was rebooted, and it worked. And nobody knew. Do you know if that's true?

Tevanian: That is possible. I don't remember. I believe there was a hot spare anyway. We've always had hot spares for as long as I can remember.

Markoff: Yeah, so you could swap out. It was supposed to be the luck of Steve Jobs that it would happen backstage and no one would know about it. Bill would always give demonstrations, and it would crash during the--

Tevanian: Right, right. Yeah, it's possible. I don't remember.

Markoff: What was-- just your-- going to NeXT and working there, just sort of top level description about-- you came from an academic environment. All of a sudden, you were thrown into a Steve Jobs world. What was the shift like?

Tevanian: That's a good question. Let me think about that for a second. So, for me, a lot of it seemed the same because I was just always working hard trying to make things work, right? There was probably a little bit more of a feeling of being a part of a whole team that is doing more than just building this OS. I mean we had people building the hardware. We had people worrying about how to sell it, how to market it. We had HR teams. We had this whole thing. And we also had a different level of sort of frenzy in terms of it's actually got to work. This is not research. This is something people are going to pay for. And we actually have deadlines. So, when we announced that October 17 or something announcement, it was going to be announced then. We weren't going to change that. And so, we had to work twenty-four by seven to make it work, at least well enough for the demo.

Markoff: There was a famous Wall Street Journal story which quoted a PR woman in the first paragraph. Cathy Cook was an outside PR woman. She was quoted as saying, "They're carrying them out in body bags," to describe how hard you guys were working. Do you remember that? It created quite a stir outside the company. I don't know what it was like inside the company.

Tevanian: There were no body bags.

<laughter>

Tevanian: There were no beds inside. But I remember my personal work habit was to work as long as I could, go home and sleep, and then come back and work as long as I could no matter what the time was. And I remember there were many of us who would be working all night, and then we'd go to Denny's at three a.m. to get some food, and then go back and work some more, and then go home at seven a.m., eight a.m., sleep a little bit, and then come back.

Markoff: Were you single at that point?

Tevanian: Of course, yes.

<laughter>

Markoff: When you came out to the Valley, where did you live initially?

Tevanian: I lived in Mountain View. I had a small apartment in Mountain View.

Markoff: So, it was a hacker's existence, basically.

Tevanian: It was a hacker's existence, and I loved it.

Markoff: Yeah. And so, you came out with that title. Were you responsible for NEXTSTEP? Is that the right way to describe your initial role?

Tevanian: Not initially. Initially, I was responsible for the core OS, which was-- in fact-- well initially, I was an engineer, okay? I was one engineer of several. They looked up to me because it was my codebase, a lot of it was. But I was responsible, basically, for making sure that what we had built at Carnegie Mellon had been ported to the NeXT computer and worked. Then, you know, like a year later, I took over the whole OS Group, which meant owning the compiler and a few other things. And then finally took Bud's job.

Markoff: Yeah, yeah. And architecturally, this was the 68040, 68020?

Tevanian: I think it was a 30.

Hsu: 68030.

Tevanian: 68030, 25 megahertz.

Markoff: And the PERQ had been a minicomputer, it had been a microprocessor basically.

Tevanian: I think the PERQ was custom architecture.

Markoff: Yeah, yeah. So this was your first real experience with the 68000 family? Or no, you'd been a Mac programmer, so you knew it pretty well.

Tevanian: I had been a Mac programmer myself, but we had never-- I don't think we'd ever ported Mach to the 68000 Series. But I was-- I mean, being a Mac programmer, I knew the instruction set, that's probably an advantage, but I'd never done OS level stuff, and the Mac didn't even have virtual memory in it. So we were working at a very different level.

Markoff: And did the-- Steve had taken this team, or some version of this team through this drill before with the Macintosh. He'd sort of run this drill once-- well, several times before. But you know, the Mac experience was this very sort of dramatic and well-documented. Did you feel like there was Mac culture still in NeXT organization, or had he built another kind of culture at that point?

Tevanian: There was a little bit of Mac culture, but I saw that more from the perspective of everyone who wasn't an engineer was using a Mac. So if they're doing their email-- well, actually there wasn't much email back then. But they were doing desktop publishing on their Macs, or whatever they did, they were doing pretty much on their Macs. Only the engineers had the actual [NeXT] computers 'cause they didn't quite work. And so, you know, you have to remember, I didn't know what the Mac culture was back then anyway, so I can't say for sure if it was or wasn't. I'm sure some things were similar, some things weren't.

