Oral History of Dave House

Interviewed by:
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Gardner Hendrie: All right. We have today [April 20, 2004] Dave House, who has so graciously agreed to do an oral history for the Computer History Museum. Welcome, David. Thank you for your time.

Dave House: Thank you, Gardner.

Hendrie: I think where I'd like to start is maybe you could tell me about where you grew up and whether you had any siblings. What your parents did. Some of the general background to understand where you came from.

House: Okay. So I grew up in Muskegon, Michigan. My parents both grew up on farms in large families, ten kids in my mother's family, seven in my dad's family. Neither of my parents had gone to college at the time I was in high school, and my dad worked in the automotive industry. [He] was [a] machine operator. He made everything from crankshafts and camshafts and engine parts for Continental Motors. Later he went into labor relations and even later went into planned giving at a university. But as I was growing up, he was in the automotive industry. I'm actually the second child, although I'm the oldest living. My parents had a baby before I was born who was severely handicapped and died when he was 18 months old. I was born about another year and half after that. This was during World War II, and my parents discovered that uh…I'll give you a little psychoanalysis here. My parents discovered that my mother was RH negative, and my dad was RH positive. At that time the medical profession didn't know how to handle that. That situation is pretty easily handled today medically, but in those days the word my parents got was, usually the first child is okay but any after that probably will not carry through to live to birth, and if they do, they won't be right. So World War II is going on. Dad hadn't been drafted yet. I pop out. I'm the miracle baby, [be]cause I appear to be normal. Dad goes into the service then, and so mom figures that he may never come back again. He's in the Pacific region in World War II, and so I kind of got a lot of special attention when I was a kid, so some people say that I think I'm the center of the universe, and that's probably why because at that point in the formative years before I was five, I was. But my dad came back from the service. Nine months later my brother was born, a boy, was I pissed about that, to find out that I wasn't getting all of the attention. Then another three years later when my sister was born and she was just as cute as a button. She really got the attention and now I had to work harder to get attention and then three more years and another sister came. So I'm the oldest of four living children and the second of five. So that's kind of the family history.

Hendrie: Okay

House: I knew very early that I was going to be an engineer, and it's just genetically in my code. I was the kid who always took his toys apart and put 'em back together, and when it rained, I'd go down by the hill where the water ran down the road and I'd build all these dams when I knew is was going to rain, so that it'd fill up with water and I could watch 'em break, or I could break 'em and then flood the next one, and see if I could build a dam that would withstand the break of the previous dam, I was always doing

things like that and fixing thinks at home. As I got older I started fixing the appliances when they broke, and fixing the cars, and my dad being in the automotive business would, when there was something wrong with an engine, we pulled it out of the car and fixed it. Being the oldest son I got to start out holding the light and handing him [dad] the tools. Later I wound up doing the heavy work. When I was in high school I got a job at Universal Cam Shaft, a company that designed camshafts and manufactured camshafts. They did a lot of high-end submarines and race cars and that kind of thing, especially camshafts. It was a small company and we had one engineer and one draftsman, and one administrative person in engineering. The head engineer said, well, what are you going to do? I said, "I'm going to be an engineer". He said, "What kind of engineer"? Well, I hadn't really thought about that. So I said, "Well, probably mechanical".

Hendrie: How old are you?

House: I'm in high school.

Hendrie: Yeah, Okay

House: So

Hendrie: Every <inaudible> is to you

House: Yeah.

Hendrie: On the subject so.

House: Yeah. Probably 16, 17.

Hendrie: You already had decided you were going to be an engineer.

House: Yeah, I wanted to be an engineer, 'cause it was always natural to me. Science and math came easy. I couldn't get languages for anything.

Hendrie: Yes.

House: I didn't see any sense in all of that artsy fartsy stuff when you could actually build stuff - and understand how things operated. So this guy, this chief engineer said well, you should look at electrical.

And I said, “oh, yeah? Why?” And he said, “Well that’s really where the future is”. So I, as I went on and started thinking about engineering, I started … I didn’t know anything about electrical. I had a friend who repaired televisions at a TV shop in those days when you used to bring in your TV when the tube’s blew out and they’d fix it and he had that job. So I talked to him a little bit and, when I went to Michigan Tech, I wound up going into electrical engineering and…

Hendrie: Okay. Now how did you, when did you know that you were going to go to college, I mean? Because your parents said not to?

House: Yeah. Well, my dad said to me, “Dave, you know we really want you to get a college education and we’ll do anything we can to support you in getting a college education. Unfortunately, that won’t be financial. Cause we can’t do it”. So I [lived at home and] went two years to community college. I had a professor there, Professor Bruning, Paul Bruning. He taught physics and I did well in physics ...

We used to get in trouble for acting out, pulling stunts in physics. Other than that I got good grades. I went to Professor Bruning and I said, I’m really interested in going to college, and I need to get a scholarship, ‘cause I don’t have any money and I don’t have any way to go. I’d like to get a good engineering degree. He said, well, you ought to go to Michigan Tech. I didn’t even know what Michigan Tech was. I applied to Michigan Tech, the only university I applied to and I applied for a scholarship and I got full tuition, fees, and scholarship. It was good for 24 months. For two years.

Hendrie: Now where was Michigan Tech really?

House: Up in- 500 miles north. It’s up in the Upper Peninsula of Michigan, on the Keweenaw Peninsula sticking out into Lake Superior.

Hendrie: Oh my gosh.

House: So it’s east of Duluth and west of somewhere in northern Ontario and west of Sault Sainte Marie, the Straits of Mackinac and it’s a kind of a snow capital because the cold winds come across Duluth and they hit Lake Superior and they pick up just enough moisture that when they hit the Keweenaw Peninsula they dump it all. The year I graduated we had 300 inches of snow. I’ll never forget. I went up [to visit] in February [while I was going to Muskegon Community College]. I wanted to see the campus before I signed up to go there and I’d already been accepted and had the scholarship, that’s the only place I applied. It was pretty well given that I was going to go there. So I had a car. I got three other students at community college who was interested in going, and we [shared the gas costs and] drove up there. It was a really cold spell. I mean super cold. It got down to 35 below zero at night and the warmest I saw during those days, ...I drove up one day, stayed on campus three nights, and drove back the fourth day….. the warmest I saw was 16 below zero. And I still went to school there. <laughing> I did. I was dating my

first wife, Joyce, at that time, and we talked about [how] we'd get married after college. After I graduated from Community College. I went back from that trip and proposed the next weekend. I said, let's get married now. You're going to be working in this Danish pastry shop for two years and I'm going to be up there. Why don't we just get married now? So we got married that summer.

Hendrie: Oh, wow. Okay

House: So I could tell you all kinds of Michigan Tech stories, but they're probably not as relevant as the most important sort of defining events that happen in your life, that change everything. One of them was… I forgot his name, Red- Red uh… I have forgotten the chief engineer's last name, saying, "go electrical". Bruning saying "go to Michigan Tech". I went to Michigan Tech. I had 88 semester credits transferred and I needed 222 to graduate and I had 24 months. I went to orientation and the president of the university gave this talk. There were all these freshmen there. I'm an incoming middle of my sophomore year kind of person. He said, look at the person on the left, the person on your right, because one of you will graduate. The other two will drop out. I thought, oh, those aren't good odds. And he said, look at your row, because there's probably ten people row and one of you will make it in four years. And I'm thinking, "I only got 88 credits. I need 222. One out of ten make it in four. The odds aren't good here, are they?"

Hendrie: The deck is stacked against you.

House: Yeah. And I'm going to run out of money in 24 months. So, I went to school four quarters a year. I went summer semesters and took my sophomore EE classes the first year and then during the summer, the summer from hell, I took all of my junior EE classes. All on a compressed schedule. I mean, I just killed myself that summer. Then my senior year I moved up a class so I'm with the class of '66, and then I'm with the class of '65, and graduated in 1965 from Michigan Tech. I had an objective of being in the top ten percent of my class and as I recall I was number 7 out of 67 in electrical engineering so I made it on a rounder. Another defining event was beginning of my senior year where I just moved up a class. Dean Hunsinger had the highest grade point in the department. He and I are walking between classes. He said, Dave, are you taking computer design? And I said, no. You know, I didn't see that course. Dean replied that it's a graduate class. I said, but I'm not a graduate student. Dean said, well, yeah, but if your grade points above 3.0 you can take it as an undergrad. I said, oh. So I went and looked at it, and I thought this would be interesting. I went and dropped one of my other classes and took it- added computer design. So I go to this class and we're going through logic and Boolean algebra and Quine-McClusky, the minimization of sequential state machines and, and I'm saying, what's- what's the point here? What's the point? I mean, this is so obvious, why- when- when are when are we going to get into this?

Hendrie: When are we going to get to the hard stuff?

House: Yeah. Right. Exactly. And then I realize that there were other people in the class that weren't seeing it quite the same way. I thought, this probably is a, I mean, if I'm good at this, I probably ought to do this. And that was a very defining moment because I probably would have been doing wave theory or communications...antennas or something like that.

Hendrie: Or radios.

House: Radios. That's right, because Michigan Tech had a strong communication program and a guy, [Professor] Jon Soper, who was sort of a mentor and had gone in that direct[ion], that was his work, and so I probably would have gone in that direction. Instead I wound up heading for the computer side. I don't know if these personal stories are interesting, but.

Hendrie: Yes, they are.

House: I'm coming up to the winter quarter and this is when all the companies come and interview people for jobs. I want to go to graduate school. I want to get a Master's degree. But if I do that, I gotta work- I gotta work full time and go to school part-time. But there was a big demand for electrical engineers in the winter of '64-65 and so there were a lot of companies coming to campus and I interviewed... I decided that instead of interviewing companies, I was going to interview the United States. I lived in Muskegon, Michigan, all my life and the farthest south I had been was my grandparents in southern Illinois. The farthest north I had been is Michigan Tech. The farthest west I had been was Chicago. And the farthest east I had been was Niagara Falls. Except for these little excursions north, I only had a few hundred mile radius kind of experience base. So I decided Muskegon, Michigan may not be the economic capital of the future. I've always been a strong advocate of you can't create luck, but you can always put yourself in luck's way. If you put yourself in positions which increase your chances of being lucky, eventually it'll hit you. So you're not going to put yourself in luck's way in Muskegon. So I needed to interview the United States 'cause I don't know anything about it. So I took job interviews strategically placed. I took 14 job interview trips.

Hendrie: Oh my goodness.

House: And I went to Boston, and I went to New Jersey, and I went to New York, and I went to Virginia, and I went to Florida, and I went to Alabama, and I went to Minneapolis and St. Louis and Chicago, and- and I went to Dallas, and I went to Phoenix, and I went to southern California, and northern California, and I went to Seattle, and all around on these job interviews, knowing that I'm not looking for a job, I'm looking for where I'm going to eventually be. And then secondary, I'm also checking out the universities for part-time programs. So I finally decided I'm going to California and I took a job in Massachusetts, because turns out that there were a lot of universities right there around [the] Massachusetts area and there were some programs and after I got there, I realized that probably Northeastern was going to be the

best fit for me because they had a strong co-op program and I wound up getting my master's going nights at Northeastern in a three and a half period of time. So that turned out to be great. But as I was doing that, I'm working. So started out doing data acquisition work.

Hendrie: So what company were you with?

House: Raytheon. Raytheon in their Norwood, Massachusetts Communication and Data Processing Operation. We're doing data acquisition equipment. Military. Solely in the military.

Hendrie: Now what was the kind of the places that you looked, I mean, what were the other top contenders?

House: So- so I really was in…

Hendrie: Which you decided <inaudible>

House: I was really interested in Control Data. But at that time Seymour Cray took all the college grads and put [th]em on the production line checking out the brand new 6600s. He said that's the way that you learn, you start there and you work your way up the the ladder. I said, I don't see myself on a production line debugging machines for a while to earn my way and they didn't have the best night [graduate degree] program. GE in upstate New York, had some incredible education programs, but I wasn't just that excited. They had a deal where they tea-bagged you around to different positions, and then you wound up settling into something, and that wasn't going to work very well for going to college at night, cause I was going to have to wind up moving [around to different locations]. I could...I was going to rent an apartment anyway and so I could move, but it wasn't going to work very well for going to school. At IBM I had a great...I had this incredible interview. They interviewed me about four different places. I had this just great interview in the CP design group. I was like- we just clicked. And I thought they're going to give me an offer and I'm going to work for IBM. But what IBM would do is with all the candidates, they'd get together and make one offer and my offer came out of a different place than the one that I thought it was going to come from - that I fell in love with and I thought they fell in love with me. It came from a different place. I said, screw it. If they aren't where I want to be, I'm not going to go. So I didn't go there.

Jon Soper from Michigan Tech, had done [a] one year sabbatical at Raytheon so that's how I- why I interviewed Raytheon. I went and I met a guy by the name of Steve Longee and Steve said, "I'm a specialist in generality". He said, I'm not going to be able to go really deep in any particular area here but I can tell you about the whole thing. He said, "I'm a system engineer. I'm not a component engineer. I'm not a circuit designer. I'm not a software programmer. I'm a system engineer. I design systems." That was attractive to me. I thought that was a nice philosophy so I wound up going to Raytheon in Massachusetts.

I took all of my belongs, sold my house trailer that I lived in when I was in Michigan Tech that I'd pulled up behind my car when I moved to Michigan Tech. I packed everything in a U-Haul trailer and put it on the back of a new car that I'd just bought with a loan from my dad. My car had broken down and my dad said - I'll make the first five payments and then you just make five more payments to me at the end, then I bought a new Pontiac and I towed that U-Haul-trailer with everything I owned to Massachusetts and went out and spent $600 and bought all the furniture that I needed for my apartment.

Hendrie: <inaudible> was that?

House: I built the rest of it [furniture] myself and made $667 a month. I thought I was in pig's heaven and I had as much money as I could ever spend. It was like ...after having budgeted things down to the 35-cent sundae on Sunday afternoon while I was at Tech, I was in fat city. I had a two bedroom apartment and I was in great shape.

Hendrie: Now you didn't have any kids yet.

House: No. But I did have my first child nine months after I graduated.

Hendrie: I'm in pig heaven money now.

House: Yeah. That's right.

Hendrie: I can afford one.

House: Well the deal always with Joyce [my wife] was - we won't have any kids while we're in college, but once we get out, we can start a family. We both wanted a family and sometimes you get lucky. There were exams [before I graduated] and then there was one right before the family arrived. Nine months later there was a baby.

So…so that gets me to Raytheon. I did a data acquisition system, I finished a data acquisition system. Seems like my career's been full of a bunch of- in the beginning, in the first eight years - there were a bunch of finishes- starts and finishes. After eight years I really wanted to do something all the way through and so I went to Intel for almost 23 years. I spent only three and a half years at Raytheon but I got to really see a bunch of things through the complete process. I started out with a data acquisition system that someone had designed that didn't work. I had to fix it, make the engineering changes and install it and get it accepted.

Hendrie: Okay. Who was it for?

House: It was for the Air Force. It was delivered to Eglin Air Force Base in Florida, the one that's down on the Panhandle. I think it's Eglin [Air Force Base]. It was a data acquisition system that basically took a bunch of inputs from a filter bank that was connected to a radar receiver, or a big dish receiver and broke it down to the frequency bands and digitized it. We had an A to D data converter, which I had to make work, [be]cause that's what you used to design 'em. That one didn't quite work and I had to redesign that and then the whole acquisition system just didn't have the right power and ground and timing stuff set up and I had to go through it. I was able to save the skins.

Hendrie: Oh, that's major.

House: Made big changes. But the problem is that there was a committed delivery date, and the company said we're going to ship it. We have to ship it then- and you're going with it. So I took a technician and went to Eglin Air Force Base and lived there for awhile, while I got the thing to pass the acceptance test. Then I worked there [Ratheon in Norwood, MA] a little bit on an airline reservation system. It was basically a switch for a very early communication system for an Air France airline reservation system.

