Intel 386 Microprocessor
Sole Source Decision
Oral History Panel

Participants:
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Moderated by:
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Jim Jarrett: I'm Jim Jarrett, former VP of Global Public Policy at Intel. We're at the Computer History Museum it's August 14, 2008. And we'll be talking about Intel's decision on second sourcing the 386. This is all just for historical purposes so that 100 years from now when they find this tape, they'll know what it's all about. Please can each of you say your name and your latest title at Intel. Tom.

Tom Dunlap: I'm Tom Dunlap. I was the Senior Vice President and General Counsel of Intel.

Ted Jenkins: I was Vice President and Director of Corporate Licensing, retired in 1999.

Dave House: Dave House. I left Intel in 1996 and at that time, I was running the Server Products group.

Jack Carsten: Jack Carsten. I left Intel in 1987 and I was Senior VP of the Components Group.

Jarrett: Let's start by talking about second sourcing, generically, in the semiconductor industry in the sixties and the '70s. How did it get started? And why did it become entrenched and a very common practice?

Carsten: Okay, Jim, I'll take that. You know, when I started in the semiconductor business in 1965 almost all of the business was military. And believe it or not, the military has a license to any patent or IP that's been granted copyrights and patents in the United States. So if they contract with someone to manufacture it, there's no licenses needed. So since most of the business was military it was fairly common for a number of people to bid on a job to supply particular kinds of integrated circuits and various kinds of proprietary things. A lot of that stuff initially was custom but it increasingly became standard products and the process of second sourcing sort of developed out of that because the products that weren't good enough to sell the military, you had to sell to somebody and so we sold them commercially and issued data sheets and so forth and so on. But the practice was largely one of trying to attract the second source and get them to issue a data sheet, and admit that they were, at least, planning to build something. Then the trick was to make sure that they were never able to ship because what you wanted was as many paper sources as you could find but no real sources that could actually compete with you.

Jarrett: Okay. And wasn't there also some concern on the part of the customer's regarding the manufacturing processing itself. It wasn't all that reliable in the early days of the semiconductor industry was it, Ted?

Jenkins: Well, there are a couple of problems. One is the reliability of the components themselves and actually, some of my colleagues came from Fairchild when they had had a big meltdown with micro-cracks in the military business. But then there's also the demand volatility. The entities are not able to forecast what they need and neither are the manufacturing people able to forecast what they're able to do. So, from time to time, you have some exciting moments when you don't have enough for everybody and it gets a little tense. Redundant sourcing can flatten some of those issues out.

Jarrett: And it also gave the customers a little price competition?

Jenkins: Certainly, there was that too. Although, as you know, the military products had extended temperatures, extra reliability, and everything else so it always provided a premium price; and usually that wasn't as much as an issue as availability and reliability.

Carsten: But in the '70s, the computer industry took over a lot of the demand and people like IBM, Honeywell, and GE and a lot of other people bought a lot of the product and they just sort of picked up the practices of the military. And as a condition of being designed into a particular computer often times the purchasing department would require that multiple sources be a part of the design decision.

Jenkins: That was quite often a function of the complexity of the device. I mean, if you have 100,000 devices, or 10,000 devices in a piece of gear, if any one goes down your gear is no good. So when you think of a big computer, the reliability requirements are pretty stringent and very much military-like.

Jarrett: So Tom, from a standpoint of the legal department, looking at this, I mean there were second sources and there were second sources, right?

Dunlap: True. There was another practice that developed in the industry and that was known as patent cross-licensing because a number of companies had patents on either the process or the circuit and so you might need 100 or 1,000 patents in order to actually make the semiconductor device in let's say the early '80s. And therefore, we would cross-license each other with our patents, rather than actually have what we would call mutually assured destruction where both companies would just fight each other with their patents instead we said, well, let's just cross-license each other. So that really allowed companies to become second sources if they wanted to. That patent is really the only thing that truly prevents a company from a legal standpoint from competing with someone else. But because of what Jack mentioned where our customers wanted second sources, it became necessary to either encourage them or actually help them. So in the days, of the 8085, as an example, we would transfer our technology to our competitor because the customer wanted a true second source that they knew was using the exact same mask set. And in the case of the 8085 there was like a dozen second sources around the world. Some of them we had helped, some of them just did it on their own because they had a patent license.

Jarrett: So going on with that same thought, what was our strategy on second sourcing at Intel for like that 8086 which came out in 1978 and the 286 which came out in 1982? How did we handle second sourcing at that time?

Carsten: Well, Intel had an early second source for the 8086, a company in Texas called Mostek The CEO of the company (named L..J. Sevin) happened to be an old friend of mine and I cajoled him into agreeing to second source the 8086 so that for the purposes we mentioned earlier we would have a second source. And that occurred in about 1979 or so, about the time the product was introduced. We also had discussions with, I think, Siemens, in Germany, and Fujitsu in Japan, where for various considerations in [terms of] rights to ship product [internally] to their computer divisions, and for them to pick those products up, they agreed to be second sources. So we thought we were in pretty good shape for second sourcing. However, in I believe, it was late 1980 I got a call from L. J. Sevin, my old buddy, and he said, “Jack, I’ve got some bad news for you. That 8086, you never really gave us any help on the thing, and we’ve got a hell of a deal from Motorola to second source the 68000,” (which was our arch-nemesis at the time) “So we’re dropping the 8086 and it’s going to be in the press wire tomorrow.” And I still remember saying, “L. J., I’ll fly down to see you. Wait a minute, wait a minute, stop.” I couldn’t talk him out of it. They went with the 68000 and so we lost our domestic source. Meanwhile, neither Siemens nor Fujitsu could build the 8086 even with our help and so we didn’t have a second source.

Jarrett: So then what happened next?