Markoff: And did you get involved, as you got in on the project and got more responsibility, did you have at any point responsibility for some of the higher levels of the stack. The AppKit, Interface Builder, NEXTSTEP layers, or was that--?

Tevanian: Yeah, so, I don't remember what year it was, but when I became VP of Software, I had all that stuff.

Markoff: Yeah, and sort of just roughly scale, when you came, how many people were doing software, and as you-- sort of how did it grow over time?

Tevanian: Okay, so when I got there, the company was probably 70 people.

Hsu: Hm, wow.

Tevanian: I was employee 80-something, and I assume a few people had left. And most of the people were in engineering, and they were probably roughly evenly split between hardware and software. Exact numbers, who knows?

Markoff: Yeah.

Tevanian: So it may be 25 software, 25 hardware. Then everybody else in finance and marketing and sales, things like that.

Hsu: How big was the OS team?

Tevanian: The OS team was probably--

Hsu: The core OS team.

Tevanian: Three or four people.

Hsu: Wow.

Markoff: I have two very clear memories of Steve giving me factory tours. Once I got a tour of the Mac factory, and once I got a tour of the NeXT factory, which was-- both of them actually were highly automated. You know, this was '85-- '83 to '87/'88. Did you involve yourself in the factory at all?

Tevanian: Not really. We had meetings over there every once in a while, just, you know, I was part of the Executive Team, so once a month or so, we'd have our Executive Team meeting over there, just to keep them connected, and so we were aware of what was going on. But I didn't work with them really-- not really at all.

Markoff: Yeah. This was not Hollywood, but this was sort of Silicon Valley's equivalent of that world, but it was just intense interest at that time, sort of from when Steve started to, you know, everybody wanted to know what was going on in NeXT. Did that affect you at all?

Tevanian: It didn't affect me at all. And you know, it's probably because I was so focused on the work, right, and it dominated everything. And it wasn't on my radar. Now yeah, I mean, sometimes I'd be out at dinner, and maybe I'd be with Steve, and people would recognize us, and ask us things that are going on or whatever. But that was not necessarily the norm. That was just on occasion.

Markoff: So there were these kind of myths that drove Silicon Valley. You know, going all the way back to Alan Kay's Dynabook. Sort of this notion. And during the Macintosh days, Steve probably expressed it best when he referred to the personal computer as a bicycle for the mind. And that he was clearly doing that with NeXT. I mean, it was clearly in line with that kind of tool to learn and do science and all of that stuff. Did that capture you? I mean, were you sort of in that kind of worldview? And--

Tevanian: Yes and no, but you know, I was an engineer. Okay? And I was like let's-- I mean, I loved the technology, but I'm like, "Let's get this to work, and the other people can worry about these grand visions." Okay? But I'm like, "This is so cool, I want to make this work. I remember the first time I got audio to work. I had no grand vision of what was going to happen with audio in computers. Okay? But one day the hardware guys gave me a board and they said, "We think audio works on this board. Can you make it work in the OS?" So I spent a couple of days and did. I went, "This is so cool!"

Markoff: Yeah.

Tevanian: And you know, I was always the type of person who was, "Okay, what's the task at hand? How do we get it done? How do we push that envelope a little bit more?" Right? And the grand vision will take care of itself.

Markoff: Interesting. But then as you moved up and became a Vice President, did you get involved in the strategy component of sort of where NeXT was going as a company much?

Tevanian: Absolutely. And I would say I had a chance to do that, well, before I became a Vice President. First of all, we were a small company. Second of all, I had formed a good relationship with Steve and the rest of the management team early on because of my role. So they didn't look at me as your run of the mill engineer they hired to work on piece of software X, so I always had really great access-- like I said, I was part of the Executive Team, even though I wasn't a VP. Which is kind of unusual. So I'd get to go in and listen to what was going on, and to be honest, in those earlier years, I was more in learn mode than anything else. Look, here's all these really great guys who know what they're talking about, and I'm learning from them.