Then I got called into the FAA's en route air traffic control system design at Raytheon. I had moved up to [highway] 128 in Waltham. The building next to- remember the big Sylvania building? We were just down the street from that. There was a team of nine system engineers, and I was number nine. I was the low man on the totem pole. Our job was to design this redundant system. The system was fully redundant, parallel- so there's two of everything. It had busses so it could switch back and forth. It had a whole cabinet that contained one meg of memory. Of course another cabinet right behind it with another meg, which was the redundant [part]. The busses were such that you could switch in and out individual functions. My initial job was about the bus design, the bus architecture. There were five major busses and I felt we could combine some of these and so I did. Wrote some software, did some simulation, and proved that you could do that. Then we got the architecture set up with it–that particular bus structures. I was the bus structure guy.

Then I went to work and designed the display processor. This is a vector display so we were taking in information from radar, and we're actually painting the radar so it looked like a radar screen, because that's what the air traffic controller operators were used to. They were used to old radar screens, so we'd simulate in digital by making a blip and then we'd go back one normal radar trace and make a lighter intensity blip, and then two radar traces, and a lighter one. So we were recreating the look of a radar. And then we'd write in there the flight number and the altitude and stuff like that with a vector display. Well, then I went to work and designed the display processor, the thing that drove the display. So the data's back in the memory bank, and the operator could zoom in, so when he zoomed in I had to change the display by reading from the memory and make it bigger on the screen.

Hendrie: Yeah, exactly, all those things.

House: Do all that kind of stuff. But my display processor fed a vector generator. So I could feed it the characters and it [the vector generator designed by another engineer] actually handled the analog part of the strokes.

Hendrie: Yeah. It would actually go off

House: Yeah, the strokes. I just had to do the filtering basically and display processing and get the signals- the same information from diverse places [in memory]. Anyway, that was that design so I got to see that through, and then I got…you know this mini computer thing was happening and I got very interested in mini computers.

Hendrie: Now what time is it?

House: So this would have been in 1968. I got a call about coming to work at this company that Honeywell bought, Computer Control [Corporation – 3C's - which became Computer Control Division – CCD - after Honeywell bought it] , where you and I met. And you remember Chris Newport?

Hendrie: Yes. Chris Newport.

House: Chris was looking for someone to lead the design of a machine which would bracket the PDP-8 The PDP-11 was from Digital Equipment. They [Digital and CCD] were more or less equal size competitors in those days. Both had started out doing logic modules and graduated to mini computers and 3Cs- CCD - had the 116, which was succeeded by the 516 by this time, and they were in the process of developing the 316, a lower cost version of the 516, which we have [had] in [the Computer History Museum's Visible Storage], and of course, the Kitchen Computer right here. The 516 is in the IMP processor next to it, interestingly enough. Two very futuristic things that came out of that architecture. Digital had their 12-bit PDP-8, which was their mainstay. So if you needed more addressing range, and more power we'd win. And if you needed lower cost, then DEC would win, with their 12-bit PDP-8. So Chris's idea was coming out with a 8 [bit] machine, and bracket them. That was what they [CCD] wanted to do. So they hired me to run that program, come up with an 8-bit architecture. You remember back in the late '60s there was a whole a rash of 8-bit minicomputers that came out. A bunch of in Southern California. Microdata being one of those, by the way. I think there was a company called Bit, and there was a company- and I forgot the company name. There were a number of companies that made 8-bit mini computers. And so I started to design this thing called the X-12, cause everything [computers in development] had a X number at CCD.

Hendrie: Right.

House: That's the machine for which Honeywell gave me the Harold W. Sweat Engineer Science Award, but by the time that we got the design done on that machine, Honeywell and GE merged. I think you had you left by that time?

Hendrie: Not yet.

House: Okay. So remember Ugo Gagliardi?

Hendrie: Yes.

House: From Harvard, I guess, he was - who had been brought in to lead that architecture and basically the job was - we bought the GE business, and we have the Honeywell business, and how do we merge these product lines?

Hendrie: Exactly.

House: And they formed a committee … I had been called in for some reason, I don't know why, maybe because of the Harold W. Sweat Engineering Award, or something. [I was] to brief Ugo on cache architecture. Now, we didn't have any cache memories on the X-12, or any of the 3Cs machines. So, Okay, fine, Okay that's the job. So I go start doing some reading, and I start reading about the 360s and I start reading about these other machines, and I said you can have these types of caches, and there's different mapping algorithms and this is how they work. And etc. I had like an hour or something [to brief Ugo], and I go in to - this is the way they work and this is the way you do it, and these [are the] options, etc., etc. And this was kind of the landscape. The queue does this, etc., etc., etc., - and I left. Later I got some feedback through my boss, "Oh, Ugo said you did a great job". Okay, fine. So the merger happens and they create this task force for a new architecture and there were - three teams. On for the high end, which is like the big Phoenix GE machines. One for the mid-range, which is like the Honeywell 200, which was compatible with the IBM 1401.

Hendrie: Yes, yes, yes, the 1401 compatible .

House: Compatible, yeah. And then one for the entry level systems. I got appointed to be one of the architects on the entry level systems. I thought, wow, this is wonderful, you know, boom. This is cool. I'm going to be able to help put this whole thing together. The committee had representatives from I think it was from GE Phoenix, GE Oklahoma, I think Oklahoma City. I was from Massachusetts and then there

was somebody from Honeywell Bull - Bull Machines or whichever it was called in Paris. And then somebody from Bull Italy. So there were five of us on the committee and we're going to meet in Paris, and so I go to Paris for two months of meetings with this big architecture group which was quite an experience in itself. I show up at Honneywell Bulls' location on Avenue Gambetta, and I get met by the guy who's kind of there to integrate me and we go in. We start having these meetings and talking about how to do an entry level machine. To me it was obvious. I had become familiar with what Intel was doing and I should go back and talk about it in a second, but uh... and I said we ought to buy the 8080, and we'll put it on a printed circuit board, with some memory and an RS-232 port, and put some switches and lights on it, and we ought to make that be a machine that we sell to industrial control and machine control automation, and small business applications. I thought that was a pretty good idea. But what I started to discover, during the course of those meetings, was that this was not a technical committee. This was a political committee. Not only was it a political committee, but governments were involved, particularly the government of Italy, and the government of France, which had very close interests because how this went would determine where they would be designed, and they wanted the design to be in their countries, and so there was- I got all this back channel noise.

Hendrie: And then they were built where they were designed, of course.

House: Of course. There was a proposal, a counter proposal... there were several proposals, some of them to make things out of TTL, and [one to] make custom chips. But in Phoenix and Oklahoma [mainly Oklahoma], there was a group that did printer controllers and device controllers, like I think disc controllers, as well. For certain [they made] printer controllers and key punches and that kind of thing. They had some logic they had designed which was custom logic, multiple chips, but custom logic, which they called the Basic Logic Unit, or BLU, and what they proposed is that what they should do is, we should start with the original BLU, they called that Old BLU, but they had conceived of this product called New BLU, which they hadn't developed yet. But it was like six chips or something for a processor and New BLU would be what we would make. And we'd make that, use that for our entry level machine. I argued about standard products, and one chip versus a bunch of chips, and that's when I really discovered that I wasn't talking technical here. We were talking political and geopolitical.

Hendrie: Exactly.

House: So the decision was headed towards doing New BLU, which is what they wound up making the decision in the committee. I don't know where it eventually wound up.

Hendrie: Yeah. You don't know actually what happened.

House: Yeah. What actually happened. But it was very clear to me. Now I'm out of my old computer control division. I've moved my office up to Billerica, Mass and I'm part of the big Honeywell, and the big

Honeywell is totally enamored with the [Honeywell] 200, and not the minicomputer business. They started shutting down the 3Cs kind of stuff and this just doesn't smell good. I'm flying on a plane- here's another one of these defining moments. Before I go on to- the flying in the plane, I think an important piece of information is - when I was designing the X-12, I had been approached by Computer Design Magazine to write an article. So I thought, well, that'd be a good [thing] to do… write an article for Computer Design. So I went and talked to Russ Hensel, who was…I don't know if he was my boss or my peer, but he was a more senior guy and we talked about it and we brain stormed around, we said, well, it'd be kind of fun to write something about how the semiconductor industry's been moving on, because every time we go to design a new machine, we've got so much more to work with. I mean, I remember when I started working with two NAND gates in a TO5 can. And I remember- I remember, some of these things. You remember. I remember hooking a scope probe on one of the leads of the TO5 can and shorting a lead to another lead, and blowing up a $56 integrated circuit. I did that twice in one day and my boss gave me a warning, 'cause I had burned up two expensive chips. Now they were 56 bucks a piece and there were only two NAND gates inside one of those things. Then we had to deal with dual in line circuits, first it was DTL, and then we went to TTL, and then we got an MSI, and then I remember when I saw the first 4-bit ALU. It just blew my mind that we could put 4 bits [of ALU] in a chip, cause I was used to designing ALUs out of lots of different parts and that was a whole person's job.

Hendrie: Exactly. That's your project. That's your job to design an ALU.

House: And now you can get 4-bits and you just cascade this thing, and make it be 16-bits, and wow. We're seeing this progression of semiconductors, and we thought it'd be fun to write an article on the impact of semiconductor technology on minicomputer architecture. So, the fifth person who discovered America and thought he was first - we were the fifth person to discover Moore's Law, and think we were the first, cause we plotted all these things versus time and noted this rate of change, and of course this was after Gordon had published. We just hadn't found- I hadn't found that.

Hendrie: You hadn't seen it.

House: I didn't call it Moore's Law or Dave's Law or anything else. I just said this is kind of a trend, and we wrote this article and we made conclusions that supported the X-12 architecture, in writing the article. So I'd written this article on this topic so I was kind of like tuned into the semiconductor thing, and how it was affecting design. I'll never forget one day walking by Ike Templeton's office. Ike was the big boss and he had a bulletin board outside of his office, and he used to cut out articles from magazines and newspapers and pin 'em up on that bulletin board. I'll never forget going by and seeing this article. I'm walking by and I see the headline on this article - Intel introduces a single chip computer. Bamo! <mouth sounds> And I went and right away…and it's about the 8008. I went right over to the components group, and said, because we had, I had used 1103 memory in our- in- in my X-12... and I went over to the components group, and got the data sheet and I read the data sheet. And it's serial and it's slower than shit. ….but it's a computer. It's got a program counter, it's got some registers, it's got an accumulator. It

passes the Turing machine test. It is a computer. It's not just part of a computer. It's a real computer. But it's no competitor to our stuff, of course, but, then I'm thinking of these lines I'd drawn, and the trends, and I said, whoa, that's significant. I went home and told Joyce, my wife at the time, I said, I learned two very important things today. She said, what's that? I said, well, first of all my job's going to change. She said, what do you mean? I said well, low cost, high volume computers, the thing I design, they're going to be designed by semiconductor companies instead of system companies. And that's pretty important. She said, oh, okay she said, what's the other one? I say, my job's going to change coasts, 'cause those companies are on the west coast. She said, oh, now that's important. But we had kind of decided we were going to go California anyway, so that was okay.

Along this same story, the Intel connection. My first experience with Intel. We'd got the X-12 development approved and I'm in charge of the development and Bill Jordan ran the memory department, you remember. So I'd gone to Bill, and Bill had assigned Hank Bodio, I think it was, to design the core memory. So I'm working with Hank about the design and the card and the format and the size and the cost, and all that sort of thing. And Bill comes to me, he said "I'd like you to put a semiconductor memory in the X-12" and I said, "What's a semiconductor memory"? He said, well, there's this new thing from Intel called a DRAM and I say, what's a DRAM? He said it's a Dynamic Random Access read write Memory. I said what's dynamic about it? He said, well, it's capacitor storage and so you have the charge on the capacitor that leaks off so you have to refresh it periodically. Well how often? Well, like every millisecond…

Hendrie: You've got to be…

House: And I said, Bill, what happens when you turn the power off? He said, oh you lose the contents. I said, get out of here, there's no way anybody's going to use a semiconductor memory. First of all, you're going to spend all your time refreshing the stupid thing, instead of using it like it should be used. And second of all, people turn the power on and off on these computers all the time. I count on stuff being in there. Yeah. And he said, no, no, no. This is going to be the next big thing. Oh, yeah, sure it is, Bill. So Bill comes back to me probably a week or two later, and he said Dave, I have a certain amount of development money that's my own... Cause I'm funding him to do this core memory for me. But he said, I have a certain amount of development funding, to do memory development and what my proposal is, is that I will develop a semiconductor memory to go in your machine that's plug compatible with the core memory. Just fits right in. So you won't- no more cost to you... It'll just be my own project, but I'm going to do it in your form factor so it'll fit in your machine, and we can test it in your machine. I said, well, you can do it only if it doesn't slow down my designers at all. I don't want any impact, 'cause I don't believe in your folly.

Hendrie: Right. Oh that is so- that's great.

House: So- so he goes ahead and he develops this card and uh…

Hendrie: Yeah. Excuse me. Take a break.

<crew talk>

Hendrie: All right. We're back in business.

House: So we're back in business. So Bill Jordan and the X-12 semiconductor memory. So Bill goes ahead and he develops his- I- I think he signed Bill Regitz to do the [semiconductor memory card]… as I recall. Bill Regitz did the semiconductor one, and Hank Bodio did the core one, or vice versa. But I think it was Hank on core and Bill on the semiconductor.

Hendrie: We actually have all this history. Both Bill Jordan and Bill Regitz.

House: Okay. Very good. So they built this card and and it doesn't work. It's not working. They can't make it work. I said, of course not. I know its folly. And one day Bill comes over and gets me, and Bill can be so evangelical about things. He's very, very positive. Dave you gotta come see this memory work. So I went over there and he's got a tester and it's storing bits and reading bits, and I look at it and this card has got a wire soldered to the gold cap on each of these white 1103s. So it just daisy chains it's way all around the array, and then it goes up to this power supply up on the bench. I said, what's that? He said, well,, we found out that we have to back bias the substrate on the chip and it turns out that the cap is electrically connected to the base where the die is mounted and the substrate, so, we just put a minus 3 volts, - 3 volts more negative than anything else...it was minus 16 and, or minus 12 and minus 15…., so we had to add this minus 15 back bias to the substrate and then it works.

We had started out with 12 pin dual inline packages, then 14 pin and had by then gone to 16 pin...and this is a 16 pin dual inline package. I said, Bill, there's no more pins, you know, you don't have anymore pins on this chip. How you going to do this? He said, well, yeah, get back to you on that. So about the next morning I get his memo….- this was before email…., this memo that said [in the subject line] the Industry Standard 18-pin dip [dual inline package]. In here [the memo] Bill very eloquently explains that because it's needed, it will be there and it's only a matter of time, and therefore Intel will be able to make it happen, and they'll go to the package guys and they'll get 18-pin dip. Sure enough, the original part was named the 1102 and when they put it in the 18-pin package to make it work, they renamed it the 1103. So that was the development of the 18-pin dual inline package. Intel went to the Japanese manufacturers and got 'em to make an 18-pin version of that ceramic beauty and sure enough, we had a semiconductor memory for the machine. So I was back to the point where that's when they put…

Hendrie: What were the 1102s that he…

House: The 1102s that he put in originally?

Hendrie: Put in the original.

House: Right.

Hendrie: Okay

House: The 1102 never was sold.

Hendrie: I got it. Okay I got it.

House: Because it didn't work. It had to have the back bias added to the substrate.