Dunlap: So then comes Bill Davidow with the idea “We’re always doing these one-of-a-kind deals, why don’t we set up a system where we can get second sources for our products on a regular basis?” And he approached AMD. AMD was interested in participating in this kind of a program. They were a second source for the 8085 where we had helped them, and so forth. And so in 1982 we signed an agreement between Intel and AMD and the concept was a mutually acceptable exchange of products, so that rather than just randomly coming up with products to exchange, we had an equation which would calculate the complexity of the product. And based on that complexity and various other factors we would sit down and if we had an exchange that was acceptable, the value was based on this complexity factor and then the exchange would go through. There was also some products that AMD could obtain for cash and that was necessary because in 1982 when we were about to enter this exchange, Intel had products like the 8086 that we wanted a second source for. AMD wanted to be that second source. So we allowed them to obtain that product for cash and they would pay some royalties. There were other cash products in [the agreement], but the idea was that after a period of a few years, this would all change. They would develop products that would expand the Intel portfolio and then we’d have these exchanges. So the real goal over the long-term was to exchange products to broaden the family, not to just obtain royalties.

House: I think, though, another point, Tom, was that AMD had second sourced the 8080 and then 8085 but then had changed camps and gone to Zilog. And didn’t they sign an agreement with Zilog to source the Z80 and Z8000.

Carsten: They not only signed an agreement, they were advertising it. They were manufacturing it. They were heavily involved with Zilog.

Jenkins: Right. AMD’s genesis was second sourcing in military products. That’s how they started. They were just going to basically take on the high volume products and second source them and come out as what we would call a commodity supplier today. One thing I wanted to add on the complexity factor [is that the formula was designed to work regardless of the design rules. So as we went forward in time and got the tighter and tighter design rules or if we were ahead on technology versus AMD there would be a compensation for the actual complexity of the device regardless of the technology. It was really proportional to how much design effort that the product took. So that was a clever idea. It was not a bad way of trying to, at least, get the design effort out. It didn’t take into account anything about the market size, but it was design effort.

House: But it was a plan that would really allow us to have a larger product line by allowing AMD to develop some of the products, largely peripherals for your [PCO] business unit at the time, [while] Intel [would largely focus on developing] the processors, and therefore, [we would have] a broader product line overall. That was the theory, at least.

Dunlap: Well, not only a product line but a broader market. So the whole idea was [that if] we had a second source more of the computer companies would buy the 8086 family and therefore, the overall pie would get larger. Intel might end up with instead of 100 percent [of the 8086 market], we'd have a smaller percentage, obviously, but the [total 8086] pie would be much bigger.

Jenkins: And the customer benefit was, again, going back to our comments about why the military was so sensitive to second sources was that we would balance out any of these demand fluctuations, supply fluctuations, and the customer could feel more secure going with these products, as opposed to XYZ.

House: Of course, the assumption was everybody would execute.

Jenkins: Yes. Or maybe we'd execute better than some of the other people would execute.

House: Well, but for the exchanges to happen, everybody had to execute.

Carsten: But Jim, I think, it's important that everyone understand that it was Intel that had to take the initiative on this second sourcing. And as I think it's been well publicized, we had won a design with IBM in Boca Raton for what later became the IBM PC and a very ubiquitous product. And as was fairly common at the time, the IBM purchasing department said that they weren't going to allow that design to go into production [without a second source]. And, in fact, they had a competing design using the 68000 that Motorola and Mostek were supplying that they were going to use, unless Intel came up with a domestic second source that could actually ship the product. And so I remember very well in the executive staff meeting as we were discussing this issue, the discussion was, "Well, who do we think would be a good second source? Let's ask IBM. Let's ask our sales people and so forth." And because of their reputation of being a good second source and a reputable one at that, and because we used them in earlier generation, everybody thought AMD would be a great idea. But as Dave mentioned, AMD was already engaged in a big advertising campaign with a competitor. So we decided--well, Jerry Sanders and Bob Noyce are old friends, let's send Bob over there to ask them. So we sent Bob over to talk to Jerry and he came back and he said something like, "This ain't going to be cheap." Or something like that. And so then David [House], Bill [Davidow], and I went over to meet with Tony Holbrook and Jerry [Sanders] sort of stepped back and neither he nor Noyce were really involved. But we had quite a wrestling match with them to try and figure out something that wasn't a total giveaway where we just basically gave them all of the tooling and [rights to] the whole line and didn't get anything in return. And so that's how this complicated deal got cooked up where they were supposed to give us products that we needed in return for basically instant sourcing and tooling and the [rights to] whole thing for the product that IBM wanted.

House: Well, I remember it just a little bit differently, Jack. The IBM design win, the PC design win, really happened in 1980 and the PC was announced in '81. And, I think, the AMD agreement was signed in '82. And the PC design was really [designed by] a renegade group down in Boca that was outside of the control of the purchasing people at IBM. And so the design was all ready done, the product was launched and started becoming unbelievable successful [before the second-sourcing pressure was applied], I think, a number of us were surprise how successful the IBM PC was right out of the chute. And [and it wasn't until] that time [that], the IBM purchasing people got engaged and put extremely high pressure on us to add a second source. And I don't know, when did we first allow IBM to make their own internal second source?

Dunlap: That was in 1983. In 1983 we negotiated an agreement where IBM had a right to a number of microprocessors basically the Intel entire microprocessor family but only for internal use, and only to put it in their computers so that they could be their own second source, but they were not an open market second source.

House: But they also agreed, at the same time, to buy a certain portion of their requirements from Intel.

Dunlap: That was the exchange in that case. And it was [that] they'd get the right to make the product internally, but they have to agree they will buy a certain percentage of their requirements from Intel…

House: If we can deliver.

Dunlap: If we can deliver.

Jenkins: Back to this renegade group in Boca Raton, I was involved in the IBM business, and I remember, a couple of the negotiations before they got under the aegis of Poughkeepsie group. And they were quite proud of the fact that they were renegades. And, I mean, I think, they even behaved in a way just to exercise that independence that they really didn't need to do. But those were some of the wildest and woolliest negotiations I've ever done. I mean, the PC had the processor; but it also had all of our peripherals in it which was like six or seven other chips. And it was a very, very tough thing. I mean, I remember one negotiation [when] somebody happened to hang around in Florida because it was a nice place to be after the negotiation. It was Harry Nystrom and the whole damned negotiation started up all again, which really irritated the rest of us. But they were very tough and very proud of the fact that they were buying standard products. But, as time goes the IBM culture overtook them and it became folded in.