Markoff: Yeah, yeah. I have to tell you, from the outside, I always thought of you as one of the Executive Team. I'm just thinking back on NeXT, and if I think of who the key guys were at NeXT, you were-- that's the way it looked from the outside.

Tevanian: Well, and that's because I had an unusual role as an engineer. I quickly did become a Manager, and a Director, and from Day 1, they used me externally to talk about things. So when we would do a conference, I would be a speaker, and I would talk about different things, so I did have some of that role.

Markoff: And then, Steve cultivated the higher education community assiduously, before and then during. Did he use you in going outreach to the higher education community? And were you involved in that sort of dance that went on?

Tevanian: A little bit. You know, obviously computer science departments were a pretty good target for us, and so when there'd be an interesting computer science department to visit, they would make use of me. And even beyond education, when we diversified to more customers, the sales force used me quite a bit.

Markoff: And so just, I'm trying to remember, there were a bunch of interesting people who were part of the NeXT team. And one person who came down from Reed [College] was a physicist. And I'm trying to remember-- I'm blanking.

Tevanian: Richard Crandall.

Markoff: Crandall.

Tevanian: A very good friend of mine.

Markoff: Did he work with you?

Tevanian: So Richard-- so I don't know if you know, but Richard died a few years ago.

Markoff: Yeah, I do, I do.

Tevanian: Sadly. Richard was probably my best friend at NeXT. And so my best friends at NeXT were Richard and Steve. And this great story about Richard. So when I arrived at NeXT for my first day in Palo Alto in April of '88. And I flew into San Francisco, I think they put me up in a ho-- they probably put me up in a hotel for the night. And it was evening, and I had nothing to do, so I said, "I'll go into the office." So it's like ten o'clock, eleven o'clock at night, and I'm going into the office. And I go in there, and I find Richard. And he was the only one there. And we just hit it off. And you know, from then on, we were just like best friends.

Markoff: And what kinds of things did he do inside NeXT? I always thought of him as sort of outward facing to the educational community. Did he design stuff, too?

Tevanian: So Richard was our curmudgeon. He would always find things wrong. And that night I went and met him for the very first time, he was like, "Who are you? What are you doing here?" And I explained, "I'm brand new. Dah-dah-dah." And he said, "Oh, well, you should know everything's broken." <laughter> And that was typical Richard Crandall. And so what Richard would do is, he was an education ambassador. And so he would write educational apps. And what he would do is he would force us to make sure everything below that worked. So he would try to push the envelope. And so his role from an engineering perspective was to say, "Well, this doesn't work, and I need to use it." And he was a physicist by trade, so he didn't always do things the way they were intended to be done. So we'd find interesting things based on him trying to use things. But then he did have a big outward role, too. I mean, he was part of that first keynote, demoing some of the apps that he'd written. Very smart guy. Very interesting to be around.

Markoff: So you showed up in April of '88, and the computer was introduced in October of '88.

Tevanian: Right.

Markoff: Okay.

Brock: Wow.

Markoff: And at that point, I'm trying-- going back in history now, when you launched, it was still an educational strategy, educational-- Steve had found a way to carve out this space for himself where he wasn't directly competing again- or he said he wasn't directly competing against Apple and Sun and IBM. What did it look like? What did it feel like inside the company in terms of that market strategy.

Tevanian: That's exactly what we thought, too. I mean, we knew we were building a general computer, right? But we always thought of our primary market-- maybe not only market-- but our primary market as education.

Markoff: Yeah, yeah. And are there sort of the attributes of the, you know, sort of those little vignettes you gave of like meeting with Rick, or working around the clock. Describe NeXT culture. Is there anything else that was sort of emblematic? Now we know Google culture, what was NeXT culture like?

Tevanian: So we did have a little bit-- I mean, in retrospect, there was a bunch of us that worked in my mold. But we also had some people who were married, and didn't work that way. They worked the more nine-to-five job. And there's a little bit of, you know, we didn't always get along or see eye-to-eye on a lot of those things. Just a little bit. But at the end, we all pulled together, and knew what we were doing. But you know, we believed we were on a mission. And we were building-- I mean, what we built was incredible for the time. And we knew that. And we just knew we had to make it work. And we knew that we were, you know, setting the stage for everything to follow afterwards. And so we all knew we were on a mission, just in general working really hard. Now it was also a very stressful, because it was a lot to get done quickly, and a lot of new things that we were inventing. Things that had never been done before. I described the optical drive. You know, no one had ever done that before, and it had some hard things, where you don't just write the optical drive, you erase it, you write it and then you verify it every time you write. And that had never been done before. And to take an existing OS and make it work in that model efficiently was not trivial.