So, anyway, I wind up on the Honeywell- I'm on this architecture political committee and on next generation entry level systems and I'm asked to give a talk at the IEEE Computer Workshop in Lake Arrowhead. I'm flying out there to give a talk, and I happen to be sitting next to somebody and start talking to him and it turns out he's an investment banker and he's doing a stock offering for this company called Microdata. He's telling me how great Microdata is, and I'm saying, hmmm, naaah, I don't think so. He said, well, would you just come and talk to em? You're going to be in California, anyway, Okay? Well, I want to give this paper, and I got this all planned out and I don't know that that's going to work. Well, would you talk to the VP of engineering if he came up to Lake Arrowhead? I said, how can I say no to that, of course I'll talk to him. So Don Sabbot [spelling?] came- came up there. Don's the VP of Engineering at Microdata and he came up to Lake Arrowhead and he and I talked, and it sounded very interesting. He had this machine. They had these 8-bit machines and they'd developed a 16-bit machine, and used this guy Roberts uh... what's Roberts first name? Well, the guy in southern California had designed a number of machines, had been involved in the early days of Microdata and now was a consultant and they brought him to design this 16-bit machine. He had come in and supposedly designed it and now we needed to take it into manufacturing. Well, I got pulled off the X-12 about the time that we did the GE merger and we had the machine working and we'd tested it, but we hadn't launched it yet. Then with the GE merger, it never got put into production so I thought, it'd be kind of fun now to do the second part, just put it [into production]…

Hendrie: I can't do it on the X-12.

House: Yeah. I'll just take this machine, and I'll launch it into the market place. I'll get it in the market place, so I wound up going back to Microdata [after the Arrowhead IEEE meeting], and I took another trip

out there and they made an offer. I accepted the job and I'm now in charge of computer development [at Microdata] and working for the VP of Engineering. He has software and he's got hardware, he's got disc drives, that kind of stuff. I got the CPU business.

Hendrie: How big is this Microdata at this time?

House: Blllllp- [??]

Hendrie: And it just went public.

House: Manufacturing was in the back, like it was in the good old days, and the women out there were stuffing - putting chips inside the boards and shipping product out in the back door - and the whole thing… I'm guessing was less than a 100,000 square feet. So there weren't that many people in the company. Their systems had largely been sold in the business. Remember Dick Pick and the Pick Operating System? The Pick Operating System ran on the old 8-bit machine and was sold through Basic Four – they were the sales channel into the small business market place and they'd done a masterful job of marketing. They called the programming language, which was a PL1 derivative, they called it English. And the system was called Reality. Reality was programmed in English. And… <laughing>

Hendrie: Oh, oh.

House: …and it was neither reality nor English.

Hendrie: Exactly. You're right.

House: But the system actually… Dick Pick joined the company and the Pick Operating System was put on that system. It sold good volumes quite well. Later the company was sold to McDonald-Douglas. They had been a big customer and I suspect they needed to keep it running. So I arrived there and the deal is, we just got the boards back from FAB. You just need to build this, put it together and debug it and we'll ship it and then we'll go on to the next thing, right? So just finish it up and the idea of finishing it up sounded- sounded attractive to me. So I showed up and sat down and started looking at the logic diagrams and I got out my TTL handbook, and I started looking at worse case timing analysis. I looked at timing loops and it didn't pencil out. I mean, I don't think there had been any timing analysis done. So I went back to the guy, to the consultant, and he said, oh, it'll work. It'll work. On an average these chips are faster than what the specs say they are anyway. So, I went back and I did all the typical numbers, and I said, it just- it still doesn't work. It's not going to work at typical. He said, well the actual chips are faster are than the published typical. I said, well, I don't think so. I don't think we're goning to do this. So I had the thing already assembled. I mean, it was already assembled. So I powered it up, and guess

what? I put oscilloscopes on it and the signals didn't get there by the time the clock got there. So, okay, okay. So I went back and redesigned it.

Hendrie: Yes. Oh, my goodness.

House: This time, with complete timing analysis, etc, etc. One of the reasons that they were attracted to me to run this, is they had decided to make the big step and go semiconductor memory, they were using the AMS 6002 1K DRAM. They had subcontracted the design of this board to AMS [American Micro Systems Inc.]. And the memory was here, but guess what? The memory didn't work either.

Hendrie: Surprise.

House: And they knew that. They didn't know the CPU didn't work when they hired me, but they knew the memory didn't work. So they figured, well, he could fix the memory and the CPU will be fine. I had to fix both of them and get them both working. But as soon as I showed up at Microdata, Regitz and Bodio and Jordan etc., the guys who had gone from Honeywell CCD to Intel, got wind that I had actually left Honeywell. They had known I was off on this high level architecture project and, you they figured - he's untouchable. I had actually left Honeywell and I was now in Southern California. So I got a call and they wanted me to come up for an interview. I was going through a divorce at that time, and so my kids were living a few blocks away from where I was living. I was seeing them on the weekends and spending a lot of time with them. I just wasn't interested in that, separation and moving away from the kids. I didn't feel I could ask my soon to be ex-wife to relocate to Northern California, having already convinced her to move from Massachusetts to Southern California. I thought it was going to be a little tough to do that again. Finally they convinced me to come up to Intel. Hank Smith had been the application engineering guy, the applications guy and he'd left to go back to New York and did something in the finance world. Ted Hoff who was the inventor, one of the inventors, of the microprocessor and was off doing the bipolar microprocessor, the 3000 series at that time. Hank Smith was the only guy who really talked to customers about the applications. They needed a guy to come and do applications. Ed Gelbach was running marketing sales and applications. Ed called me up and he wanted me to come up and talk. I came up and I interviewed with a bunch of different people and I went back and they made me an offer. I thought, well, this would be a fun thing to do but I don't really want to work for a guy who's job is sales and marketing, first of all. That would be like crossing the Rubicon. Yeah, I don't want to do that. Besides that, I don't want to be separated from my kids. I'm not going to ask Joyce to move again 16 months later - less than a year later at that time. So I went back to my Microdata machine, and Gelbach called back and he said he I would like to talk to you again. I want you to fly up here. I said, we've been through this - my family situation, etc. He said, well, why don't you just come up this weekend and I'll pay your way and you can just... I said I have a date this weekend. He said, bring your date. Well, I don't know. I don't want to come up, have her not have anything to do while I spend the day with you. He said, here's the deal. You fly up. I'll meet you at the San Jose Airport. We'll have drinks at the airport, we'll

talk. The three of us will talk. Maybe an hour. I'll pay for the rest of your weekend in San Francisco – hotel rooms, meals, flights, you and your girlfriend. Not a bad deal. I fly up.

Hendrie: Yeah. I would say, hey. Is that all I have to do. Only cost me an hour.

House: That's right. So I went back and they made me a better offer. Now I really have to think seriously about it. Now- again…family values win. And I turned it down again.

Hendrie: Okay, but they upped the ante.

House: They upped the ante. Then a couple of months later go by. I got another call from Gelbach. I said, not you, Ed. He said, yeah, I really have to hire you. I said what do you mean, you have to hire me? He said, well, here's the deal. We agreed at executive staff that the person I hired for this job had to have the approval of Les Vadasz who was VP of engineering at the time. Ed was VP of sales and marketing, and because it's the kind of a job that straddles engineering and marketing... and we've interviewed 43 candidates, and you're the only person that we both agree at. <laughing> So I have to hire you. I said, no, Ed. He said he wanted me to come up. I wouldn't come up. He said, well, I'll come down. We'll have dinner. I said, I don't want to have dinner. We've been through this, Ed. I don't want to have dinner. Well, I'll tell you, I'll come down, we'll just have a drink. Okay Ed, you're a nice guy. We'll have a drink. So he and I meet at the Disneyland Hotel at about 5:30, 6:00 o'clock. At 11:30 -without having had dinner yet - we leave the bar. <laughing> Having spent all that time talking. The offer got a lot better this time. The stock was a lot better, the salary was a lot better. But the closing deal is Mr. Salesman - Ed knows how to overcome objections, he said, don't live up here. Live down there. He said, I'll pay for your apartment. I'll pay for your airfares. You spend four nights up here, three nights down there. Come up Monday morning, go back Friday night. He said, how much do you see your kids during the week anyway? I said, well, maybe one or two nights, because I would go to Little League and that kind of stuff. Ed said, but how often do you work on the weekend? I said, well, I work most Saturdays and sometimes I go in on Sundays. So you will have all these Saturdays and Sundays to go to your kids' games and all that sort of thing. You'll have more time for your kids then. I came back and I said, I will accept your offer under one condition - the title be changed [from Manager of Applications] to Manager of Applications Engineering. I had to keep my virginity there. Yeah. I couldn't….

Hendrie: I'm not going to go.

House: I'm not going across [the Rubicon]. All right, I have to report into sales but I can't go into sales and marketing [I need to stay in engineering]. I just can't do it. So I took the job [with the new title] and I started flying back and forth.

The [Intel] stock started doing well, and I said to Joyce, let's get the kids out of an apartment and into a house. I'll buy a house for you and the kids to live in, and, by the way, as long as we're going to do this, would you look into living in Northern California? So I got her to come up and look and I bought a house in Northern California for the kids to live in. In fact, she still lives in that house. So got the kids moved up to Northern California.

My job in the early days was fairly straightforward - I was the only senior person there who had come out of the computer business. There had a bunch of chip guys, and so when it came to angstroms and oxides and metals and all that stuff, I'm all ears - and eyes. But when they start talking about customers, they proposed things and I'd say, screw [forget] it. Design engineers – this is not what design engineers want. So I played this key role as the spokesman for the customer. We did some important things. First meeting I went to we decided to hire the first field application engineer, because one thing I knew is the design engineer didn't don't want to talk to another salesman. They wanted engineering help. I hated the sales guy that came and all he could do was take to me lunch. I liked the guy that could answer the questions when I had questions about the product.

Hendrie: Right. He knows about the product.

House: Yeah. Okay. Call somebody in the factory and ask that question.

Hendrie: Or call Paul Considine. [ph?] ????

House: That's right. Exactly. So I wanted to hire engineers in the field, and it turned out that my job was … first of all, the 1103 didn't work. I mean, it basically didn't work. The 1103 had this thing called POV, which is ... it had a pre-charged clock and then a main clock that had this incredibly precise timing- these two signals had to be within this very narrow window. You could produce that on a tester with one chip, but putting it on a board and getting that signal there with respect to each other…

Hendrie: All the different parts of the board.

House: To all of the chips.

Hendrie: **To a**ll of the chips.

House: That was a challenge. My first job at Intel was basically . . . [to make the 1103 systems work]… because the 1103 was pretty flakey…., But the 1103 got off the ground because the major computer guys had made a commitment to plated wire memory. You remember plated wire memory. That's another

thing that worked in the lab, but not in the field. The computer companies had used plated wire memory generally for the control store. It didn't work in production. The 1103 came out and it had the right speed characteristics and size and density to replace the plated wire memory, so a number of companies had gone in where they originally had plated wire and designed in 1103s. What would happen, I remember more than once, I'd be in my office and Gelbach would come into my office and say, House, I need you to go to Burroughs, or I need you to go to Univac - now. My first reaction was, Okay sure. What now? Ed would reply – Nina , or whoever his secretary was then, has your flight scheduled. I replied well, I'll swing by my house, I'll pick up some clothes...Ed would reply - No, no. Now. Buy the clothes when you get there. Go directly to the airport. I would ask - What's the matter? Ed would reply, Well, we just got a call from Burroughs [or Univac or …] and they told us to put shipments on hold. We asked why and they said, because our computer doesn't work and we need to stop the line. Ed would then say - we need you to go there and make it work so we can start shipping them 1103's again.

Hendrie: The line just has to be restarted…

House: … So we can start shipping again. We had a quarter to make.

Hendrie: Right.

House: So I'm on the plane, out to the factory, into the plant. Okay, glad to meet you. What's the problem? Here it is. In with the oscilloscope. capacitors, green wires added, etc., etc. And boom! -the thing works. Fly back home. Great. Great job, Dave. Two weeks later, Univac. Out I go. In those days no one had any experience in designing with dynamic memory. The result was generally the same. They all made the same mistakes. I generally had a reputation at the various companies I worked, that I could figure it out and make it work. I could get the product to work.

Hendrie: That's what you did.

House: Yeah.

Hendrie: Nothing would stop you

House: Yeah, right. I'll figure it out. That old engineering approach. You start narrowing it down, narrowing down, measure it, take some data, run some experiments. Isolate everything. Put it all back together. Boom.

Hendrie: They wouldn't have engineers that could do that?

House: I don't know. It just seemed-

Hendrie: That's strange.

House: After having done about a half a dozen of those trips, it became clear to me that there were only three things that people did wrong in their 1103 memory designs. First of all, they didn't have good power and ground distribution- the first thing I would do would be to I find out where the power and ground pins were, then I would go to the far corner of the PC board and put an oscilloscope on the power and ground, and say, look, this is not within spec. You're not meeting the power spec down here at this pin. Yeah, you're regulating your power where it enters the PC board, but up here, it's going crazy. Going bonkers. So, put in a power and ground bus or plane. In those days separate power and ground layers in a PC board wasn't the standard thing to do.

Hendrie: Correct.

House: It was very expensive to do multi layer boards.

Hendrie: Multi layer boards are very expensive.

House: So we're worked very hard at getting the power and ground run on the two layers we had available. This usually required adding wires or bars for power and ground to the PC board. The second thing was that when that pre-charge clock switched - it charged a bunch of things inside that chip - the power supply would glitch – you would get these noise spikes on the power and ground lines - high frequency noise spikes any time the pre-charge clock switched, then you'd see it in the power plane. So we had to add decoupling capacitors - a particular kind of high frequency decoupling capacitor. I would then wire a bunch of those capacitors on the PC board. Then, third, the old faithful pre-charge clock to clock timing - the famous TOV - the time between the pre-charge clock and the main clock. It would be correct when it entered the PC card, but it wouldn't be right when it got to all the chips. So capacitors, power ground plane, the distribution of those two important signals- actually the timing relationship of those two signals. So I wrote an application note, and then I didn't have to go to the field to fix computers anymore.

Hendrie: Very good.

House: So I started having more time, and focused on issues about product evolution - of product definition, and, memory product definition. Meanwhile, I'm saying to Gelbach, you're really not making the best use of me here because I'm worrying about 4k DRAMs and multiplexed versus non-multiplexed

address lines, the 16-pin versus 22-pin package, and whether the outputs float or not, and all this kind of stuff.

Hendrie: Now, what years? What- how long were you in memories

House: So I started in February of ’74.

Hendrie: Okay

House: I went to Intel February of ’74, and in May of ’74, we introduced the 8080.

Hendrie: Okay

House: When that was introduced - that’s the part that I knew about way back at Honeywell, and was promoting to go into their entry level system. When we introduced the 8080, I’m saying, you really should be using me on that stuff, because I’m really not a memory guy. And I’m not a circuit guy.

Hendrie: Yes, exactly.

House: I’m more of a system and computer guy. But I ran- they put product marketing under me for memories. So for ’74 and ’75, the first year was Application’s Engineering as I called it, which was really heavily involved in the product definition and product positioning. Then I had product marketing under me. So everything from the sales meetings to positioning to ads and that sort of thing.

Hendrie: Yes, yeah, yeah so.

House: Get…

Hendrie: How long, I’ve got to ask you, how long were you at…

House: Microdata?

Hendrie: Microdata.

House: Sixteen months.

Hendrie: Sixteen months.

House: Yep. Very short period of time.

Hendrie: Yes. Okay.

House: And most of that time they were trying to recruit me at Intel. I wouldn't leave until I got the machine through acceptance tests so when I accepted the [Intel] job, I said you got to change the name to Application Engineering and I will not start until I pass the acceptance tests. So Gelbach said, well...and this is like a month away or something…., and so Gelbach said, well, when is that going to happen? And I gave him a date and then I beat it by a week.

Hendrie: Very good. Okay. Cool.