House: I think it's hard for people to realize today what the environment was at that point in time. IBM made all of their own products, they made [nearly] all of their semiconductors and AT&T made [nearly] all of their semiconductors. And then there was the BUNCH, Burroughs, Univac, [NCR, CDC, Honeywell], that bought commercial product. Of course, the military didn't make their own [semiconductors] but then they had a different situation. And I really credit Jack with having the vision that Intel could get inside of IBM and …

Jarrett: When did that happen?

House: Well, Jack, you came …

Carsten: Well, I joined in 1975 and at that time, Intel was just building memories DRAMs and SRAMs and that sort of thing.

House: And a few little microprocessors.

Carsten: Right.

Jarrett: How were those microprocessors being used in the mid ‘70s?

House: Traffic lights, [blood analyzers] and scales.

Carsten: Yes. I think it was all standalone in [what] I would call embedded applications. , What we would call today controller applications and there were some wins in business calculators, and a few industrial controls of various kinds.

House: Of course, the MITS Altair came out at that time with the 8080 which was really very different than most of the rest of the [microprocessor] marketplace. And of course, that was where Gates wrote the Basic interpreter. But most of the applications were really just doing control inside of other pieces of equipment, embedded as you said.

Carsten: But in any event, the earliest business that we had with IBM was actually [memory] systems business. And at the time, we were building a lot of memories that were, let’s just say not completely working..

House: They were just - very tight specifications.

Jenkins: What we called literally a refresh problem. You had to refresh it twice as often as the spec, and so we said, “What are we going to do with these?”

Carsten: And so we called them partials. And most of them, instead of throwing them away, we shipped to our Memory Systems Division who mounted them on cards, tested the hell out of them and shipped them in boxes that were sold in competition with IBM for the System 360, what was called "RAS Store" which was basically the main memories for their mainframes. And we were approached, I believe, in 1978 by IBM saying, “We have a secret project for you. We would like you to sell us your add-on RAS Store. We have a big shortage in our ability to manufacture our own semiconductors for all of the people that want to buy 360s. And so we would like to replace all of the RAS Stores that we are using internally for our manufacturing operations, our sales operations, and in our various offices around the world. We’re going to take all of that IBM store and lease it out, (the business was generally leased back in those days), lease it out to our customers and we’re going to use your [RAS Store] memory.” And boy, we thought, that’s a heck of a deal because here we were a little struggling vendor in this business, and the credibility from this is tremendous. So we said, “Okay, we’ll do it.” They said, “Well, there’s only one thing, you’ve got to keep it a complete secret. Nobody can know. All of the boxes you ship have to be marked IBM. We keep the lids closed and nobody is ever going to know what's inside of there." And we said, "What's our next choice?" Okay. And then they proceeded to buy an enormous amount of this stuff. We were a small company then doing, I think, a couple of hundred million dollars a year. And I remember one year they bought over $40 million worth of this stuff. And when it was time to report our earnings it was considered by our accountants (Ernst and Young) that it was a material event and so we had it disclose it. And so we went back to IBM and we said, "Sorry, but our accountants say we're going to have to disclose this." And they were like, "No, no, no, no." And they went and talked to the accountants and all of this kind of stuff, and finally, the accountants won. So we disclosed it. You have never seen so many orders for our memories come pouring in. That caused an explosion in our business. And I would say an explosion in the credibility of this little company at a fair amount of embarrassment for IBM at the time. But it was the beginning of our relationship with IBM which led, as I think most of us know, to them ultimately purchasing 20 percent of our stock. But that's how the IBM business got started, and it led to more memory business. We shipped them a lot of DRAMs. And then, of course, this microprocessor [PC] design, I think, was the first logic product of any consequence. We did have this Display Writer design that we had won back in the 8085 days. That was about maybe 1978 or something like that. But it wasn't that important a product to them. They weren't that strong a factor in that [market].

Jarrett: So what was the Display Writer?

Carsten: The Display Writer was a word processing system. It competed with products like Wang, and NCR and Burroughs, [they] all had good systems in that area. IBM was not particularly strong. I remember I had one in my office, sort of as a demonstration of what Intel microprocessors could do.

Jenkins: I thought it was your secretary's office.

Carsten: It was my secretary's. You're right, Ted, it was in my secretary's office. But anyway, that product was sort of the precursor of the IBM PC because they had written a bunch of word processing software for that machine. And the people in Boca, at least initially, intended to use that software and by staying with the Intel architecture, they were able to use that software. So it was just one more example of how you had to build a product line that was compatible from series to series because the initial product that IBM designed used the 8088 which was the eight-bit version of the PC processor. And we never really understood why they did that.

House: Well, it was largely because they wanted to use the 8080 peripherals because they were so much less expensive. Our 16-bit peripherals were just coming out and we charged a lot more. The eight-bit ones were mature, they were second sourced, and they could get their costs down. Basically, it gave them a 16-bit address space with an eight-bit IO BUS and the ability to use those lower cost peripherals.

Jenkins: Yes, by the way, I was going to say outside of memories, really the first product ramps that we had with IBM was [with] these peripheral devices. I remember going from almost nothing to 100,000 8255s a month and 8253s and I can't remember whether the 8251 was in there or not. But those devices ramped in the period of a quarter from almost nothing to 100,000 units a month. And I remember that because I had just become the PCO general manager, and I was still responsible for manufacturing. And you and [Dave] Gellatly were off somewhere. IBM came in and it was a poorly organized meeting and they begged me to come to the meeting. And I said, "Well, I don't even have my white shirt on." And they said, "It doesn't matter, Ted. We need somebody anyway." And they were explaining their quality program which made sense to me. But then two of the guys from Poughkeepsie peeled off and caught me later and said, "Hey, we're watching how you're doing here," and they're talking about the weekly quantities, which quite frankly, we didn't watch that closely. We looked at monthly volumes. And they said, "You're trucking along here and it looks like you're running about a week-and-a-half late based on your commitments. And you've got to go from here to 10 times this number in another five weeks, and quite frankly, we don't trust that you can do that." And I was honest with them, I said, "I think if I were you I might share your skepticism." And I said, "Let me check into this and we'll be in touch." And I got in and basically rang the all-alarm.