Markoff: Yeah, there was so much-- that was one of the points of skepticism about-- you know, there was a performance point of skepticism around optical. And what did-- I mean, outside it was sort of show-me. And what did it look like inside from a sort of building comm--

Tevanian: Well, we were all worried about it, too. No question. And but, you know, when you're an engineer, you try and solve it, right? And so, "Okay, we know that writing is incredibly slow. Okay? So what are we going to do to minimize the writes?" And you just try and make it work. And in the end, it was a limitation, and we put in a hard drive.

Markoff: Yeah, did it ever ship with the optical?

Tevanian: It did.

Markoff: It did.

Tevanian: It did.

Markoff: Ultimately, yeah.

Tevanian: I think so, yeah.

Markoff: Yeah. And did you-- was one of the tricks using cache to get around the slow--?

Tevanian: Yeah, I mean, they're all standard tricks, right? Caching, having higher-level software be aware of what it's doing. "Did you realize that you're writing all this data?" "Oh, no, I didn't. I didn't need to do that." It's things like that.

Markoff: Yeah. Did you have much interaction-- there was an early app developer, I think was it called Lighthouse Software that Jonathan--

Hsu: Schwartz.

Markoff: Schwartz was the--

Hsu: Lighthouse Design.

Markoff: Lighthouse Design, that's right.

Tevanian: Yes, Lighthouse Design. I know Jonathan.

Markoff: You brought them in early and--

Tevanian: Well, so I don't know-- I mean, they were in Pittsburgh. I think they were all Carnegie Mellon people, and they loved the NeXT, and they started building apps. And we took note of people building apps. Especially good apps like they were building.

Markoff: Yeah, yeah, that's good. So did you-- there was kind of a Smalltalk-like dynamic object-oriented language. Were you involved? Did you get involved at all at the language level?

Tevanian: A little bit. A little more so when I became manager of the group, because that was part of the compiler. You're talking about Objective-C.

Markoff: Objective-C, yeah.

Tevanian: It was basically the C language with a little bit of Smalltalk sprinkled in, was the best way to think about it. Exists today. People still use it today for iOS.

Markoff: And it's still called Objective-C?

Tevanian: Yes, yes.

Markoff: So one of the questions was that we had heard that at various points C++ and even Display PostScript were considered for the development language of NEXTSTEP? Were the sort of steps along the way to--?

Tevanian: So the language for the screen was Display Postscript. That is what it was. And that was also profound. And even today, on a Mac, or an iPhone, it's basically PDF, is what's going on. It's a PDF-like thing. So Postscript distilled to PDF. So that model still continues today. For the C++ issue, we never considered C++ as a development language for the OS itself, for NEXTSTEP itself. But at some point, we had been so beat up by people saying they wanted to use C++, we built a version of C++ we called Objective-C++, which let it coexist with Objective-C. Never got used very much. It became more of a checklist item for certain customers who wanted it. But it was never a mainstream language for NeXT.

Markoff: At some point, you ended up working with Mr. Stallman. Was Richard in the loop, and what is like to try to collaborate with Richard Stallman?

Tevanian: So we collaborated with Richard Stallman, because we used his compiler, GCC. And so had dinner with him a few times, always an interesting experience. Very smart guy. Very non-traditional, though. Very set in his ways. And you know, we were very appreciative of the work that he had done, and we wanted to be a good steward of what he had done. Working hand in hand with him, giving back changes we had made, suggestions, and just that was-- you know, we never-- I never worked directly with him, but I helped to facilitate the relationship a little bit. We had some engineers who worked more closely with him and his team, is what I would say also.

Markoff: Do you want to--

Hsu: Oh, yeah, I was curious. How did you decide to use Objective-C as the basis for all the frameworks?