House: So [in] '74 we introduced the 8080. I'm still doing memories and I'm thinking well, this is not a very good use of my [skills]. They should be using me with this new microprocessor, cause I saw the significance of it. At the beginning of '76 I was moved over to become marketing manager for microprocessors, and worked for Bill Davidow at that time. For Bill and Les Vadasz, they were kind of two in the box, and Bill focused on the systems and marketing, and Les on engineering and chips. That only lasted for about 10 months, and then Vadasz had all responsibility for chips, and Davidow all responsibility for systems so I worked for Vadasz for about a year approximately with marketing responsibility for chips. This is in the days of the 8086 coming on the horizon. The 8086 got introduced in 1978, I believe it is. '74 was the 8080, and then we about '76 the 8085, and about '78, was the 8086. In '78, I took over as general manager for all the microprocessor components.

Hendrie: And when?

House: '78.

Hendrie: Okay

House: 1978.

Hendrie: Just go through for me again the sequence that did the 8008.

House: The 8008 was the machine that was uh..., the 4004 was conceived for Busicom - for the calculator and having done that the 8008 was done for what became DataPoint , and they came out quite close to each other. The 8008 was introduced while I was still at Honeywell, back in Framingham. So, that must have been...Intel was started in ’68. I joined Honeywell in ’68. So that must have been like ’70, ’71. I think it was ’71 was a 4004.

Hendrie: And then the…

House: And May of ’74 was the 8080. And it, so…

Hendrie: Well, the 8008 though….

House: The 8008 came in ’71...

Hendrie: It was a serial machine?

House: Yes, I recall the 8008 was serial inside.

Hendrie: With serial inside?

House: Right.

Hendrie: And P-channel, right?

House: And P-channel. And 8080 was parallel and N-channel.

Hendrie: N-channel.

House: I think it was N-channel. Yeah.

Hendrie: Yeah, I’m sure it was N-channel. Okay

House: Yeah. We were trying to figure out how to sell this thing, these things. We have these design kits where...you introduce the processor, and what are you going to do with it? So we designed a demo

board which had the processor and some [RAM] memory and E-prom. Then, of course, we had E-prom programmers. You could program an E-prom and plug it in. Then we made a product that had little switches and lights, kind of like a minicomputer, but right on the board. We've got those in- here in the [Computer History] Museum. You can see them.

Hendrie: Okay Good.

House: If you make it to the Intel museum - I imagine you will actually see 'em there too. I reviewed the Computer History Museum collection today. Take a look at it. It's great. They've got the 4004, the 8008 kit, the 8085 kit, I think there's an 8080 kit. We would sell these kits and they were just a way for people to be able to check out the product and start writing their code, and that evolved up, of course, into the development system, which began and- and was known as the Blue Box. When I took over- in '78 when I took over microprocessors, development system sales were larger than microprocessor sales. Bill Davidow had worked this deal at the executive staff where when he sold a microprocessor, he got sales credit for everything that went with it, all the D-rams and E-proms, and all that sort of thing. And it was still a very small business.

Hendrie: Oh, wow.

House: When I took over, I said, we got to end that. That's a drug that we're just going to get intoxicated on. This needs to be a stand-alone business. When I took it over, it [Intel's microprocessor component business] was $40 million a year, losing money and it was much smaller than the development systems business. Selling the design aids was where the money was.

Hendrie: Yeah, that's okay. Good.

House: Not selling the chips - the I/O chips and the processor chips, etc. I ran it until it was about $4 billion a year, and making more than 100% of the corporate profit. So a couple orders of magnitude there.

Hendrie: Yes. A little bit of growth. Yeah. Yeah.

House: Yeah. Right. So in the early days we were trying to think, well, what were the applications for these things? How would- how would you use one of these things? And we kept coming up with traffic light controllers. They'd be great for a traffic light control. We had an ad that had the big traffic light on it. We talked about that. And it could be an industrial controller, traffic light controller, test equipment... That'd be good. People could put it inside of a machine and do that minicomputer stuff, like industrial controller, of course. That would be a market. But we need to give more performance to people to get to

that market. We were inventing in those days, and looking for applications. What do people use these for, anyway?

Hendrie: Yeah. Oh, yeah, exactly. We had to have applications.

House: Had to have applications... I'm sure Ted has told you the story of, basically how people were- were doing calculators, and they were doing custom calculator chips, and Busicom wanted us to do a custom calculator chip, and Ted thought well, why not make it programmable and maybe I could do more than one calculator with the same chip, particularly combined with E-prom. So that's how the whole thing got started. We're like, okay, calculators, traffic lights, I remember scales. We thought a digital scale, that'd be a good application. And uh… let's see, what else can we get out of this.

Hendrie: Oh, that's really funny.

House: We tried to come up with text for ads, some of the early ads, and tried to spark people's imagination. We're like digging really deep looking for what could we do with this thing. Let's see…..

Hendrie: That's funny. Okay.

House: Ha- but traffic light control always got the attention in our discussions.

Hendrie: Right.

House: Not the biggest application area for the product now.

Hendrie: Exactly.

House: So we started doing these little design kits and then we started putting a box on 'em. We sold these development kits where the board and the instructions came with it, and you put it together yourself. Then we started assembling 'em, and then got into box business and developed the- the first real development system. The original systems were paper tape and E-prom programmers were right on the front panel. Then we developed the blue box, as it was called, Intel MDS - Microprocessor Development System, which was in many ways the precursor of the PC because it had a monitor, had an 8-inch floppy drive, and it had a keyboard. We made a few accessories to it besides, a hard drive memory and Serial I/O. It had a thing called the In-Circuit Emulator, or ICE which became incredibly valuable. It plugged into the bus of the system and had a cable that plugged into the socket where the microprocessor went. And-

Hendrie: [Where the microprocessor was] going to go.

House: Was going to go, right. And so they took out the microprocessor, plugged the ICE into its socket.

Hendrie: Yes, exactly.

House: Because you had to debug. There were some electronics out there near that connector and you could run the code for that target system on the microprocessor in the development system. Of course, you know the story there, we needed an operating system. It started out with a simple control program. We had this consultant, Gary Kildall who we hired to write this operating system, this disc based operating system for this floppy disc-based system. The operating system was named ISIS. ISIS for, I don't know, some Greek mythology character. It was at the heart of the development system business. Gary also wrote a PL/M, which was a PL1 derivative, a compiler for compiling 8080 code. And then later-

Hendrie: He wrote the OS-

House: Yep. I'm almost positive that's true. You can verify that with others, but that's my recollection. Then we had a basic interpreter we got for it, and then later more languages were written for it. Pascal was written for it. Fortran was written for it. But PL/M was the big programming language and, of course, we had an assembler. That development system business was- was big business compared to my little microprocessor business. Our customers came to us - they'd been buying these little demo cards, and these little kit systems and then we were assembling them. You can see some of those systems with their little switches and lights just like a minicomputer, in the museum collection] that they used to check out their code and single step their code, and debug their code. So we had a development system and customers used a lot of those to design microprocessors into their embedded designs and they wanted to use our operating system. Davidow, I think was probably one of the key people [in making that decision], but I'm sure he could tell you what all the politics were. Intel said, no, absolutely not [to customers using our MDS OS - ISIS]. So I'm on the components business and I want to sell ISIS. I want to sell the operating system. I want to put it on my- our price list, his price list, and sell it as a stand alone item. And he said no, it's going to hurt our- our revenue on our development systems. So Gary, who's an independent consultant, ... people knew he had written it, … so Gary sat down and he rewrote it with different APIs ... and called it CP/M, and he created a company called Digital Research Incorporated, which started selling CP/M to our customers. So here's opportunities missed [for Intel]. Intel could have been the operating system supplier [as well as the microprocessor supplier]. If they could [have] held on- they had a strong position. They could've had it [all] in the beginning. The only question is could they have held onto the OS lead. Can somebody – was Intel good enough at software?

Hendrie: If were ….

House: Well, we'll never know, 'cause that experiment didn't get run.

Hendrie: All right. Wow.

House: So, ISIS of course, then became CP/M, and because DRI [Digital Research Inc.] wouldn't give the right kind of terms to IBM [for CP/M], caused Bill Gates to acquire what was Seattle Software with their DOS, their CP/M knockoff, and offer that to IBM. There's been a lot of stories written about that sequence [of events]. I assume you have that documented somewhere.

Hendrie: Yeah. Yeah. I think I have that.

House: Yeah. But of course, MSDOS then became Windows and is the operating system today so it all goes back to Gary Kildall writing ISIS for the Intel Development System.

Hendrie: Wow.

House: An interesting little sequence. This is the system side of the story, let me get back to the microprocessor side of the story. So Apple comes along and introduces the Apple II, and that takes off, and now Grove is like- what are we doing here? Why are we missing out... why is there no Intel based personal computer out there? I'm running the microprocessor business, so the whip is coming across my back.

Hendrie: Oh, really. Okay

House: Yeah. Why are we not [there]? I tried to win Apple and I'm trying to find what the opportunity was. I'll give credit to Jack Carsten, who was my boss... for two years I worked for Jack. He was on the executive staff and for '81 to '83, I was running the microprocessor business, but Jack Carsten was my boss, and he had a bunch of other component businesses like DRAMs, and static memories and Eproms and that kind of stuff. Jack had come out of TI [Texas Instruments], and had a relationship with IBM [which was a TI customer]. The idea that IBM would buy from Intel was just foreign when Jack arrived and Jack made it his cause to get the IBM business. He went there and first got DRAM business and had successfully gotten us [business] through the sales force that reported to him at the time. But I mean, I give it to Jack for taking the initiative and having the vision to try to take on IBM as a customer in the days when they didn't buy [semiconductors from others], they made all their stuff.

Hendrie: Yes, exactly.

House: Now, down in Boca Raton, Florida, was this little rag tag group [in IBM]. We had won two design wins [in Boca], one was in the System One, their mini computer attempt...

Hendrie: Oh.

House: …and the other was in their word processor.

Hendrie: Was your design for the memory in that?

House: No, no. For the microprocessor. They were using the 8085, I believe. Now, I'm not sure exactly- I'm not as familiar with the System One design, so I don't know exactly what it [our microprocessor] did, - it may have been a peripheral controller, but it was in that system. But the Display Writer, which was their competition to Wang, was 8080 or 8085 based and that business started taking off so we had a ongoing business there.

Hendrie: Now what was the 8085?

House: 8085…so the 8080 required three power supplies, like plus 12, minus 12, and plus 5. Then Zilog came out with a part that was 5 volt only [Z80], and had a few additional instructions, a super set. Now we had a 5 volt [only] design [8085] that we'd started and we put some different additional instructions in there, but we didn't get the 8085 out in time. The Zilog Z80 was out and was capturing market share. Our strategy was - they put some additional instructions in there - this is our instruction set and we'll show 'em, we'll put some different ones in, and not compatible ones - and the world will go with ours. We did the 8085, a 5 volt only part, and we had a better peripheral set- I/O set than they did, but they were kicking our butt in the market place. This is pre-8086, and we came up with the idea of doing a 16-bit machine, the 8086 and we decided to make the 8086 architecturally compatible, but not binary compatible [with the 8080 and 8085]. That is, we kept a lot of the same architecture concepts, but it wasn't binary compatible and we made the decision not to introduce the additional instructions in the 8085, because we saw our destiny as the 8086. We saw we weren't going to beat Zilog with the Z80 with our 8085, so we were going to use the 8086 to do that.

Hendrie: Okay.

House: Yeah. Back- back in microprocessors,... 4004, then 8008, then the 8080, the [first] big, real product. Then the 8085, which kind of got stomped on by Zilog with their Z80.

Hendrie: But it was your 5 volt part.

House: It was our 5-volt only part, easier to use [than the 8080], but the 8086 was going to be our big promise. During the time that we were developing the 8085 it became clear that there was going to be a market for a 16-bit machine. There was a group headed by Justin Rattner that had an idea that we should do a different kind of an architecture and it should be an object-oriented architecture. The initial proposal was called the 8816 and this was to be the successor to the 8080 and 8085. It was going to be a 16-bit machine but it was going to be object-oriented. There was a paper written about the architecture and it was taken to the executive staff, and Bob Noyce or Gordon Moore was CEO at the time, but Gordon got kind of tasked with figuring out what to do about it. He decided to form a committee to evaluate this proposal so he chose Ted Hoff, Terry Justin Rattner who was heading software at the time in the development systems side of the business. Later [Terry] went to do VisiCalc. What was that company [VisiCorp] called before, Personal Software? Before their name was, VisiCorp? [Ted Hoff, Terry Opdendyk] and Dave House were the three people. We were to review it and come back and make a recommendation to the executive staff. Well, we reviewed the thing, and we met as a committee, and we went around and around and around, and we finally could never come to agreement, and we gave three separate reports to the executive committee.

Hendrie: Oh, my goodness. Okay

House: Gordon brought in Carver Mead [from Cal Tech] for that review meeting, to be sort of an advisor to the executive committee. Terry Opdendyk got up there and he said, object oriented programming is the way of the future, and this puts software into hardware, and it's the …, you know, we just got to do this. Then Ted Hoff got up and he said, well, on the one hand this and on the other hand that, and on the one hand this, and on the other hand that, and he just didn't take a position. Then I got up, and I said, this thing is not going to work. I said, just to read one operand out of memory, it has to go to memory ten times do to all these levels of indirection and you had to manage all these tables and if you're going to get any performance the tables have to be on the chip, and there's not enough room on the chip to be able to put those on there. You can't put any tables of any reasonable size [on chip] and even if you try to cache 'em, and use the most frequently used ones, you're not going to have enough space to put it on there [on chip]. It's a great concept, but it belongs in software, it does not belong in the chip. We don't have the silicon technology to make this happen. We shouldn't do it. So now the executive staff is like, ohhh oohh ooohh.

Hendrie: Yes, exactly.

House: We're back in ….

Hendrie: That last thing they wanted was three different answers.

House: That's right. So after conferring with Carver, they decided to spawn this off as a separate project, basically as an experiment. They started a program which [was the] 8816 [which] later became known as the 8800, and [even] later became the 432.

Hendrie: Oh, that's where the 432 came from.

House: So this started a long …., very early in the mid '70s. So we've now got this thing that these other people are doing, that I have been opposed to and I think is crazy. So I said, this 8816 thing is going to take a while, and it's gotta be all new software and all new development systems, and all new tools, and we need a stopgap product that we just do,- let me just develop it. We won't introduce it, but we'll just develop it in case we need it. In case there's some delays in this other program, and it should be a 16-bit extension of the 8085, so it's going to be 5 volt only, and I called it the 8086. It wasn't binary compatible, it was really a new machine.

Hendrie: Oh, yes.

House: But I passed it off as being 8080, 8085, 8086.

Hendrie: But it's not the 8-bit instructions?

House: No.

Hendrie: Oh.

House: Oh, no, no. It was architecturally compatible. It had similar kind of register structure, and similar kind of addressing scheme. But it wasn't binary compatible.

Hendrie: No way to migrate binary code?

House: Well, we developed an interpreter which would run the old code, and we had a translator in our plan, which would translate the code to it [from the 8080/8085 to the 8086]. Binary to binary translator, and a source code to binary translator. None of which ever really worked well, but maybe helped a little. So we started the development of this 8086 machine, and that wound up, of course, being the product that got introduced. It got out there before the Z8000, which was [how] Zilog responded to the 8816, the visible machine. They did the Z8000 and Motorola did the 68000, and I'm doing the 8086, but I can't call it 86000 because it has to sound like it's like the 8085, to get it under the radar to get it developed in Intel, because the future is the 8816. The official future of the company. Then it was slip, slip, slip on it [the

8816]. We got the product [8086] out, and we're out there selling the product, but we don't have a PC design. IBM's [has] designed our 8-bit machine into their word processor, and I get word from our sales force, from uhm..

Hendrie: That's the 8085, you said, in the…

House: In their word processor.

Hendrie: Yeah, yep.