House: …and got some more wafers.

Jenkins: They got some more wafers. Well, and it was really organizing testing and everything else. And we kind of met their requirements. We were running a little bit behind but two months later they said, "Okay, we're not worried anymore." But I mean, that's just one facet of a look into that thing but it was dramatic for us to handle that volume. It was a big deal at the time.

Jarrett: Let's go back to that Display Writer for a minute, how much of a push did IBM put behind the Display Writer? I mean, this was a little bit, right, they're usually making mainframes.

Carsten: Well, you've got to understand, the Display Writer, first of all, it was an eight-bit machine instead of 16-bit. It used eight-inch floppy disks and it sold for $20,000.

House: It did word processing.

Carsten: Yes. And you used to pay a secretary about 25,000 bucks a year back in those days so you had to have a heck of a productivity improvement to want to use one of those things. Whereas the standard at the time was the IBM Selectric [typewriter] for 450 bucks, and carbon paper or something, I don't remember. And Xerox machines were just coming out. So the idea of electronic word processing---unless you were, perhaps in the legal profession or some area where there was really heavy duty editing---it was just too expensive a product.

House: Wang had that market pretty well tied up.

Carsten: Yes, plus a bunch of competitors had a lot of that document [management] business already. .And you had the issue, back in those days, of incompatibility between these systems so that if you had a floppy disk with the Display Writer code on it, it was useless except with the Display Writer. It wouldn't transfer to anything else, so that was an issue.

Jarrett: So it's 1981, IBM brings out the IBM PC. It's got the 8088 inside and the DOS operating system from Microsoft. How important was this for the evolution of the PC? Number one, and for these two companies?

House: Well, at Intel, we were kind of on the outside looking in on the PC business. We had been inside Cromemco and MSI and MITS Altair and a few of these machines that looked like minicomputers with switches and lights in the front panel and paper tape readers, and paper tape punches. But the Apple II when it came out was an altogether different kind of machine with a keyboard and a monitor. And we were on the outside looking in. And a number of people developed PCs and attempted to be in that business. And we were being unsuccessful in getting into it. So when we first got word of the design going on in Boca Raton we were very excited about it. There was a lot of concern that IBM would not be able to be successful, and a lot of talk about the fact that they had dominated the mainframe business, but were a non-entity, basically in the minicomputer business and how it was Digital Equipment minicomputers and it would be Apple in the PC business. And to think that the big mammoth IBM could jump over minicomputers to PCs was highly suspect. However, IBM was a big company and getting a design win there was important and we [had] struck out everywhere else, basically. So for us it was quite important. I was quite concerned about their ability to be successful. And then the PC first came out and started selling, and started selling very well and then IBM wanted a lot more parts, that's when they came to see Ted, I think, we were all very pleasantly surprised.

Carsten: The thing that was different about that machine and, I think, was sort of IBM's worst fear was that because they used third party components, third party software, and third party applications, practically anybody could throw the thing together They stimulated a bunch of copycat people who immediately undercut their price. And I can remember a fellow by the name of Ben Rosen (who later became a VC) coming to my office and with his magic marker [began] sketching out the idea for an IBM PC that instead of having the display in a separate box and everything separate, it would have it's own little [built-in] display and would be what [later] became the Compaq Luggable. And he then became the Chairman of Compaq. Compaq became a clone vendor of the IBM PC. And by introducing this luggable version which you could actually move in less than a half a day of unplugging cables and picking things apart and so forth, it was an instant hit. But the primary reason it was a hit was that it was completely compatible with the IBM PC. The software was interchangeable. It had the same components, the same instruction set, and so forth. And so start ups like Compaq, as well as other major suppliers in the area like Univac, if I recall, and I think, GE and several others at the time all came out with copies of the IBM PC.

Jenkins: Even AT&T.

Carsten: Yes. And this, from IBM's point-of-view, was a mini-disaster for them because they were trying to charge premium prices, and the typical womb to tomb IBM solution and all of a sudden here were all of these second sources for the machine.

House: I think an interesting part of this was the story that I was told by Nick Donofrio. Nick, of course, was at IBM for a long time, and had just about every position from CTO to [being] in charge of their whole hardware business. But Nick recently retired. But he was the technical assistant for the CEO that, I think, was John Cary at the time that the PC was created. And Nick has related to me this story about how that happened. I asked him, “How did it get started?” And he said, “Cary was very frustrated,” I believe it was Cary that was CEO at the time, but his boss was very frustrated, “about the fact that his people weren’t interested in making a PC.” They said, “It’s a toy. It’s never going to amount to anything.” looking at the Apple, and the Commodore PET and things like that. But he wanted to see something done. And he is the guy who charged Estridge with starting this project as a skunkworks project, and he specifically told him, “Because the rest of the organization is rejecting this idea, I want you to do this outside of the organization. I want you to divorce yourself.” And that’s when Estridge rented space in a shopping center, an old supermarket, set up his lab and [his team] went and did the design. But, I think, that history is important relative to the fact that the purchasing people were not involved in the PC in the beginning, and therefore, weren’t able to put kind of this typical IBM requirements on the PC in the beginning and the renegade group were renegade because they were told to be renegade. That was the orders they had.

Jenkins: No, I know. And the other interesting aspect of it, I mean, the buzz was, when the thing came out was that they were going for the hobby market.

House: Yes.