Tevanian: So the decision to use Objective-C was done prior to me arriving at NeXT. And the fundamental reason for it was the team wanted to use object-oriented programming. And there weren't a lot of choices. So you could use Smalltalk and never have a product that ships. <laughter> Right? Or you could use C++, and not really have object-oriented programming. You would have object-oriented sugar syntax and that was it. So Objective-C was the only real object-oriented programming that existed, at least language for it.

Markoff: Yeah, yeah, okay.

Markoff: So ultimately you were able to build this hybrid of open and proprietary, which continued on into the Apple, where you were leveraging an open source community, and sort of the best of both worlds in this hybrid way. Was that strategi-- I mean, did you set about to do that as a strategic direction?

Tevanian: Yes and no. There was a feeling that there were areas where we would have just incredible added value for things that were brand new, that should be kept proprietary and unique. But other areas, you didn't need to do that. So you know, networking. Why wouldn't you support TCP/IP and be open? Right? There's no reason to have a whole new separate networking language, if you will. And so that was sort of the general thinking. And the nature of our business was we had many things where interoperability, where re-use was more important than being proprietary. And other areas where you could do something, where proprietary really wasn't going to hurt you, and it added a lot of value, it had a lot of differentiation.

Markoff: Very pragmatic then.

Tevanian: It's very pragmatic.

Markoff: Yeah, yeah.

Hsu: Yeah.

Markoff: I remember, sort of after you guys got OS X up and running, Bud came to give a talk at Berkeley once, and at some point, like half of the lines on the code of the OS X, he said, were open source. I was just struck that the number was that large.

Tevanian: That does not surprise me. And it's because there's a very large UNIX core, that's basically these days all open source. And actually, we open sourced our version of it as well.

Markoff: Yeah. And do you-- so I think you kind of answered-- you have this practical view of open source. In terms of getting-- of shipping NEXTSTEP, did it stay in beta after it was out in the world? When the NeXT was shipping? The first Cube was--?

Tevanian: So I think the first Cube we shipped had Version 0.8, which obviously was-- we didn't call it beta, we called it 0.8. <laughter> And then we shipped the 0.9, and then we shipped the 1.0. I don't remember the exact dates. But we realized that the first version we were shipping wasn't 1.0.

Markoff: Yeah, yeah.

Markoff: In Brent Schlender's book, he writes that you wrote the music synthesis program that played during the keynote demo. Is there-- did you?

Tevanian: That is not correct. I don't know if he wrote that or not, but I know if he did, it's not correct. So what I wrote, I described a little while ago was the first test program to verify that sound actually worked. The demo-- at least one of the demos, the most interesting demo at that introduction was when the computer played with the violinist. And that was done from the DSP with synthesized instruments, and I did not write that. I worked with people that wrote that, but I did not write that.

Markoff: And I think you-- I mean, if you look back at the NEXTSTEP project, and the challenges in getting it to the market initially, what do you remember as being the hurdles? Like hurdles that stick out in your mind as--

Tevanian: Well, so, I talked about the optical drive, huge hurdle. Most things were just good old engineering work. But the optical drive was definitely paradigm issues. We were getting into new space, providing developer tools at a level never done before, that required a certain level of ways to work with developers, which also required adoption. And one of the challenges was, you know, we were building a new platform, and we couldn't build all the apps ourselves, so we had to have other people who would build apps for us. And that was a big challenge. You know, I mean, pricing, right? And this wasn't really a software issue, but it was a hardware issue. The staggering cost of the hardware from the cost perspective, and then you translate it into what you have to charge for it. That was a huge hurdle. Just going into the market with a new computer, I mean, you'd be insane to do that today. Right?

Markoff: Yeah. Jumping a little bit forward, there was a point where the company's strategy shifted from educational to business productivity. What can you tell us about that process from the inside? Remember how it struck the industry. And you know, the computer trade journalism industry is like a huge deal. I mean, NeXT was shifting gears.

Tevanian: Well, so I forget the exact timing, but the big deal there was we signed a deal with Businessland. I don't know if you remember that?

Hsu: Ahhhh.

Markoff: Yeah, I do. I do remember.