House: And so I get word from .. God, what was that guy's name? Uhm... He was a salesman. He worked for... Earl Whetstone who I believe was the district manager. Uhm... an Italian name. It's going to come to me. [Paul Indaco]. He [Paul Indaco] said that they've got this project to develop an Apple killer, they want to beat Apple. So we go down there and we make our pitch that … what are they planning on using? Well, they plan to use the Z80. Well, this is a big loss. So we go down there with our pitch, which is you can't beat an established 8-bit machine with another 8-bit machine. You gotta go to 16-bits. You- you gotta use the 16-bit machine, and it's the only way you're going to beat an entrenched 8-bit machine. So then they opened up their decision-making process, and they look at the 68000 and the Z8000, and the 8086 and they said well, clearly the 68000 or Z8000 are the better of the three, but we can't meet our cost numbers with any of those three approaches.

Now, we had a chip set- in those days, your I/O chips- that was a parallel I/O, which in 8-bit was 8255, a serial I/O, which was an 8251 with a UART interface, a timer counter, which is the 8253, a DMA controller, 8257, and an interrupt controller, an 8259. We had produced those and… guess what? AMD and a bunch of other people wound up second sourcing them, and so with competition and the semiconductor learning curve, the price had gone down low. We had...when we designed the 8086, some of my engineers came to me with an idea which was... it would be very easy to take the bus of the 8086, and fold it over on itself, so that it did its 16-bit accesses two bytes at a time. In so doing, they could make the bus compatible with the 8085 bus, so they could use the 8085 peripherals [8251, 8253, 8255, 8257 & 8259]. [It was really a back up plan in case our new 8086 peripheral chips were late.]

Now meanwhile, we had a bunch of 16-bit peripherals we were developing, and if course, they were all new, and they weren't all quite done yet. We had to price 'em much higher, etc. but I'd been beaten down on price on the 8251, 53, 55, 57 and 59, by competition who was second sourcing the product, and they were very economical. They just happened to fit the wrong bus. So the design engineers they said, it won't take much to do this [the 8088 bus]. I said, I don't think there's much use for it. I mean, you're really hog tying the 16-bit machine, making it do two bus cycles, but go ahead and put it in. We just won't bond it out. We won't test it. So they put it in the design. It was there. We didn't test it. So I'm trying to get this design win, and I'm going to lose on architecture to the 68K or the Z8000, so I said, where's that

8-bit bus version [the 8088]? So I had them go pull out the design and bond up some chips and before they had even done that, we went and sold it to IBM.

Hendrie: Oh, my

House: We said [to IBM], okay, here's the deal. You have a 16-bit machine, 16-bit addresses, 8-bit peripheral chips, low cost, multi-sourced...one of the things they were big on was multi-sourcing. They later made us second source to AMD, I guess it was at that time, they made us second source the 8088 to AMD. AMD, so [later] we sourced the 286 to AMD. By the time we got to the 386, we were able to stave it off. But the process went like this. It [the IBM PC] used the 8088 and because they've been working with us with the 8080 and 8085 earlier, particularly the 8085 earlier…and then…286 being the second generation. But with the 8086, they wanted a second source and we kind of had to cave on that and let them manufacture it. So we licensed them to do it internally. We made the internal pitch that their operation be our second source on the 386. And so we sold 'em on the 8088 based on the peripheral chips, the low cost peripheral chips, and that's how we got our- our design win.

Hendrie: Oh, really.

House: Yeah.

Hendrie: Yeah, Okay

House: So it was based on- you get 16-bits compatible. All your software in the future… you can do the 16-bit bus version later when the cost comes down but I had to commit to get the price of the 8088, the 8-bit version, I had to get it- promised to get it - down to 5 bucks in two years. Had to commit to a price, gotta get it down to 5 bucks in two years. So obviously, once we had that going, the IBM PC down-announced in August of 1981, we had to get 'em off the 8088 and onto something we could make some money on.

Hendrie: Yeah. Because the…

House: 'Cause I'd committed to get the price to 5 bucks to win the design.

Hendrie: This was the loss leader.

House: That's right.

Hendrie: Okay

House: So the IBM PC is announced, and it's, it starts taking off and it exceeds everybody's expectations, including ours, and like wow. I mean, turns out to be the defining moment really for Intel, and Intel published this publication on the [Intel] 25th anniversary, the 25 identifying events of the first 25 years- or defining events of the first 25 years. In the middle of the book is the IBM PC design win. You'll see Earl Whetstone's and my picture there, the people credited with getting that design win. 'Cause the sales force was really in there every day and I was directing it from a strategy standpoint. We had a number of other people that were obviously involved up and down [the organization]. It was a team effort, like everything at Intel. But the defining moment is when- when we got that design, and then now they're developing the thing at the…It was really interesting the way they did it. They would not...they were so secretive. The story is true that they had rented this space in a shopping center of an old, I think it was a super market that had gone out of business, and they had set up all this office space in there and designed it there. When they would have a problem, we'd send in our field application engineer [Paul Indaco], or somebody from the factory [usually Dane Elliot], and they would have a black curtain up and the machine would be behind the curtain and the development system being on the other side of the curtain. We were able to- we could run our development system, and we could interface with it, but we could never see it [the PC]. They never let us see the machine.

Hendrie: Oh, my goodness.

House: And somebody would say, Okay, now put a probe on the 5 volt supply at the point that it enters the card with the processor. Now put it on the clock line on the CPU. And the ground on the ground chip on the CPU…And they have the oscilloscope out there looking at it. We didn't know what the board looked like. They wouldn't show it to us. Wouldn't show it to us.

Hendrie: Oh, my goodness. Wow.

House: Yeah.

Hendrie: All right.

House: And so the announcement got made and the thing started shipping at great, you know, great quantities and we [later] dodged the bullet with licensing AMD by licensing IBM semiconductor to make the 80286 chip, so they had the license to make the chip.

Hendrie: Oh, is that right?

House: Oh, yeah.

Hendrie: Okay

House: So, you know, they- they had made…

Hendrie: So is AMD still- already making some of your…

House: AMD made the 8080, and the 8085 under license from Intel. Jack Carsten had put that into place and the 8086 ... I took over- when I took over the microprocessors [in 1983], I said, hey, there's one thing I don't understand. I don't understand the second sourcing thing. I know I'm not a chip guy, and I know I'm not a semiconductor industry guy, I'm just a computer guy. But, you know, in the computer industry when we work three years to develop something, and put all of our engineering resources behind it, [and it's successful], we don't give the intellectual property to our competitors. Well, but you have to do that. The customers insist that you do that. And I say, well, I know the customers would like you to do that, but why do we want to do that? I don't get it. I just don't get it. I want to try not second sourcing. Well, I had the second sourcing agreement with AMD that I had to get out of. So I- there's a lot happened there. And [eventually] I spent 14 days testifying in front of a judge in the arbitration between Intel and AMD about exactly what I did during that period of time to get us out of that licensing arrangement.

Hendrie: Oh, my goodness. You got…

House: But in the end, we didn't have an obligation to license them on the 386. [We had an agreement that allowed us us to trade them the 386 for products they developed of equal or greater value.] Now, maybe Carsten had talked to 'em about maybe later we'd negotiate it, but we didn't sign any contracts [that obligated us to transfer the 386]. We didn't have any commitment, and I didn't…, you know, they weren't licensed. So what I did, is I said, I'm not going to license AMD- I'm not going to license anybody anything [unless we get equal or greater value in return]. But I licensed IBM for internal manufacture. And then we licensed them also to do…

Hendrie: And that's IBM.

House: That's right.

Hendrie: They'd probably prefer to have the second source themselves.

House: Right. Right.

Hendrie: Cause they…

House: I mean, they are semiconductor guys…

Hendrie: Cause they would pay for this?

House: Yeah. Absolutely. And that way they [IBM] could have it, and nobody else would have it.

Hendrie: Yep. Okay

House: So now we got the 8086. The 286 comes out.

Hendrie: Well, isn't there a 186?

House: There's a 186 and 286, which came out together. They were developed in parallel.

Hendrie: And what was the idea behind that?

House: [The 186 was for] Embedded control, high integration. We got one thing wrong [on the 186]. We should've made it [the peripheral functions] PC compatible. We integrated a bunch of the peripheral functions on the chip [on the 186] while so the 286 went to memory management protection. It had a whacko scheme for memory management protection, but it had memory management protection. And the 186 was basically taking the 8086 and integrating all the peripherals on it by integration. So I had a low cost- the problem is we didn't do it binary compatible with the IBM PC [peripherals]. Now, when we started the design, there wasn't any IBM PC a. And we didn't realize the significance of it [compatibility]. So [it][the 186] got use- used for embedded control b. But didn't get used for any PC. A few people tried to make PCs out of it, but you had too many software workarounds. It wasn't worth it. And the 286 was faster, 'cause it was a new engine. We architected the processor, and put new architecture features in it, and then put this memory management protection model on, which by the way, never really ever got used by anybody. Cause the 386 one [memory protection model] was much better and that's the one everybody used. But we could sell it [286].

Hendrie: Okay. Okay.

House: So IBM went to work and designed the 286, we had licensed them for the 8086 and the 286. They weren't going to design it [286] unless they were licensed, and so they're licensed to do that. In August of 1984, they introduced the IBM PC AT, for advanced technology.

Hendrie: Oh.

House: I went to the announcement, and I spoke, IBM introduced me, and I got up and said some words about the 286, how great it was, and sat back down again. [Bill Gates was there at the announcement but IBM did not ask him to speak.] I came back to Intel thinking really good about the fact that they had recognized Intel and its role that it was a 286 and they actually had the Intel executive in charge come and talk at the event. I come back to Intel, all puffed up about it, thinking I'm proud.

Andy Grove, in the typical Grove style beat the shit of me because we weren't getting enough recognition. He said, listen, the monitor's the same, the case is the same, the power supply is the same, the DRAM's the same, the keyboard's the same; The only thing that's really different is the processor, and that's what's making the difference and people don't know that. He said, House, you gotta make people know that. That it's the processor that makes a difference. Like blblblblblblbbl-

Hendrie: Well, how did you think?

House: Whoa. This is a tough assignment. How am I going to… ?

Hendrie: That's right. He didn't help you with this as to how you might try.

House: No, no. You just gotta make 'em know. We're not getting our due recognition. The user needs to prefer the 286 from Intel.

Hendrie: Right.

House: blblblbpbpbpbp. How do I do this? I'm like, oh, my God. It's not my customer. It's their [IBM's] customer. I'm going to be dealing with my customer's customer. How do I do that?

Hendrie: Yeah, right.

House: So I take it back to my staff and we started working on this problem. In 1985, I think it was, so that would have been maybe six months later, Intel is losing money for the first time since it's a public

company. We're in the downturn of the semiconductor business. Budgets are being cut. Projects are being cancelled. It's right up before the [end of the] quarter. We're about ready to have the big review meeting for our plan of record, PORs we called it, for the quarter. I'm trying to save every last engineer I got and every last dollar. I go into a one-on-one [meeting] with Grove, like he used to have on a weekly or bi-weekly basis, and I go into Grove, and I said, "Andy, if I could spend $5 million next quarter and make $15 million more margin, would you let me do it?" He looked me straight in the eye, he said, "Dave, it's a trick question". I said, no, let me show you. I had a piece of paper and I had plotted zero to 100% [vertically], and month one, two, three, four, five, six, seven, after introduction [horizontally]. I had plotted the 8086 to 286 conversion and it followed a nice S shape curve. I said, this is what actually happened when people moved from the 8086 to the 286, and here's the shipments of 386s versus 286s [showing the conversion from 286 to 386]. We're just a few months into this here, but we're right on the line and we're getting right to the steep part [of the curve]. We're just starting to get here and if I could get three percentage points more market share…because remember I had to price the old parts much cheaper. It's like a $45 part versus a $275 part.

Hendrie: So the 386 is

House: Yeah. On my

Hendrie: <inaudible> is back out there.

House: Right. And- and if I could get just 3% more conversion [of 286 to 386] than I [would] naturally get, …I'll give you that I would normally get this much…., but I'm going to get 3% more, [it's worth] $15 million or more. And we can do it for $5 million bucks. You want me to make people know that the processor makes a difference, that's how I'm going to do it. So, Chip Shaffer, Chip Shaffer is a guy who had left Regis McKenna and created his own agency and we'd been talking to him and he came up with this campaign [the Red X campaign] which...a very risky campaign, but I had it in my back pocket when I had this discussion with Grove. We wound up running it...I had to negotiate it with Grove, and it had to be….- with Andy, everything's gotta be measurable. It's gotta be scientific, so we had to be able to document that we were getting $15 million more, 3 percentage points. So what we did, we took 12 cities, target cities and we took, I think it was, 6, or maybe it was 12 control group cities. And- and

Hendrie: You did this like a drug test.

House: Right. Just like a drug test. We ran it [the Red X campaign] in the 12 cities, and we compared it with the other 12 [control group]. We went to the major chains…In those days you used to buy PCs through CompUSA, and other stores, computer stores.

Hendrie: Yeah. Store fronts.

House: So we went to the major chains and we would get their data on what was selling out. So we said, we'll base it on the major chain sales, and we'll do this- we'll run this in 12 cities, and we'll take these 12 control cities and the campaign was a six-week long campaign, and it was a billboard [campaign]. Nobody'd ever done billboards, but I gotta get to the end users, right? It was in the financial newspapers, the Wall Street Journal, and Business Week, and I think Forbes and Fortune, where we ran it. And it ran in the billboard sign form. It was a white billboard and it had the letters 286 in the font that we used for the 286 and it had the Intel logo lower right hand corner and it had a big, red X spray painted across the 286! For two weeks that billboard was there, and people thought, that's a pretty simple Intel ad, and who's defacing it? I mean, what's the vandalism going on here? What's going on? But in the print [form] it ran in prominent positions...and we insisted it always be in the same position…., it ran in the print with the red X. So at first you saw it typically on the billboard, and then you saw it in print. What's going on here? So then, for the next four weeks, those same billboards and the same pages in the same publications… the big white billboard [had] the letters 386 in the same font, Intel in the lower right hand corner, and then spray painted the letters SX, which was a low-cost version of the 386 that we had introduced. Basically it said don't buy my [older] product. Don't buy the product that's 90% of my revenue.

Hendrie: Right. Exactly. Yes.

House: Buy the [newer] product that is going to make me money. It was ... we got like [a] 9% increase over the norm in those cities where we ran it, and the other cities were almost-… because we bought the geographic version of Wall Street Journal, etc…, we were in some Wall Street Journals, but not in others.

Hendrie: But not in all, yes.

House: In the control group, it [386 sales] was right on the curve, and we just blew the numbers off [in the advertised cities]. It was a big deal in making our quarter. And Grove said, can you do it again?

Hendrie: Of course.

House: And I'm like, no, that's a lot harder. Because we've already done the shock treatment. So we went out and we talked to the press about how this was such a bold move, and Grove made- created "you must the eat your own children" quote there.

Hendrie: Which?

House: Eat your children.

Hendrie: Oh, yes.

House: You have to eat your children. You have to- we had to eat our old product. We had to kill our old product [286] to make room for our new product [386]. IBM and Compaq went nuts, 'cause they had a big inventory of 286s [PCs] out there. They had been slow in moving to the 386. There was like very little product…or none. I don't remember. The only guys with 386s were the Taiwanese, and the off brands [plus Compaq had an high end 386 product]. Those sales [386 PCs] were going crazy 'cause everybody was saying Intel was saying don't buy the 286, buy the 386. We're talking to our customers, and [they say] what are you doing? You're messing up our market place. And- da-da-da-da-da-da-da.

We ran a few other ads that were in the graffiti series, in advertising, you can't get married to one concept. You gotta always be doing something different, and that [the graffiti series] was- just wasn't a sustainable deal.

Hendrie: Yeah, right. Of course.

House: So now we have some budget to do this stuff [end user advertising]. So we're starting to do some serious stuff, and allocating money to international and running unique things in different places. Nippon Denzo was our advertising agency in Japan, and the Japan organization had come up with this deal that did largely TV spots, commercials. They were like 10 or 15 second commercials. In Japan they ran these little teeny short commercials. They came up with this plan that was called "Intel In It". Like in a play on the Intel name. "Intel In It", and they put a little circle around it, and they had these little cartoon characters and they would blah, blah, blah in Japanese and there was a computer in there doing stuff. And you know, frustrated with the computer. Then you'd hear, "Intel In It" at the end of- because it [those words were] was in English. "Intel In It". They had print advertisement but it was largely TV. But it was making an impression in the Japanese market by our measurements Grove and his measurement system, everything we did was measured.