Jenkins: And, you know, IBM in the hobby market, I mean it was …

House: And Donofrio tells about Estridge sending his engineers home for a month with an Apple II and told them, “I want you to understand this machine. I want you to play with this machine. I want you to show it to your kids. I want you to show it to your wife, your relatives, your friends. And when you come back in one month, we’re going to design a machine to beat this.”

Jarrett: And how long did it take?

House: The design, I don’t have the exact dates, but it was about a year from the time they started until they introduced the product. It was in early 1980 that this happened and it was August ’81 so maybe 18 months timeframe that they introduced the IBM PC.

Jenkins: Did he tell you how they picked the 8086 architecture?

House: We talked about that. They started out looking at the Z80 because that was the popular machine. [Recording stopped at this point to change tapes. This comment was not continued when recording restarted]

Jarrett: So in 1980 Intel was fighting Motorola pretty hard, and we had a big push to get design wins, and one of those was the IBM PC. How did that happen?

House: Well, we got word through the sales organization that there was a design going on in Boca Raton and this renegade group that had been set up specifically to do a PC, we didn’t know exactly what it was [that they were designing] at the time. And we got the understanding that they were leaning towards the Zilog product first the Z80, then thinking about the Z8000. From talking to Nick Donofrio and also Federico Faggin, I know that the fact that Zilog had been bought by Exxon who had a big push to go into the office products business as a competitor to IBM at that time was the reason that IBM didn't use the Zilog product. They didn't want to buy something from a competitor. They [then] looked at the 68000. So it became an issue of 8086 versus 68000. Once they realized that if they were going to compete with an existing eight-bit machine, the Apple II, they needed a 16-bit machine to compete. They needed to move to the next level of technology. And so they were looking at 16-bit product. Zilog was our, our first competition. Motorola and Intel [were then] the two competitors. The 68000 peripheral products were lagging behind the Intel products, and the cost issues were very high for both because both generations were fairly new. We had done this design on the die of the 8086 to be able to, as a fall-back in case our peripherals didn't work, to fold the bus over or double clock the bus, and instead of getting 16 bits at a time, we could do eight bits twice. So it was going to double clock the IO. And we had actually put it on the design, but we had never bonded it out. We had never built any. And so we had this idea of this eight-bit bus product. And as we're dealing with IBM and dealing with the cost issues, and the uncertainty issues, one of the proposals we made is well, why don't you use your existing eight-bit peripherals from the 8085 designs, and use the eight-bit bus version of the 8086 which, of course, required us to bond parts out and deliver the samples on this part. And it was the fact that the peripherals existed, they were multi-sourced and most importantly they were low cost that, I think, really was a big decision factor in choosing the 8088 over the 68000.

Jarrett: So IBM PC comes out, big success, Intel in order to meet the needs of IBM and others does a second sourcing agreement with AMD. The PC business starts to really blossom. We come out with the 186, and then the 286. How did that work with the AMD second sourcing agreement as we brought out these successive generations?

Dunlap: Well, the 186 and the 286 were microprocessors that were part of that agreement. So it was something that was contemplated could be an exchange. And they came out in the '83, '84 timeframe. Now, the 8086 was an easy one. It worked well right off the bat because AMD wrote us a check, we transferred the product, they became the second source. But by the time we get to 1984 there were still no products on AMD's side that we wanted to exchange. And what happened was we came up with the concept of a loan. But instead of a loan of dollars, we made a loan of these complexity factors that were used under the agreement to measure the value of the products. But the idea was still, we want to eventually get more peripherals. We want to have a better product portfolio than our competitors, so we want AMD to actually deliver products. So we'll loan them the complexity factors that they need, so that they can get the 186, and they can get the 286 and then pay it off over time, pay some higher royalties until they pay off the loan. And so that's how we ended up getting a second source for the 186 and the 286. But, again, Intel had to find a way to encourage AMD to become that second source, which we did by giving them this loan.

Carsten: It was basically a House giveaway.

House: Well, remember the 186 and the 286 were not the most successful products that we ever developed. Second of all, although I signed that agreement, one month after I took over Jack's job, Jack is the guy who gave it away is my story, and I'm sticking to it. But that had been negotiated and agreed to and we finalized it at that point in time.

Carsten: And I would contend the 186 and 286 were never very popular products. We needed second sources just to get them out there. If you remember, winning designs on the 186 and 286 was not the piece of cake that it was on the 8086 and the earlier [processors].

House: We didn't exactly have the best product in the market.

Carsten: Exactly. So, I think, that's in strong contrast to the 386 which I think we all felt, myself included, was really a winner and was a different kettle of fish.

Jarrett: Let's talk about that. The 386 comes along in October of 1985, what made it special?

House: The 8086 was designed as a gap filler until the 8800 which became the 432 could be the next generation after the 8080/8085. And so we basically made it very culturally compatible with the 8080/8085 with the 16-bit address. And in those days, in 1978 that was an infinite amount of memory.

Jenkins: Be specific about infinite.

House: Sixty-four kilobytes. And so we could address up to 64K bytes at a time in that machine.

Carsten: That's what the Apple II had if I recall and it was considered to be plenty.