Tevanian: I don't know if that was in conjunction with our push into business, or I sort of went along with it. And they, I believe they committed to buying something like 100 million dollars' worth of product, over some interesting period of time, maybe a year or something? And I remember shortly after we did that deal, they invited me and Steve to go down to some event where Ronald Reagan was speaking, of all people. Just, you know, to celebrate that we had done that deal. And so we were really jazzed about that, because Businessland was a real company that sold to businesses, and they had basically produced, you know, soft POs for a hundred-million dollars' worth of product, which was way more than we had ever sold. So we were pretty jazzed about that. But then they went out of business. So. <laughter>

Markoff: I'm trying to remember now where that stood with sort of the politics of OS/2 and what was going on in the broader industry. Were you-- at some point were you moving toward competing head to head with this new sort of-- there was a phase change in the broader desktop industry as well.

Tevanian: I remember our biggest competitor was always Sun. We were more compared to the workstation market, and we had-- I remember we had done some marketing programs specifically. I remember we did this one program where we had two programmers, one programming with NEXTSTEP, one programming with the Sun tool set, side-by-side on camera. And the NeXT guy obliterated the Sun guy. And we did a little 15-20 minute video. It's probably on YouTube. So we really started competing at that level.

Markoff: Yeah, yeah. And the transition, so then there came the transition to the Intel hardware, moving away from 68040. Do you remember why you chose to move away from the Motorola architecture and go with Intel?

Tevanian: Well, the Intel was not about using Intel hardware ourselves. It was about selling software on PCs. The thinking there being, "These guys building PCs can do it for zero profit margin, right? And they're at scale and we're not. Simple as that.

Markoff: But that, for you, that meant then you had to take this operating system and move it to a new architecture. How hard was it to move NEXTSTEP?

Tevanian: That was our specialty! Remember, we had Mach, which was already portable!

Markoff: Yeah, yeah.

Tevanian: So, you know, that was easy. And in fact, we ended up porting it to the x86, to the PA-RISC, to the POWER Architecture, to SPARC. You know, we were churning them out. You know, give us the funding, or commit to go, and six months later, we'd have it running. We ported to some processor that never shipped. The 88K. Remember the 88K?

Markoff: I do remember the 88K.

Tevanian: We had it running on 88K prototypes.

Markoff: Yeah, yeah. And the decision process inside, was it, you know, did you debate inside about whether to go from one architecture to a software base?

Tevanian: Of course!

Markoff: Do you remember who was on what side, and what it was like?

Tevanian: You know, I don't remember exactly. But obviously, that kind of decision is something that hardware people don't like. And almost everybody else does, just generally speaking.

Markoff: Yeah, yeah, that's-- And do you remember where Steve was? Sometimes I know that Steve has to be brought around on issues, and then he becomes a champion at a certain point. Do you remember--

Tevanian: That's right, and usually, you know, to expand further on what you're saying, usually things have to get pretty bad before he gets brought around. Not always, but usually. And I think that's what was starting to go on here, which was-- I mean, this hardware business is a tough one. Not only are we not selling very much, but it's capital intensive, and you know, risky, and still not working. And oh, by the way, most people see the value in the software.

Hsu: Where was Bud Tribble on that issue, porting to Intel?

Tevanian: I do not remember, and in fact, it may have been that Bud had already gone to Sun. So I'm not sure.

Markoff: Bud had-- I mean, there were people who had been so close to Steve, who at various points left. Do you remember that as being painful?

Tevanian: Bud leaving?

Markoff: Yeah.

Tevanian: Absolutely. That's another one of those things I remember vividly. For some reason I was at home in my apartment, not working. And I get a phone call from Steve, and he was practically in tears. He said, "You're not going to believe this; Bud is leaving." And I said, "Really? Where's he going?" He said, "You're not going to believe this; he's going to Sun."

Markoff: Yeah, yeah.

Tevanian: And he just could not believe it. He's like, "I don't understand how he could possibly do this.

Markoff: Yeah.

Markoff: And were you close to Bud at all? Did you get a view into that about what his personal--

Tevanian: I was pretty close to Bud. I'm sure I talked to him after this, but I don't really remember what we talked about, it was so long ago. I'm sure he gave me some good reasons about why he was doing it, what the opportunity was, something like that. But I don't remember exactly.

Markoff: Do you remember-- oh, go ahead, I'm sorry.

Hsu: What was it like to work with Bud?