In the early days of Intel our byline was Intel Delivers. In the early day's of semiconductors [1970's]- they [companies often] booked all the orders they could book, independent of how much output they had, then they'd ship the highest ASP orders. So you never knew if you were really going to get your parts, and so you'd have an incentive to offer more money, right? Intel had a policy if we take an order, we ship it. We don't ship by ASP, we ship- we don't at the end of the quarter go to shipping the profitable stuff and postponing the [low] margin stuff. We ship what we commit to. So "Intel Delivers" was our motto and that worked. The customers loved it. Then other people started adopting it [shipping what they committed to], and everybody was doing it. So our logo didn't make a lot of sense anymore. So I suggested we change our logo to "the Computer Inside". Grove is beating me about the head and shoulders to make sure people know it's [our processor in your] PC. Somebody else came up with those words, but I was looking for something and it worked. We latched onto those words and so all of our stationery had "Intel, the Computer Inside" and all of our ads had the tag line, "Intel, the Computer Inside".

One day Dennis Carter comes into my office. He's working for me, he's running [microprocessor] marketing. He said, Dave, I think we should bring the "Intel In It" campaign to the U.S. I said, well, first of all it's probably a good idea, but second of all, "Intel In It". "Intel In It". That's Japlish. That's not English. It's not Japanese. It's Japlish. I then turned around and took a piece of stationery, 'cause we used to have stationery, remember before laser printers? Out of my desk, and I laid it down, and I said, what does it say on the bottom? It said, "Intel, The Computer Inside". I said, try "Intel Inside". Yeah? Oh. Okay. Carter said we'll test both of 'em. So he ran a focus group - and of course "Intel Inside" phleeelp-blew away "Intel In It". So we're starting to figure out how we do a campaign with "Intel Inside". How do we,...we're going to run our own ads. But Intel saying it doesn't carry any weight. What we really need to do, is we need to get our customers to advertise it has Intel Inside. How do we do that? We were talking about….., well, we started talking about it. So this is a team effort, Dennis and I and some of the people on his team, and Grove would be in one-on-one discussions as, you know, we gotta figure out how we incentivize those people to do that. Somebody made the comment that, well, it's really ingredient branding. You're branding an ingredient, not the product, but an ingredient and we started talking about- I remember picking up a Diet Coke can, and saying how did they get NutraSweet on here?

Hendrie: Right.

House: How did- and I sent Dennis Carter and his team to go visit NutraSweet. We said, how did you get NutraSweet on a [Diet Coke] can? Well, we have two different prices. The price if you put NutraSweet on the can, and a price if you don't. Ah. So then we looked at Teflon. How do you get people to advertise Teflon? Gortex? How do you get people to- and Carter came in - he said, I found another one, he said. I found one. He said, Pop Tarts with Smucker's Jam inside. They [Pop Tarts] advertise on the box, with Smucker's Jam. So we thought, okay, there are people who have done ingredient branding. We gotta figure out how to do it. So we tried to figure out how to make this happen.

Well, we're coming along to the end of the year, and at the end of the year, we'd do an annual plan, and we'd figure out what our prices were going to be by quarter, and our customers, who were doing their annual plans, had to figure out the cost of their products, when they're going to develop new products, and they, of course, wanted to know if our old processors versus new processor, what the pricing was going to be.

Hendrie: They want to know what's important to pricing.

House: Exactly.

Hendrie: Of course they do.

House: So they wanted us to commit the pricing. So every year we had to go and deliver a price sheet basically to the customers, and…

Hendrie: For the next year.

House: [In] the fourth quarter [prices] for the next year, and sign up for it. We normally generated that [quarterly price forecasts] by taking any given speed of the microprocessor and decreasing it 30% over the course of the year, the semiconductor learning curve. Then we'd always introduce higher speeds, and so we kept….- [the] objective of continually increasing the ASP of our processor. We got to the point where, when - at least when I stopped managing the group, it was $275 was our average selling price. That was a lot of money for a chip, especially when you're selling millions and millions of 'em. That's why we were by then 70% of the corporate revenue, and over 100% of the corporate profit at that time. So we'd been bringing the price [of any given processor speed] down 30% per year. We were at a point in time when AMD was particularly weak. The 8086 and then the 286, and you know, things kind of go in jumps and starts. They were kind of in a weak time at that instant in time.

I said, I never really understood the semiconductor economic stuff. To me, it seemed like we could do this a little differently so I said to Grove, this year I'm only going to reduce the price on any given speed 20% but I'm going to offer 5% back in a rebate, if they put "Intel Inside" in their ads. I think the original one [rebate] was like 3% for the ad, and 2% if you put it on your product and on the box, the little sticker on your box. You had to put it on the cardboard [carton] too, I remember that. It was important to us for some reason. The way that the program that we developed worked was starting at that instant in time [when you sign the "Intel Inside" agreement], you accumulated a fund, a marketing development fund, based on 5% of everything you bought from us in microprocessors. And you had one year to spend that. You could spend it by running ads that had the "Intel Inside" logo, and a certain amount of white space, and a certain size, and all these specs. You could earn it by putting the sticker on your box and on your cardboard carton. So, [that's] all you had to do- and we would pay up to 50% of the [cost of the] ads- the print ads for doing this, out of this fund. So of course, the no-name guys just loved this. This is wonderful. They had been asking us 'can we put Intel on our box?' Can we put something about Intel on it? 'Cause they were looking for any kind of credibility they could. [largely the Asian manufactures]

Hendrie: Yeah, yeah, yeah. Because they're so…

House: We got a 386 in here.

Hendrie: They're no name on it.

House: Yeah. They're no names. So of course IBM and Compaq thought that was just the stupidest thing we could ever do, and they hated it. So we went to these guys, and all the- the no name guys

picked it up immediately, and they started advertising more. Dennis Carter had a really great idea. He said well, why don't we aggregate the volume of all these ads? Since we're paying 50% of the cost, when you went to the publications they had rate sheets. The more you advertised, the cheaper it was. So why don'….- since we're paying for half….- we want to aggregate all of these deals and get on one rate sheet, one volume price. All the manufacturers that put "Intel Inside" on it. Well, all the no name publications thought that was a great idea and the big guys like Ziff Davis, said, hell no. So we went to all the no name PC guys and said we got a special deal for you, but it only works in these publications and their magazines got thicker and Ziff Davis got smaller, and Ziff Davis said, well, maybe we'd better accept that and so then they let us aggregate [all Intel Inside advertising onto one rate sheet], and we had everybody. Now the cost for no name computer companies to run an ad in any publication was cheaper than the cost for IBM or Compaq to run an ad. Cause we'd aggregated bigger volumes.

Hendrie: Yes, of course.

House: And we're paying half the cost. So these guys are loving it. So the magazines are getting thicker, everybody's advertising. More and more people are joining the bandwagon, IBM and Compaq are saying, hell, no. This is our brand. We can't put your name on it. Well, I gotta get these guys on board and uh... margins are getting really tight on PCs, skinnier, skinnier and skinnier and their divisions are having a harder and harder time making money and I did something that was arrogant, it was funny but it was also arrogant. I was a signatory for Intel checks. I could….. you above a certain amount [above which] you had to have somebody from treasury and an officer [sign a check] and so there were just a few of us who could do that. I would have a check cut for the amount of money in IBM's and in Compaq's market development fund, their 5% on everything they've bought. I would be the signator on the check and I would go down two weeks before the quarter was over and I'd meet with the head of the business, and we'd have a review of processors and speeds and all this sort of thing. Then I'd say, look, "Intel Inside" and they'd said well, you know, we really can't do that. We have branding. And I said well, let me give you a check. The check was like $15 million and I put the check out on the table, I said, at the end of the quarter, it's going to be on my bottom line or your bottom line. Can't be both places. I'm going to make $15 million more this quarter, or you're going to make $15 million more, depending on whether you do this. No, no, we can't do it. So I ripped it [the check] up. Left it on the table. I came back the next time [quarter] , now it's like $35 million. I don't know what the real numbers were, but it was big numbers. It was over $100 million [at IBM] by the time I was done. And- I'd leave the check there [in pieces]. And it's like we got to do this. Boom. Two quarters in a row I did it, and the next quarter people [IBM and Compaq] signed.

Hendrie: Exactly.

House: I mean like this is stupid. We're, you know.

Hendrie: Yeah. What are we doing there? Yeah. This is-

House: And that's really how the "Intel Inside" program got started.

Hendrie: Wow. That's great.

House: We had- we then decided to move into TV. And uh…

Hendrie: Okay Can we do a pause?

House: Yeah.

House: So the program's working so well in print, we decided we should take it to TV and radio. In radio, in particular, how do you do the, what we call … "the bug"…, the little…"Intel Inside", thing with the circle around it, how do you do that on the radio? I think it was Dennis Carter who said, well, do you ever use your AT&T credit card? You hear the bong? You know, it makes that noise? You always know what that noise is. It's an audio trademark. Let's come up with an audio trademark. Let's come up with our own "bong." So we sent the advertising agency away and they came up with a ding, ding, ding thing that you see on TV and you hear it on the radio whenever you play an ad Intel has co-opted. But the whole idea on that was we could have gone out and printed all the ads we wanted, saying how important it was to have Intel inside but it would carry nowhere near the weight as a customer standing up and saying, "it's got Intel inside."

So, the whole movement towards ingredient branding at Intel was a big dramatic step for Intel and it was difficult for Intel because it... when I first came to Intel, Intel had gotten into the digital watch business. There was a business making chips to go into digital watches and Gordon had observed that what we were getting for the chip wasn't anywhere near what people were getting for the watches and there wasn't much to it. So we wound up buying a digital watch company, Microma and Intel had run its first, and for a long time, only end user ads for the Microma watch. It [the end user ad] was called 'Father Time', it was just lightning out of Heaven and there was this guy like Moses or something, I don't know, in this ad. But a famous TV ad that Intel ran just before Christmas for the Microma watch, an end user product. Well, the more we got into Microma, the more Gordon realized that it was more of a jewelry business than it was an electronics business and that this just wasn't, this wasn't… Intel. I remember one Christmas, maybe it was when we did the consumer ads, but we sold out basically all of the inventory in the watches. I remember going to the executive staff and it was Dick Boucher who was running the [watch] business at that time and Gordon said, "what's the inventory?" Dick pulls out the number. "But I'm getting them in…" He's like, "I'm going to build the inventory back up again." Gordon said, "Well, what would it cost to stop this?" <laughs> So finance went away, and it turned out it wasn't going to cost that much to get out of the [watch] business. Just pull the plug. Gordon's rule was [then], "no end-user advertising. We're not an end-user company. No end-user businesses, no end-user advertising." So when I first proposed the

Red X campaign I had to overcome the no end-user advertising. But Gordon saw the wisdom and bought it.

Hendrie: <Inaudible>.

House: That's the only way I'd get it approved. That's right.

Hendrie: _____.

House: Yes. It is all measurable and it's all the numbers and there's the test case and here's the control group and here's the... I got a drug test, I got a control group. <laughs>

Hendrie: <Inaudible>?

House: So Intel has now got the "Intel Inside" program going, the revenue's going like crazy.

Hendrie: Are you up to the 486 yet?

House: Well there's an interesting story about the 386. I told you we'd licensed IBM on... we licensed IBM on the 8086 and most importantly on the 286. So I've now got the 386 and I'm trying to get a design going at IBM and I'm getting nowhere. I mean, I'm just not getting them to move. So... got the sales force doing some detective work and we find out that in Manassas, Virginia, they [IBM] have a group designing a CMOS 286. [The original 286 was NMOS]. [IBM is designing a] 286 in CMOS, a 16 megahertz CMOS 286. Yeah. Well, I'm designing the 386 [in CMOS] and it's a 16/32-bit machine. It's got a 32-bit address structure, but the 16-bit operand work and [it's 16megahertz]…

Hendrie: Is it in CMOS?

House: It's CMOS. It's CMOS.

Hendrie: Oh, the 386.

House: 386 - first big CMOS [microprocessor] development. So by the way, the 432, first called the 8800, [then the 8816] by now it couldn't be the 8816 anymore. It's floating along and so I'm still doing these Interim follow up [products]- I've got a fill in the gap, stop gap products. <laughs> With the [original] IBM PC design, I'm in pretty good shape. So I get the 386 developed, I can't get a design [at

IBM] and I find out there's a 16 megahertz CMOS 286 [in IBM development]. I go to Boca IBM PC division and I said "Listen, I know you guys are doing this product, but you have to realize the fastest way to CMOS 286 is a 386. You don't have to use these new instructions. You don't have to use this new 32-bit address. It's a 286 in 16-bit mode, a 386 in 32-bit mode. I kept pushing on them and they kept resisting and kept holding out for their own internal design [CMOS] 286 because they had to... they were trying to take over their own destiny. Remember OS/2? [IBM had] taken over OS/2, they've got the PS/2 Mouse port and they've got….. they're trying to remake it [the IBM PC] proprietary this time. So they [IBM] want their own, they've got to have their own processor and so we got it... [Go to] Compaq… [with] the new 386, and [Compaq] does the Desk Pro 386 and that came out in September of 1985. It wasn't until late in '86 that IBM came out with a 386 product. Compaq just got on the map with that 386 machine. Of course we're out there running Red X campaigns, fighting the 286 with the 386 and so IBM had their little soiree with- with proprietariness of recapturing the PC and bringing it back into the flock and making a propriety IBM [product].

In the end Windows winds up winning and OS/2 is dead and Intel takes over the bus structure design and architecture with PCI [Peripheral Component Interconnect] and the USB's, Universal Serial Bus, and starts defining what the level 2 caches are and everything about the PC...basically [Intel] took it [the PC architecture] back from IBM and from Compaq and other strong companies by just doing an excellent job on developing the silicon. So I had my little soiree with IBM, and IBM never, although they had to race to develop, they finally stopped doing internal developments on competitive Intel architecture products. They had a number of different developments along the way.

The story of the 386 architecture's an interesting one. When I took over the microprocessor business, the 286 and 186 were in development. We got that done and I said, "We need a machine with a 32-bit address. How are we going to do this?" The movement from 8085 and 8086 had been so painful, relative to new software, and now there's enough [new] software out there We've got to do this in a compatible way because you've got to run the IBM PC software. So I say, "We've got to do a machine that runs the binary on the IBM PC, but has a 32-bit address." You know, this sounds like two computers on one chip and it sounds like too much cost and too much complexity.

Meanwhile I'd been introduced to a guy by the name of Glen Myers who was at IBM Research and had done a bunch of neat work. I met him and I was really impressed with the guy. So I went... put out a full court press to hire Glen and I got him working for me on my staff. I said, "Glen, you've got to figure how to do this." Glen comes back to my office, not that many hours or days later, he said "this is pretty simple." I said, "what do you mean?" He said, "well, look at this..." and he opens up the programming manual for the 8086 architecture where there's a bit in the op code that said whether the displacement that follows is an 8-bit or 16-bit displacement. He said, "we're going to make that a mode sensitive bit and we're also going to have a one-instruction flip flop and what we're going to do is, we're going to redefine that bit so if you're in 16-bit mode, it's as it is. But if you're in 32-bit mode it's 8-bit or 32-bit displacement. And we're going to have an 8-bit op code and here it is…., [he/they had] picked it out of the available ones...and it flips you to 32-bit mode, and another one that flips you to 16-bit mode, then

we're going to have one that said, for the next instruction only, use the16-bit or 32-bit mode." So he/they put that in.

Hendrie: <Inaudible>.

House: One.. one instruction, you get one..

Hendrie: <Inaudible>.