House: Sixteen-bit addresses. So an analogy would be- if you write code in 64K and if you want to address data or program somewhere else, you had to pick up and move to somewhere else. It's like if you had an airplane with a 500-mile range, and you wanted to go to the East Coast, you had to keep landing and changing planes, and then go to the another, et cetera, and daisy-chain your way over. It was a very inconvenient way to write software once memories became larger than two-to-the-sixteenth or 64K bytes. So Moore's Law and the increasing size of memories and 1K, 4K, 16K, 64K, et cetera, 256, one-meg memory chips were growing the size of memory making it much more cost effective. Meanwhile, the applications were requiring more memory. And graphical user interfaces were kind of the straw that broke the camel's back. They required large amounts of memory to handle all of these pixels. And here we're stuck in the 286 with a 16-bit address, a 500-mile airplane. And other people got planes that will fly twice around the world without stopping. They can address a full 32 [bit address], two to the 32nd power,size of memories. And so we were at a significant software disadvantage. And we thought we had to do something incompatible. We thought we were going to have to do a 432 to get a 32-bit address base. And I had hired a guy by the name of Glen Myers out of IBM Research. And Glen was an architect and I talked to him about the problem. I said, 'we need something that's fully binary compatible and has a 32-bit address. [A processor that] runs all of the existing flopping disk and has a large linear address space '. And he came back and he said, "You know, this is actually pretty easy. We can do this by taking the eight-bit instruction that's got a bit that means that the displacement that follows is eight or 16-bits, and we could have a mode change that says it's eight-bits or 32-bits. And when you enter a routine you'll say, okay now we're in 32-bit mode, and when you leave you jump back to 16-bit mode and then you can mix 32 bit programs in with 16-bit programs and everything will work and it will all be compatible." Wonderful idea, the birth of the 386. And so when the 386 came out it was revolutionary in a couple of ways. It was CMOS. It was faster. So it was the best 286 you could ever have because it was lower power and higher speed. But more importantly, you could now write 32-bit sub routines and include them in with your 16-bit software, in an invisible kind of fashion from the software world.

Carsten: And we got rid of those 64K segments which was the other …

House: That was the 16-bit address we had.

Carsten: …part of the silo stuff that we had to deal with.

House: Yes, it eliminated that.

Dunlap: Dave mentioned very briefly the 432. But the thinking in the early '80s, certainly in '82 was you could not make a 32-bit version of the 8086 architecture. And so Intel had a totally separate project going which was the 432 and the idea there was [that] it doesn't have to be instruction set compatible. We'll have a real 32-bit machine. That's the way to go. And, in fact, that is the product that is in the 1982 AMD agreement that they had special rights to obtain because they were concerned of getting this 32 bit product.

House: In fact, when I went to launch, well my team under me launched a 386 development there was push back within the company from Bill Lattin and the 432 group that that was their territory. They were going to handle 32 bits. And I had to position the 386 as, "Well this is just another interim product. I mean we can get this out quickly and we'll just fill the gap until you come out with your real 32-bit machine."

Jenkins: I wish I had a nickel for every 32-bit architecture we developed.

House: Most of them are worth a nickel, except for one.

Jenkins: I know. Have you ever counted them all up? I can't tell. I mean, it's like five or six isn't?

Carsten: Jim, I think it's a very interesting parallel path that Richard Tedlow is going to talk about the birth of the 360 architecture and how it aligned a multitude of incompatible IBM architectures that basically couldn't communicate with each other back in the '60s. And the development of that architecture [led] to the enormous popularity of the System 360. I think there's something similar that was going on here where there were many competing forces and I know hundreds of millions of dollars were spent in R&D on incompatible 32-bit architectures, both what was originally called the 432 and then another project called the Gemini under the theory that you couldn't produce a compatible product line, all the way from eight bits to 32 bits to 64 bits out of the same core architecture. And whether that was reality or hubris or whatever, I think, Glen is one of the little known heroes of the Intel story to come up with the scheme that would make this possible. And Dave for his insight to jump on it and turn it into a product, This, I think, had more to do with the success of Intel than anybody has said [so far].

Jenkins: There's another implication, I think, about the 386 architecture, Dave touched on a little bit, and far be it from me to really opine about the marketing, but this really allowed a graphical user interface. Apple was already going to it. They had gotten it from Xerox. You had to have it to do that. And this is the thing that took us from the DOS environment up to the Windows environment and thank God we had Microsoft writing the code to do that. But this took the PC from accountants with green eyeshades down to you and me and the rest of us that can use this and just click on icons and have the machine do what we'd like it to do. So, I think that was a huge step forward; and it absolutely required 32-bit to do it. And, I think, it's kind of interesting that a frailty of our 16-bit products in memory segmentation was a little extra impetus for us to crank on this and, you know, God bless Dave for making it legacy compatible.

Carsten: It took us still another three years to kill all of that [incompatible] stuff in work

House: I just ignored it. It died of its own accord. But the irony is when it got time to introduce the 432 …

Carsten: I gave it to you.

House: They transferred it to me saying, "House, you go introduce it."

Jenkins: We're talking about up in Oregon and actually that's where the other 32-bit businesses are …

House: The official 32-bit.

Jenkins: The official 32, the real one, that one didn't have this extra baggage on it.

House: The baggage of compatibility.

Jenkins: But the good news is the 32-bit [386] can handle baggage. That was one of its advantages.

Jarrett: Let's move then on to the decision to a sole source, no second source on the 386. This was standard industry practice to have a second source. What had changed in the industry, what had changed at Intel that we decided that we could go off and do this on a sole source basis?

House: I think a lot of things had changed.

Jenkins: It was Dave taking over Jack's business.

Carsten: That was four years prior. [DH note: I took over Jack's job in 1983. Second sourcing stopped soon after that.]

House: Unlike Ted and Jack, I didn't come out of the semiconductor industry. Intel was my first job [in the semiconductor industry], although I first started really working with the semiconductor industry the same year as Jack in '65, but I was [working]bas a user [of semiconductors]. I was designing first data acquisition systems and network processors and then mini-computers for most of the nine years between the time I started as an engineer and [the time that] I joined Intel. And when I came to Intel I was amazed at how much different the economics were, the big gambles with wafer fabs, the long process development. I'm used to being able to develop a computer in a two-year period of time. And these products were taking much longer and much more expensive. But the thing that really amazed me was in the business I had been in, the mini-computer business, we all bought semiconductors from Jack at TI, or Sylvania before that, and Fairchild before that, and we'd get the latest level of integration we could and we'd build the most competitive machine we could and we'd introduce into the market against Digital Equipment and Data General. I was at Computer Control Corporation that became Honeywell's Computer Control Division. And then we'd fight it out and one of us would win, and we'd make a lot of money and the other guys would go home with their tail between their legs and start designing the next generation. And I came to Intel and people designed products and they spent even more money and they got the products out and they fought in the marketplace, and they got successful, and as soon as they got successful, they gave their design to the competitors so they could compete. And I said, "How does that work? I don't understand why we want to do that." Well, Jack's explained the history of the military and Ted's talked about the fact that in the early days they weren't very reliable so that was a different culture, but it was strange to me. So I was, I think, probably the first voice against the whole idea of second sourcing, but in the end it was Jack's decision and Grove's decision and we did the second sourcing we did. When I took over the microprocessor business I had been running it reporting to Jack, Jack moved over and took over the fabs and the manufacturing and the memory business, and when I started reporting directly to Grove in 1983, things were starting to change. The PC now was two years old. And it had taken off very well. And clones were starting to develop. And I remember going to the introduction of the first IBM 286 based machine in August of '84 and they had a big …