Tevanian: I loved working with Bud. Bud, one of the smartest people you'll ever meet. Very nice person. Always wants to do the right thing. You can always have a great discussion with him. Never got very social with him. Probably because he was married and I wasn't. But he was just a great guy to work for.

Markoff: And did Dan'l [Lewin] leave before or after?

Tevanian: I think Dan'l left before.

Markoff: Yeah, yeah.

Tevanian: I think Dan'l left pretty early.

Markoff: Yeah, yeah. So in terms of your time at NeXT, going from engineering to management, what was that as a learning experience, and sort of learning to be a manager, and--

Tevanian: It was trial by fire. You know, I became a manager like within a year of joining NeXT, I think.

Hsu: Wow.

Tevanian: But we were small. We all knew each other really well. There wasn't much managing to do. Again, I'm coming from being thought of as that benevolent dictator on the Mach project, which is probably not a good management trait. And I'm sure I learned that along the way. But again, as far as I was concerned, we were also heads-down at that point in time, just trying to get things done. You know, yeah, we did annual reviews, but as to standard HR practices, very little. At least at that time. So you know, I was learning trial by fire, learn what works, learn what doesn't work.

Markoff: In terms of sort of picking a replacement for Bud, were there others who were in contention? Do you remember how Steve chose? Was it Paul Hegarty was being considered as well? Do you know if that was correct?

Tevanian: So I'm not sure who took over after Bud. It might have been Paul. But I'm not sure. I don't remember.

Markoff: Okay, but then ultimately.

Tevanian: Then ultimately I took over.

Markoff: So in that period when you managed software, what are the sort of milestones that you accomplished?

Tevanian: Well, so I think if you look at sort of the-- I assume you're asking about sort of the big ticket items, things I got done. So I mean, obviously, we had NEXTSTEP starting with the intro, making it into a real product. I think we took it through like 3.0 or something as a product. We introduced some really innovative features in it like Distributed Objects, Enterprise Objects Framework. These are things that were just groundbreaking at the time. We had it such that they could communicate with window systems over the network through an object model. We built this product called PDO, Portable Distributed Objects, which was our distributed object technology, running on any OS. That was part of the Windows angle. Then we ported it as a whole OS to all these different architectures, Intel, HP PA-RISC, POWER Architecture, the 88000, etcetera, etcetera, etcetera. And then we took the higher levels of it, and turned it into OpenStep, which then ran on Solaris and Windows. Was gonna run on AIX at one point.

Markoff: That's right. That was an Andy Heller deal. Do you remember this?

Tevanian: I remember the deal, I don't remember Andy.

Markoff: Yeah, he was the head of the RT business.

Tevanian: Okay. And then, so I mean, these were all really great innovations through the years. And then we had this, what I thought was a revolutionary product, WebObjects. Which was the very first server-based application service ever-- ever!

Markoff: What year would that have been roughly? Would that have been '94/'95 by then?

Tevanian: Ahhh, yeah. Maybe. I think so.

Hsu: The [NeXT SEC] S-1 [IPO filing document] says it shipped in '96.

Markoff: Okay, so a little bit later.

Tevanian: That's when it fi-- could be. Somewhere in that range, yeah.

Hsu: Yeah.

Tevanian: We would have been working on it before that, so maybe '95-ish.

Markoff: So we haven't asked you about this, but you know, the web was built on NeXT. How much of it was-- I mean, from being inside NeXT, how much did you have an early sense that the web was going to be a world-changing architecture?

Tevanian: So I think we got that, not because of the client being on NeXT, but because we built WebObjects.

Markoff: Yeah, okay.

Tevanian: And the client thing on NeXT was kind of cool, but all you had was static websites, which was interesting for researchers and a few things like that. But when we built this first web server, and we started thinking about all the things that could now be done-- you know, we built demos of a car selector, where you picked models and options and colors, and it's changing in realti-- you know, you have to refresh the page back then, but it changes. And we built the first system that ever tied into SABRE for booking tickets! I mean, who would have ever thought?!

Markoff: God, yeah.

Tevanian: And so we just knew then that we had something!

Markoff: Yeah. And yet, NeXT, you know, you could almost see a business strategy based on that insight, and yet you weren't able to sort of take it to the scale that the web became.