House: Yep. You flip right back, right, so you're in 16-bit [code] and... at the entry point in every program [routine], they would just put this- this 8-bit byte [that said the mode of the routine], there's enough memory space because it's a byte-oriented machine that would put it into the mode that the code was in. So you'd write something in 32-bits and you go to use a 16-bit driver and the first byte was 16-bit [put you in 16 bit mode] and then everything... it'd run in [16 bit mode] , and then at every entry point an [instruction] byte would say what the mode [was].

[DLH - The way it was visualized to work at that time was that all software was assumed to be 16 bit. When you entered a 32 bit routine you would flip to 32 bit mode and when you left the routine you would flip back to 16 bit mode.]

So it was very easy to implement from a hardware standpoint. I [the programmer] just had a 16 bit or 32-bit displacements. We had absolute addressing, we had offset-pointers, displacement addressing, and either one would be simple to do. So he [they] came up with this really elegant 32-bit extension and he said, "By the way, the protection system can't be this crazy objected-oriented-inspired, 432 inspired, protection system that was in the 286 with its ring structure. It's got to be this more conventional protection mechanism. So we'll put that in, when you're 32-bit you use that." I don't know anybody ever, except Intel, wrote any [additional] coding [for compatibility]. Never. Protection of the 286 [software] , everything was done to the 386 model. And that allowed us to run all the 8086 and 286 software directly. When the 386 was introduced, all it really was a 16 megahertz 286. Glen said, "How are you going to get people to use 32 bit mode?" And I said, "you ever leave candy around children? Programmers are going to use this. Don't worry, they will use it." <laughs> Sure, right away, 32-bit addresses, stuff started merging and then DOS and Windows made its conversion into 32 bit mode But there are still a bunch of 16-bit drivers out there. They still run. They run on a Pentium. All that stuff. They're still using the same architecture in the 386. 386 is the architecture of the Pentium. It's on the 486, [we just added caching and] more pre-fetched look ahead [etc].

Hendrie: <Inaudible>.

House: Yeah, yeah. Every time around, it's okay, we're up here on Moore's Law. Or when we get this done we'll be... because you've got to shoot ahead of the duck, right? Never shoot at the duck. You've got to shoot ahead of the chip. [audio glitch] so we got these guys in technology and we would be initially developing the process and developing the chip [at the same time]. Every once in a while the process guys would come in and say, "We can't do that. We have to go back and change the chips inside". But more often the thing that was so incredible about those years at Intel designing those microprocessors is the silicon guys just kept delivering. More often than not they'd come in and say, "Could you use this?" And we'd say, "Oh yeah. We could use that." It was good communication between the chip designers and the process guys and the process guys delivered [what] the processors required. And when they put them in manufacturing, we could put these things out by any number. They just worked and they were reliable and they were fast. We always had to work on speeding- getting the speed. We'd tweak the process and tweak the design and everything was done with numbers in a scientifically Intel method. We just started laying these things out, one ahead of the other and we'd introduce higher speeds and higher prices and bring the prices down and the next one, higher speed, and the next generation is a higher speed and a higher price. [We] just kept bringing the money in. In the early days when Grove was beating on me about the fact that people don't know that it's our processor inside. He's saying, "We're making all the difference and they're getting all the money." In the end, we were getting all the money. <laughs> And the cuss words [from PC manufacturers] were [we're making] paper thin margins and we were [Intel is] making like 80, 85, 90 percent margins on these chips. We'd captured half of the dynasty.

The Intel Microsoft story, the one you asked about, I remember going with Gates to IBM back in the early days with the original idea of PCs. Really with the 286 before the AT was out and making these visits back there and talking about, the three of us needed to get together because we're all linked and... at this time we're... we were suppliers to them. We're your two key suppliers. You're the king of the hill. The power struggles ended up happening and then I started meeting regularly with Bill. We'd go up to Microsoft and they'd come down here [to Intel] and we'd go up to Microsoft and they'd come down here. And for a long time it was just Bill and I and our staffs.

All kinds of great Bill Gates stories. Bill would... he was like Grove, he'd just get on something and he's like a bulldog and he's... whir, whir, whir, except he was a whiner. Grove is not a whiner. Bill was, he'd be going on and on about how we were doing something that wasn't in his best interest. I'd say, "Well, you know, I [Intel] need to do that." "Well, you know, we've got to…", and he'd pull every trick out of the book at leverage and support and all that sort of thing. I'll never forget one day... "This coffee cup… ready?" I'm sitting here and I've got this coffee cup and it's empty and I'm done with this coffee cup. It sat in the middle of the table and he started going and I'm kind of going… like this with the coffee cup [flipping it upside down, then right side up and back again] and I'd turn it back over again and I'm turning, I keep turning this over and Bill is on one of his tirades and he's going and he's going and he's going. I'm just like, this guy is out of line. He's got no right doing this and he is just red in the face and he's leaning in and I'm kind of sitting back like this, and I… this was calculated, I knew that I had to figure out how to deal with Gates and.. after a while.. he's going for a while, I kind of lean back like this and I went, <pounds the table> and I hit that coffee cup and I just smashed it and.. and Gates went…, he sat back

like this and he grabbed the arms of his chair and I went, “nah, nah, nah, nah.” He goes, “okay, okay, okay, okay.” <laughs> After that people... we had these meetings and Gates would go on these tirades and I’d say, “oh, come on, it’s not that way”, you know I’d deal with him with logic. And when he was on his tirades it’s like he had an answer for everything and- and nothing polite. So like I say, you’ve got to fight fire with fire. Being known as this even-keeled kind of guy who never blows his temper, I just, wham, and went right back at him like he did to me. And he’s just like... <laughs>. So after that I started treating Bill differently.

Hendrie: <Inaudible>.

House: So from my career standpoint, this is a little-told story because it’s... I kind of hesitate here on tape because, you know, I’m telling it, but... Grove will tell you it’s true. Must have been about 1981, ‘82. I’m working for… because I’m working for Carston - in ’83 I went to work for Grove directly. Jack comes to me, and he said, “Dave, we’ve decided we’re going to go into the commercial microsystems business and we’re going to take our development system and we’re going to make office computers. So we’re going to take our ISIS operating system, etcetera and ask Jim Lally to lead that effort.” Jim had been running the development system business, “so we’d like you to take over the- the development system business... regular blue box [business], engineering support business.” I said, “Oh, okay,” I said uh... “Well, I’ll give you an answer on Monday.” Jack said, “It’s Tuesday. What do you mean you’re going to give me an answer on Monday.” I said, “Well, okay. I’ve been offered a job to be president of Fairchild Semiconductor. Schlumberger had bought the company. They brought in their guys, they’re looking for a CEO and they’ve offered me a job. I told them I’d give them an answer on Monday and if I accept this, you’re going to announce it tomorrow and we could both-- if I decided to go to Fairchild, we’re going to look really stupid on Monday.” <laughs> So let’s just hold off.

Okay, 15 minutes later phone rings, it’s Grove on the phone. “Dave, get over here.” “To where?” “My office.” “Okay.” So I get in my car, drive over to the other building, go up to his office. He said, “Come here. Let’s go for a walk.” Out the door, down the hall, down the stairs, out the front door, across the parking lot, turn right, down to the corner, turn right, past Intel building and down the street and into the . industrial park there and I said, “Andy, where are we going?” I mean, I know why he’s called me. He said, “I’ve got to talk to you.” I said, “Okay, let’s talk.” <laughs> “I’m getting out of breath.” And he said .. “well, I told the board that I’m going to retire when I’m 55.” I said, “Andy, A: why and B: so what?” He said, “Well, why is because I’ve always worked for Gordon, When I left to college I went to Fairchild and I was one level under Gordon and then I worked directly for him. I've been working for him, since I came over here. I’ve never been able to do anything on my own and I want to do something on my own. I’m not going to do anything to compete with Intel, but I want to retire when I’m 55 and I told the board.” I said, “oh, well, I’m glad you’re… but you’re only like, 45, aren’t you?” And he said, “Yeah, but the board asked me for a list of people to replace me and... and I put in three names and you’re one of the three.” I said “That doesn't make any sense, I don’t even work directly for you. There are a lot more senior guys around here.” And he said “Yeah, but they’re too close to my age, Dave.” <laughs> “You’re in the right age category and you’re one of the three. So I don’t want you to go to Fairchild.” I thought about it and

decided that... that amongst other reasons that I wasn't going to go there [to Fairchild]. One is the Schlumberger kind of culture wasn't mine. And so I stayed. Then Grove would come back [yearly] and say, "well, I'm still on my track [to retire at 55]."

Later it became known publicly that he was going to retire and they [the press] ran articles about it. *BusinessWeek* ran an article about, he's going to retire at 55 in a couple of years, and [they ran] my picture, here's the guy who's going to replace him, etcetera. So I'm thinking, you know, why not? Might happen, why not? But it would be fun to run a company. Grove was coming up towards his... he's getting about a year away and he goes on a sabbatical and he comes back from the sabbatical and we had dinner like we often did. He said, "I went on my sabbatical and I was with this friend and he said "Why in the world would you quit? You've got the best job in the world. Why… what's wrong with this job? I mean, so what? Gordon doesn't bother you, does he? You get to run your own show." And he [Andy] said, "I decided not to retire."

I said, "Oh my God," .. I said, "for one thing, as a stockholder, I think that's wonderful because I don't think any of those of us who you have considered as your successor are as smart or as articulate or as great of a manager as you are. So it's great as a stockholder." He said, "yeah, but how do you feel personally?" <laughs> I said, "well, I'll tell you how I feel. I feel like I've been preparing for all these years for a marathon race and I finally enter the marathon race and I'm running and there's the crowd and I'm halfway through, I'm starting to move up in the pack and I get ahead and I'm leading and.. and I come up over the top of this hill and I look ahead and there's a banner and it said "Finish" and there's all these people and photographers are there and they're all waiting at the finish line and I look over my shoulder just for a brief minute and I'm up, like, 15 paces ahead of the next guy. Then when I turn back and really start to sprint to the end, they're taking down the banner and people are going to their cars. I get to the end and they said, "well, we called off the race." That's what I feel like. <laughs> But I still think it's the right thing to do."

So he [Andy] had slapped some pretty heavy stock options on the candidates and Intel stock had been going up nicely and I said, "So Grove, I'll stay around. I'll stay around because I won't ever have to work again if I do." <laughs> It was working pretty well. "So you're going to stay on. I'll be too old by then [when Andy does actually retire] and, I won't be the right guy. But the way we are currently organized doesn't make sense. At the end of the four years, when this option's due, I'll probably go run a company". And I said, "and the way we're structured doesn't make any sense. I get 70 percent of the revenue of the company [in my business]." He said, "You're right." He said, "We really need to break up the organization and have you do something [different]." Then I moved over to run marketing and applications and we created the architecture [group], Intel Architectural Labs at that time. I had said, "what are you [andy] going to focus on?" He said, "Well, I'm going to be doing this, this, this and this." I said, "that sounds like the stuff I used to do." And he said, "Yeah." When he announced that he wasn't retiring to the executive staff, he said, "I'm basically going to do what Dave's been doing" <laughs> So that was a big, you know, a big change. I said, "Well, who's going to do what you've been doing, because I'm not qualified." I mean, he'd been doing operations... Barrett took over operations. He [Barrett] was

obvious, it was clear that he would be the right person to succeed Andy in those tasks. Plus, I wasn't going to stay around for him to turn 65. <laughs> I was going to leave.

One of the things I had advocated during that time period was… we really had captured the desktop and we beat Apple down to less than ten percent of the marketplace. We had a run on the workstation [market] that looked good. I took Moore's Law and I plotted it and I said, "Looks [our workstation position] pretty good to me." We've been fighting RISC and to me the RISC argument never made sense because of the advances of semiconductor technology always overshadowed the little bit of architecture advantage you could get. And software rules. I mean, all the software was there and the momentum, we know the momentum of applications. So I really advocated that we get into the server business. So far I had run corporate marketing and the architectural lab and applicant… field applications for a year. Then I took over corporate strategy for two years and worked on this server thing. Then when my options were about ready to vest and I'm going to go and…and Grove said, "Well, I think I'd like to reorganize the company and organize around desktops, notebooks and servers. I'd like you to run the server group, the chips and boards and boxes [for servers], the whole deal, and get us into the server business." I thought, that's too good of an opportunity. I think we can really do this. We didn't have much in the server business in 1994.

Hendrie: Yes.

House: This was 1994, somebody else had notebooks and somebody else had desktops. Carl Everett had desktops. Someone else had notebooks and I had servers. We got into the server business and got the whole thing going and…

Then in1996 I got approached by John Thompson of Heidricks and Struggles who I'd talked to before about a few jobs. They had come after me from Xerox and Polaroid and few other walking dead. <laughs> And Bay Networks. At this time...Intel's got a sabbatical program… I go on a sabbatical, an eight-week sabbatical, and I started thinking, I'm having a great time with this server thing, but if I'm ever going to do it, this is probably the time.

Hendrie: Yeah. If you're ever going to go run a company.

House: Yeah. It's probably the time. So I met with Paul Severino, I said I'd have one meeting with him. I met with him just before I went on sabbatical and I talked to him about it and then I thought about it and I came back [from sabbatical] and I said, "I'm going to quit. I'm going to leave. I'm going to go back and quit. But I'm not going to quit the first day because I need to go to work one day and go home at night and sleep and then come back and if I still feel that way, I'm going to quit. So Tuesday after sabbatical I'm- I'm going to go." "What are you going to do?" "I don't know. But I'm going to go." So I called up Thompson and said, "you know, I just told them I going to quit. I'll stay- I'll stay through the end of the

year, but I'll just line somebody else up to run this [server business]." This is the beginning of October. So I had several meetings with Bay Networks and that was really, I mean, that clicked right away. They had a broad product line, a great engineering team and customers wanted them to win, they wanted an alternative to Cisco and they liked the product line. [But Bay Networks had] no adult supervision. Total chaos. It was the merger of SynOptics and Wellfleet. Wellfleet [was in Massachusetts and SynOptic was in Silicon Valley and], interestingly enough I had worked for seven years in Massachusetts and then worked for 25 years on the west coast and they had a merger of a west coast and an east coast company. So "you're kind of bilingual, Dave, bicultural. You could work in both environments. You can pull this together." But when I got into it I discovered that the east coast company was a west coast culture. Paul Severino wanted jeans. He bragged about the fact that the desk in his office was one that had been left by the last occupant in the building because he didn't think it was worth moving and he loved to go out and talk to the engineers, and loved to go out and talk to the customers. The guy on the west coast, Andy, was from Xerox and he wore a white shirt and a tie and had a big office with blonde furniture. He managed things in a sort of hierarchical fashion, didn't go out and mingle a lot. Things worked well for the first year. Severino's saying, "Well, I'm going to go play golf and be the Chairman of the Board." After a year... revenue doubled the first year… then went flat. Then Severino and Andy… Paul and Andy did not do a good job of communicating and resolving issues and it became a west coast and an east coast camp. People would start developments on one coast and then there would be a competitive start on the other coast. The children were starving for lack of birth control and everybody was starting projects and nobody had the staffing. It was just bad culturally. The company knew that it needed to change. It was already unfrozen which… the hardest thing in change is getting people convinced to change. If you've got people that already know they've gotta change, you can do a lot. Quickly…So…just before…we're going to announce that House is leaving, I accepted a job at Bay. House is going to leave at the end of the quarter and it's I think, October 30th of '96…up over there [at Bay Networks on October 30] and I get introduced by Severino who had taken over two weeks earlier as CEO.. so at that time he was CEO and chairman. They [Bay] knew that they had to make changes and had already made that change. I showed up and the press is there and employees are there and management's there and they say, "What are you going to do? What's your plan?" I said, "I don't know." They said, "You don't know?" I said, "No, I don't know. But I can tell you how I'm going to know." They said, "Well, how are you going to know?" "I'm going to talk to customers and I'm going to talk to the employees. Then I'll be back in 60 days and tell you."