Jenkins: PC-AT.

House: The PC-AT [this may have been the PS2], and they had a big announcement, and they had one non-IBM spokesman at that event, and that was me. They had asked me to speak. Gates was there but he didn't speak. And I came home and I thought it was really great that we had got the publicity of Intel and had a speaker there, and Grove said, "But Dave, you don't understand," he says, "It uses a plastic case, it uses DRAM, it uses a keyboard, it uses a display, it uses everything that the last generation did. The different is it's got a 286 instead of a 86, that's why it's different. That's what makes it." And if you think about it it was really true that the difference was the new processor, and new generation and we had control of that. So as we started going forward with this AMD exchange and AMD came forward and did not have products that we wanted: their products were [too] big, they were complicated, they didn't meet the market needs, they were too expensive. And Ted, your group really evaluated those and …

Jenkins: Right. I mean our disk controller …

House: Communication controller.

Jenkins: A SCSI, a small computer system interface controller. And they were not particularly imaginative or creative from a design standpoint. I mean it just goes into …

House: …a lot of complexity factors.

Jenkins: Yes, there a lot of complexity factors. I mean, even though memory was discounted a little bit one of these chips was more than half memory which, ironically now, most microprocessors are too. But at that point in time, there wasn't that much design effort in it. There really wasn't that much of value that we were looking towards. So we just basically said, "Hey, it's really not quite worth the trouble of developing our own testing and putting it into manufacturing and pursuing that ourselves."

House: In fact, I asked Ted's group at the time, "If you got them for free would you use them?" And he said, "No, we wouldn't even bother to put them in production."

Jenkins: That's true.

Carsten: There were a couple of other factors, I think that changed the direction of the wind in all of this. And it's not completely my story, I think, Tom ought to comment on it. But we had an unauthorized source for the 8086 in Japan in the form of NEC who repeatedly denied that they were building the 8086 and then all of a sudden NEC came out. And in a sort of unprecedented legal opinion, we took the position that they were copying our microcode and Tom could, I think, elaborate on that. But at the end of the day, we won that case and proved that microcode was software and was copyrightable and was protectable and it gave Intel a new kind of legal defense to stop unwanted copying. A related issue is that even though we had the licensing agreement with IBM and we had to give them basically all of the guts and the details of our processors, they started a major project to build a version, I think a slightly different version of the 286, in Manassas, Virginia, and had a huge program to essentially break off and build what they thought was going to be a superior 286. And again, it's a little bit Dave's story, but that effort failed. So on the one hand we were able to stop unauthorized copying. On the other hand a major competent partner of ours wasn't able to produce a superior part. So the idea of producing a superior product and preventing others from copying all of a sudden had more credibility that it wasn't going to just be an exercise in futility.

House: I think there was really a window that opened up for us at this time because IBM decided to take back the PC. The PC had been started as a renegade project using commercially available products, commercial available software, totally outside the IBM system. It became spectacularly successful, more successful than IBM ever thought that it would become. And as a result, IBM decided they needed to take back the PC. They needed to get control. And the whole PS2/OS2 generation was an attempt by IBM to regain control of the PC. Of course, Intel and Microsoft and Compaq, in particular, all were very much against it. [IBM said] "we don't like the fact of having open system." And so they set off to do the CMOS 286. The plan was a 16 megahertz, CMOS 286 based on the license they had from us. They were designing it in Manassas, Virginia. They were doing OS2 which had been started at Microsoft and they had co-opted and basically took over and signed agreements. They negotiated with Microsoft on the development of OS2 and basically got Microsoft's commitment to make OS2 the product, as opposed to the Windows 3.1 at the time, product. And they came up with a new bus.

Jenkins: Yes. A new CRT interface. A new everything.

House: A new mouse interface. New keyboard interface. We still use the PS2 mouse interface, interestingly. But they basically tried to change all of the specs in the system and get their arms around the product.

Carsten: Made it all proprietary.

House: And at that time …

Carsten: Patented all of these buses and everything.....