Tevanian: Well, that's because we got bought by Apple. Right? And so I think, you know, if we hadn't got bought by Apple, WebObjects would have become a huge business. Because we know how big these web services businesses are today. And it could have been a very, very large business. And I don't see any reason why it wouldn't, because we had a huge head start on everybody. You can't even say head start on the competition, because there was no competition. There was maybe one other guy out there, ColdFusion, I think it was, that was even doing anything, and they got bought by Adobe.

Markoff: Yeah, yeah, it's interesting. So in terms of that OpenStep licensing decision, do you remember whose-- how that came about inside NeXT was--?

Tevanian: Before IBM?

Markoff: No, I was thinking about Sun. Oh, OpenStep on Solaris and--

Tevanian: OpenStep on Solaris.

Hsu: And Windows, also.

Markoff: And Windows.

Tevanian: And Wi-- well, so Windows wasn't in a licensing situation, that was us just having a product to sell. With Solaris, I'm trying to remember how far that got.

Hsu: I was told that the source code for the AppKit was actually licensed to Sun.

Tevanian: It was, and we sent some engineers over to help them port it. I don't know that they ever shipped it. It was-- we probably had things in place that made it too hard-- like it had to be done in a clean room, so that anyone from Sun working on it couldn't work on other Sun projects or talk to them. All these requirements, and maybe that had a little bit to do with slowing it down. Put some NeXT employees on site. And I think, you know, it's probably one of those things where Sun probably had some antibodies that didn't want it to succeed anyway. That wouldn't surprise me. Most companies of that size have that kind of a problem. But it just never got out.

Markoff: And a little bit more about WebObjects. You know, is there more of a backstory? So what were the sort of threads coming into WebObjects or what drove it, or you know?

Tevanian: Well, I remember, so I know I was running the software group at the time, one of the guys, an engineer, came to me and said, "Got this idea. We can have a server that you send info to, and it does something, and then sends HTML back." I'm like, "Hm, what do you mean?" And he showed me a little demo of a very simple script. Said, "That's pretty cool. We can do something with that." And so I authorized him and a couple other guys to go spend some resources on it. Said, "Okay, go build this and come back, and then show me when you've got something a little more real." And I mean, it's one of those things where the first time you see that demo, was like, "Of course! This is the way it should be."

Markoff: Yeah.

Hsu: And WebObjects was built on top of Enterprise Objects Framework?

Tevanian: I would say it a little bit differently, WebObjects was built on the side of Enterprise Objects Framework. So WebObjects didn't require Enterprise Objects Framework-- EOF, is what we called it-- but it benefited from it, if you had a data source. So you would use EOF to access the database. Didn't have to, but it was the easiest way to do it.

Hsu: Mm hm.

Markoff: Yeah, yeah.

Hsu: And how did the EOF project come about?

Tevanian: The EOF project came about much earlier. Its first instantiation was something we called DBKit, DatabaseKit. We had kits for everything. And we knew accessing databases was important, and so we built a kit that lets you access databases. And then we discovered what people liked and didn't like about it, and redid it as EOF.

Markoff: Yeah, okay. I had forgotten this. An attempted NeXT IPO? Do you--

Tevanian: Yes.

Markoff: When did that ha-- I'm totally lost in history. In my history. <laughs>

Tevanian: So attempted in the form-- it wasn't actually attempted in that there was a registration. But there was an S1 that was 95 percent done. I've donated it-- an original copy to the museum.

Markoff: Great.

Tevanian: And we were working on it-- I think the draft is dated November of '96, which was the same time we began discussions with Apple.

Markoff: Ah, okay.

Tevanian: So Apple basically preempted it.

Markoff: Yeah, okay, so the-- yeah. And at that point, talk a little bit about Java, and was there a NeXT Java strategy? And where did Java fit in the puzzle?

Tevanian: Ah, there was no real NeXT Java strategy at the time. Java came later on, mostly for compatibility reasons.

Markoff: Yeah, yeah.

Hsu: Actually, so Blaine Garst told me that he had actually created the Java bridge for WebObjects while still at NeXT. Is that correct?

Tevanian: That's entirely possible. I don't remember the exact details on those dates.

Hsu: Okay, yeah.

END OF THE INTERVIEW