So I had 15 direct reports I inherited and I created 15 teams…five persons per team, so we had 75 people and they were from different disciplines, multi discipline teams. So there's an engineering guy, a marketing guy and a manufacturing guy, a finance guy, on each team. We divided up the world and came up with an eight-page qualitative interview questionnaire. We sent people to Japan and Taiwan and Switzerland and Chicago and everywhere. We all went out and we all spent one week talking to customers, about three customers a day and…and so a lot of customers.

I found out that the HR team wasn't trusted by the people because they had been sort of henchmen from the [previous] management. So I brought in a couple of outside consultants and had them interview the top 15 [my inherited staff] and then identify the thought leaders and interview them and then created a 48-

question survey, questionnaire that was web-based and anonymous, and sent that out to all the employees. At the end of that time, I brought those two [things] together [customer and employee surveys] and I looked at them it was a 90 percent overlap. They're all saying the same thing. We have the same set of problems, etcetera. So one of the problems was that the products were late to market, they were buggy, and they were lacking features. The product line was long in the tooth. Well, that was… as you peel the onion, because there are too many developments and not enough engineers. So I pulled a group of about 60 people together... I brought in system engineering guys from the field…guys that were doing the pre- and post-sales work with the customer, mainly in the pre-sales work. [I brought in] geographic sales managers, because they knew the business issues, and I brought in the product line managers, the people from the factory, and then I brought in the development project managers and I had a two-day set of meetings where development managers stood up in front of the jury, the technical and business field and factory organizations, customer-facing organization, and they presented their product and its features and its competition and…and its schedule and…and the resources they had and the ones that they needed to meet their schedule- when to deliver and all that sort of thing. All the pluses and minuses of the product, in a standard format. We just went two days, we went over 'em all. Then I took the system engineering guys and I said, "okay, field facing guys, I want you to rank them. First thing I want you to do is [separate all projects/products into] four quadrants. What's important…what's the top 25 percent, second, third, fourth. Go through the products and prioritize them, put them in quadrants. Finance, I want you to keep track of resources needed and I want you to tell me where- how many resources we got and when we run out." And so they went and did that. Took them a day, they came back. I said, "okay, now, engineering guys, before I cancel the ones down here [below the resource limit line], I think you ought to talk to the sales guys, because we could probably… I noticed there's some duplications here and… and we could probably put a few features in this switch and get rid of that switch and… probably do a better job with what's above the line." So there was a bunch of discussions and the list got shorter and some projects got combined and, the guys down here were busy trying to get something up here and the guys up here, "How can I keep my position and…" I said, "Okay."

Then I brought in engineering management and I said, "okay, all these projects below here [below the line] are canceled and all these [above the line] will be fully staffed. But we have a problem. Because the project managers on these projects down here may be better than the project managers [on the projects] up here. So go… top [engineering] management, go reshuffle the project managers." So they went and talked to all the project managers and interviewed them and courted and wined and dined them [the best ones] for 24 hours and we had project managers for all the projects and the right [best] guys [on the ongoing projects]. Then I announced to the whole company that all these projects [below the line] were canceled but that everybody had a job. So these project managers now, they know where the good engineers are, right? So they're wining and dining the good guys. They're taking them to breakfast and to lunch and going to their houses and working nights and weekends trying to recruit the best guys. The guys down here [bottom of distribution] who are the not best guys are just looking for a job, so they're courting the project managers. "Can I get a minute to talk to you?" <laughs> There was this natural sorting that happened. Nothing got done for two weeks. Nothing. No development. Everything stopped. At the end of the two weeks, everybody had a job and every project was fully staffed.

Then I called all of the people together. I rented the Santa Clara Convention Center and I rented the Memorial Auditorium [in Lowell, MA], and I had audio and video links to all the sales offices in remote geographies. I stood up for 90 minutes and I said, “This is what the customer said and this is what the employees said and this is how they overlap. So these are our big problems. These are our steps. We’re going to solve them. We've done this with the products. These are the products we still have. They’re all fully staffed. We’re going to get them done. Here’s our mission, here’s our values, here’s what I value. I’m going to be back to you in 90 days with something [strategy] that I’ll develop with a team of people. Here’s our five-year objectives and goals. Here’s our one-year objectives and goals. Here’s our 90-day objectives and goals. I’ll be back in 90 days and I’ll grade how we did as a group and I’ll tell you what the priorities are for the next quarter… It [Objectives and Goals] was a two-page, very numerical, very measurable set of goals. And one of the things I said was “People have asked the things that I stand for, here’s some of the things I value and I’m going to stand for...”

Also I’m initiating this training program and what I’m going to do is, I’m going to focus on four major topics that I think that we need to do some improvement in this organization and by the way, the data shows... We need to have a better process for resolving issues, we need to have a better process for making decisions, getting them made and keeping them made and getting them fully supported. We need a better process for aligning our resources and our goals and objectives and we need.. we need to do a better job of when we run meetings.”

So I go to- training classes. Now, I can’t train all of you, but you’re all going to be trained by somebody that’s directly trained by me.” So I took 150 top managers, broke them into 30 at a time, five groups, and I… generated a set of slides myself and I stood up and said, “these are the slides you’re going to show your people in the next 30 days,” and I trained them on Managing for Results, which is about mission, goals, objectives and measurable goals and objectives and aligning them up and down the organization, across the organization and how we’re going to judge them and.. “I’m already showing you how to do that. Next was issue resolution, or Straight-Talk as I called it, which is how to deal with conflict in organizations. Conflict is healthy. It’s good, it gets a lot of points out. But if you don’t resolve it, it’s friction in the organization that just…we can’t afford. Next was Decision-Making, how do we get decisions made? How do we push them down to the people that are responsible and how do we involve the consultants that have a right to be heard but not a right to decide.” In that training I ended with “Properly supporting decisions properly made is a condition of employment.” Once we go through this [decision making process] and we decide, everybody gets behind it. Whether you agree or not. So we had Straight Talk, Decision Making, Managing for Results and Effective Meetings - how to have fewer, shorter, smaller, more effective meetings. So I went through the next four months and trained people. I called it the “New Bay Basics.” The employees immediately renamed it “House Training.” And HR created these badges that said, “I’m House Trained.” They gave the badges to people when they had been trained. I would train each topic five times [5 groups of 30 for 150 trainers] and they would go do it the number of times they had to do it in their organization. Everybody had been trained in 30 days and I’d be back again. And then uh…

<tape break>

Hendrie: Very good.

House: So we created at Bay, we created this set of training, my "New Bay Basics" which got renamed "House Training" and then we created what our values were and they got renamed "The House Rules." [Then there was what became known as "House Cleaning".] When I went there, I had 15 people that reported to the CEO. I completely wound up restructuring and reorganizing the company and there were some people that it was obvious that they were going to be more successful somewhere else. I just explained that to them. There were some people who needed to do a different job, either because they had a unique skill and some of them didn't see this [new job] as prestigious, but they were the best qualified person to do it. I needed them to do that job for me and sometimes they didn't want to do it and they left. And some people were…they'd been through so much turmoil with the merger and post-merger and two years of chaos and they were just burnt out. They just needed to go somewhere else. They needed to start over again. And some people had just burnt bridges and…they weren't in a no-politics environment, [they] were not going to survive and they left. They quit.

The result was that- that after 90 days, of the 15 people that reported to me when I arrived , there was one person left that reported to me 90 days later. I promoted some people to report to me. I recruited some [from] the outside. But there was one person left that was on [my staff when I arrived].. and that person was Lloyd Carney. When Lloyd was introduced [to me] by Paul Severino, he [Paul] said, "This is Lloyd Carney, he's leaving at the end of the quarter." And I said, "He leaving at the end of the quarter?" "Yeah, he's always wanted to go to a start-up and we talked about this all along.. He's giving his notice. But he's agreed to stay to the end of the quarter to help you get through this quarter because you're going to be so focused on learning everything that somebody's gotta focus on getting the revenue in. So he's going to work on operations in making sure we hit our quarter number, but then he's going to leave at the end of the quarter." So, I started working with Lloyd and it was clear to me that this guy was one of the best possible people. One of the things I assigned him was ...he came out of the development organization… and I said, "one of your jobs is, you've gotta help me recruit a head of development" because the guy that I had was not the right guy for development and I wanted to move him over to create Bay Networks Labs. I wanted him to do that and he didn't want to do it so he quit. So, I said [to Lloyd], "You gotta help me hire." He [Lloyd] was bringing in candidates, we got head hunters and he's working real hard because he's got to get out of here at the end of the quarter. Probably about the first or second week of December I called Lloyd. I said, "Lloyd, come… I gotta talk to you." He came in my office. I said, "Lloyd, I found the guy! I've got my VP of engineering." He said, "Great. That is great. Who is it?" I said, "It's you, Lloyd!" <laughs> Now Lloyd's been living on the east coast. I had to move him to the west coast…but he stayed on and he was one of the real pillars of the organization.

I brought Dave Shrigley with me over from Intel and before I ever did the deal I went and talked to David. I said, "One of the big problems here is I need a sales and marketing guy and I don't know who that is.

But you could be the guy. So if I do this, I need you to come with me." <laughs> So the first thing I did when I got there was offer him a job. And he quit [Intel]…he was on board, like, eight days later. He'd gone in and had some kind of eye surgery and.. and I'm pushing him. I've got this meeting with all the staff in Massachusetts and I'm trying to get him onboard and he goes and has the eye surgery. That morning he goes in into Barrett and resigns from Intel in the afternoon. Gets on a red-eye, flies to Massachusetts to be at the meeting the next day. <laughs> He was… we were all… flat out from that point on.

I hired a finance guy out of Tandem Dave Rynne, he really turned out to be a wise old man...that was great. Anyway, when I went there, the market cap was $3 billion. 20 months later, we inked a deal with Nortel for 21 percent of their stock which was, at that point, worth $9.1 billion which went…somewhere between $40 and $50 billion at one point in time. And then of course went back down and then back up again. [Nortel has since gone bankrupt]. Fortunately, many of us were able to liquidate before it started back down again. But I never intended to sell the company.

I told you about what we did with engineering. We restructured the whole engineering program; re-staffed and moved everything around, reprioritized, etc. That was in January, late January of '97. In the year 1998, 58 percent of all revenue came from products that were less than 12 months old. We just completely reformed the whole product line, replacing many older products with new ones. Where we couldn't fill it, we went out and bought companies, acquired companies. We just redid the whole product line. We were smoking and going.

By late '97 I could see what was happening and I said, "Okay, what's the next step?" Carriers were taking off like crazy. [What became] The Internet bubble was forming. Cisco had seen that and declared that they were going after the carrier business. They declared the Nortel and Lucent were their competitors. They tried to do a merger with Nortel and that didn't go through, later it got all that story from John Roth [CEO] at Nortel. It was about who winds up being the survivor in the process with a little Canadian pride in the formula. Cisco declared that Bay and 3Com were no longer the competition and now Lucent and Alcatel and Nortel were. So I said, "I know how to do this. We're the number two guys in routing." And we had a big system, we were running on the New York Stock Exchange and big financial institutions, so we had the multiprocessor and a router and we had some great customers. So I went to all the carriers and I… they're already reselling my product, but they're reselling [even more] Cisco product…"I need you to sell more of my stuff. Remember, John [Cisco CEO] said you're a competitor. I'm not your competitor. I'm your partner. Let's do more together. Let's figure out how..., we could do more marketing. How about if we do joint development? What do you need? Let me put your features in my product. You want to private label my stuff? Fine. Want to do joint developments, with joint funding and development? You'll have early access to it. I'll be able to sell to other people later. Let's get in bed together, let's really…

From Lucent I got “great idea”. Nortel, “great idea”, Ericsson, “great idea”. Things were heating up around the end of ’97 and in January of ’98, everything turned to shit. It started with “What about your cooperation with other people?” By March they had all come to me and said, “We had all had these really close, cooperative, technical discussions about how we were going to do it.” The engineers loved it. Then management came in and said, “It’s too risky. If our competitor buys you… we are so dependent on IP [Internet Protocol] that if our competitor buys you, we’re dead. We can’t do it.” [They] all said it within about a three-week period of time. So they all said, “So we either need to get closer or get further [apart]. We’re going to have to do it on our own- or we need to really...” They didn’t use the merge word…but we knew what they were talking about. So then I get a little bidding thing going on and…and everybody said Lucent would win because when I’d inherited this technology agreement with Lucent, they [Wellfleet] gave [licensed] the rights to our routing [to Lucent]…I got out of that [agreement] during the time I was there. Back to Intel...“Why did you give your technology away? Your most precious stuff? I don’t understand this.” So I broke the AMD deal, I broke the Lucent deal. I got the rights back. But we still had a tight marketing and distribution agreement with them [Lucent]. Everybody thought they’d buy us once they got through that period of time for pooling of interests.

Nortel, it was clear to me, had much superior technology; and was a much better fit. Alcatel was way too French and way too foreign. I had to do what’s in the shareholders’ best interest and had that fiscal responsibility on my mind, but I believed that Nortel stock was going to be worth more than Lucent stock and when I went to Nortel, I…met with [John] Roth even before we did the deal. I said, “Okay, something I don’t understand. We all know about Lucent’s technology and your technology. Your revenue’s two-thirds of theirs, your marketing cap is one-third of theirs. What’s going on here? I don’t understand.” Well, [he said] blah, blah, blah. I said, “You don’t know how to present yourselves. You don’t know how to market the company.” I really believed that there would be more appreciation in Nortel stock. I knew it was going to be a stock deal. So I had to work it to be a Nortel deal and not a Lucent deal and it turned out that way and…the last minute negotiations were a whole story in itself. But in the end we did the merger and got it completed in a very short period of time. On August 30th of 1998 John Roth and I were at the Memorial Auditorium in Lowell, Mass with all the employees that we could get in there... and everybody by satellite link, the whole company. We announced the merger to the employees and [John] Roth said …he had this thing he was talking about, the right angle turn. “We’re going to do a right-angle turn. We’re going to become an IP-based company.” He said, "And the way we're going to do it is Bay Networks. The new company is going to be more like Bay Networks than the old Nortel.” And “We’re going to make…and Dave’s going to drive this change,” etcetera, etcetera. I got his full support [that day] in doing that and making that happen. So we launched the IP version of each of the product lines. How we’re going to move the voice switch over to IP and how we’re going to move the enterprise businesses over to IP and how we’re going to move the wireless over to IP.

We renamed the groups to indicate that [focus on IP] and I said, “We’ve got to change the name of the company.” The company was Northern Telecom and I said, “That’s not the right positioning. Northern Telecom.” They had the Nortel brand but it was just a brand. So I said, “We’re going to change the name of the company to Nortel Networks” and that’s one of the things we did. We started the advertising campaign, started a big PR push, but it became very clear to me…and I traveled 191 nights during that

year. I slept out of the state of California [191 nights that year]. It became clear to me was, I'm going to all these customers and all these [Nortel] plants that if we're really going to make this change, I have to move to Toronto because I'd be talking to these senior managers and I'd look and they're doing like this, like they're trying to see behind me. You know, "Is John [Roth] back there? John? Where is John?" What does John think about this? They wouldn't say it, but I could see it. And I would say, "John and I have to be in lockstep." Then I found them going around and verifying everything with John. I said, "This is only going to work if I can put my office next to John's." Meanwhile I was just building a new house. My dream house. I'd been coveting this piece of property for 20 years. Fell in love with it, built the house, it was just about ready to be completed; in fact, I moved into it in August of '98. I was single again and my kids are out here [in California] and they're grown to point where they're not going to move. Nah. Not going to do it. Not going to do it. Not going to move to Toronto. So I said, "Okay, how about at the end of the year when I get all my benefits vested, I'll just move on." So…we announced, I think in June, that I was going to leave at the end of August.

Hendrie: I think we've run out of time. Thank you very much.

END OF INTERVIEW