House: And at that time, they were not planning on using the 386. Their direction was the CMOS 286, the 16-megahertz 286. And I remember going to IBM multiple times and saying, "The fastest path to a 16-megahertz CMOS 286 is the 386 because it is CMOS. It is 16-megahertz. It happens to have these 32-bit instructions but it runs all of the binary code on the 286, perfectly. Just don't touch the 32-bit instructions if you don't want them." And they were not…"we got our own, we're doing it our way." And so I basically got stiff armed on that. And of course, then we went to Compaq who was aware of this and Microsoft and Compaq and Intel got together and we said, "Okay, you're not going to have access to that [IBM] internal proprietary part. You need to use our 16-megahertz CMOS part." And so that gave birth to the Desk Pro 386. And Intel and Microsoft were particularly aligned with Compaq during the development of that machine. But this took IBM's component people, the purchasing people, eyes off the ball. They weren't worried about the 386. They were totally focused on "we're going to do this internally." So at the same time AMD is not delivering, the stuff that they've got, Ted isn't even willing to put the time of day into to putting it into production, so I'm not going to want to give them parts for products that Ted wasn't even interested in putting [into production]. And I reviewed what he did with his people, and I said, you're right, these things are not worth it because there were a lot of very heated discussions at that time, between me and Tony Holbrook at AMD, and me and Andy Grove and Jack Carsten at the executive staff which somebody characterized Andy (who was big on constructive confrontation) as the mother of all constructive confrontations about what we were going to do there. And that's why I spent so much time with Ted and his guys looking at exactly what had been developed by AMD and why we should take it. So IBM's kind off on their own. AMD has failed to deliver anything that we want. So the agreement is still in place but there's not going to be any exchanges. And now, the question is should we go and set up another second source? And at this point in time we decided "no", and I say "we" because it was a team effort, there were a number of people involved, I just happened to be in charge of the team, but it was a team effort. And Grove was very involved, as you know, Jack, in this whole discussion. We went to IBM and we said, "Well, you can make it inside, be your own internal second source," and then we came up with this idea and I'm not sure whose idea it was, but we could it make it in two fabs. We had a new fab we were building to make the 386 and we could make the 386 in one of our existing fabs. So we'll be an internal second source. You be your own internal second source, and you know that was a sufficient answer. [DH note: I had decided not to transfer the 386 to AMD. Jack Carsten was advocating that we should transfer the 386 to AMD. The "Mother of All Constructive Confrontations" was the debate held in the Intel Executive Staff Meeting on this topic. In the end, Andy Grove supported my decision.]

Jenkins: Interestingly, enough, about this point in time, we were actually devoting, probably, more manufacturing capacity to memory than we were to microprocessors; but that was changing very quickly and a famous [book] has been written on this. I won't belabor the point. Because we had that other capacity going into a commodity product versus what was become a proprietary product, we had the, shall we say, surge capacity to supply some of these, if there's a manufacturing problem or if there's a demand increment. We had flexibility now that we wouldn't have had before; and putting in a second fab gave us that much more. All of these were assurances to the customer that we've got various possibilities, if you've under-estimated your demand or if we have some problems.

Carsten: I think you – go ahead, Tom.

Dunlap: To tie in what the legal environment was at this point-in-time, first of all, with respect to IBM, the result of the story that Dave explained, that they're going with the 286, they don't need the 386 led to a renegotiation of this technology agreement, because IBM had, as we said, earlier, had to buy a certain percentage of their requirements from Intel if they took the technology from Intel. And so we really didn't want IBM to be their own second source if they're not going to really buy from us. They didn't want to buy from us. And so we mutually agreed, "Well, let's terminate both agreements, go our separate ways." They'll still buy from us. We'll still be a supplier but we don't have this license arrangement. So that took away IBM's ability to get help from Intel to be their own second source. The other thing that Jack mentioned earlier was the NEC case…

Jenkins: By the way, I want to step in here and underline what a landmark case this was. I mean this was as innovative from a legal standpoint as some of our designs were from a technical standpoint. Tom gets credit for this. And its implications go beyond this discussion but, I think, it's important to get back to this. So I just wanted to toot your horn here a little bit before you told us what this was about.

Dunlap: I mentioned that patents were the main thing that would be an intellectual property right that would actually prevent someone from making a compatible product. We had these cross licenses. So in the 8085 generation, people had patents, we had cross licenses with them, they had the right to make the 8085 and that's one of the reasons we ended up with a dozen second sources. Some of them we helped, some of them we didn't. In the 8086 the designers put in a small computer program called microcode. And it turned out that in that timeframe it wasn't quite clear whether computer programs could be copyrighted, but eventually Apple had a case and they were found to be copyrightable. But then the microcode was a step further because it was actually code put in silicon. So it sort of looks a little bit like hardware.

Jenkins: It's a physical implementation.

Dunlap: It sort of looks like software and ends up we ended up calling it firmware, all right. But what NEC had done is they had the patent license, that was fine. But they felt that in order to make the product instruction set compatible with ours, they had to have almost the same microcode, so they copied the microcode. And so we felt that we had copyrighted the microcode. We thought we had the right to prevent them from using it.

Carsten: And we even put a "C" on the die, as I recall.

Dunlap: That's right. We had to put a notice on the die. Exactly. And so we filed suit and there were two big issues in the case. So one issue was "could you even copyright this stuff?" Did that C mean anything? Or was it just legal mumbo jumbo or hype or something.

Jenkins: Which we had to get from time-to-time.

Dunlap: And it turned out that the judge in the first case [ruled that it was] copyrightable. And he ruled that NEC had, in fact, infringed the copyright. And for various reasons we had to retry the case. The next judge also ruled that microcode was copyrightable but he said NEC had changed it enough. But the key thing, the key precedent was that the microcode is copyrightable. So now when you go to the 186, the 286, or the 386 you can't copy the microcode, unless you get an additional license from Intel. People could rewrite, but they could not copy it and that gave us some additional protection, more from the standpoint it was harder to be an unauthorized second source.

House: The fact that microcode got much more complex with each successive generation, as we added memory management, and protection, and we added additional instructions, and then added floating point and to be compatible, it was extremely difficult to prove you were compatible. It was much easier for us to prove that they weren't compatible, than it was for them to prove that they were compatible.

Carsten: But that became an effective barrier that in the 386 and 486 and later generations essentially stopped unauthorized copying, at least, cost-effective unauthorized copying by other start ups. For example, a company in Texas called Cyrix spent three or four years trying to produce clones of the 386 and beyond, I think 486 sort of generation of product. And a number of foreign competitors tried to do this. And in my view, none was really completely compatible and Intel was able to successfully win most of the business in the sectors they were pursuing because of various small kinds of incompatibility. And it goes all the way back to this legal precedent that enabled us to have a new kind of protection against copying.

House: Of course, it really gave death to the socket compatible second source. Second sourcing was all socket compatible at that time, and today, although you can buy processors that run the Intel architecture code from other companies like AMD, the products are not socket compatible. When you start rewriting the microcode you change the timing of the instructions, that is the time sequence that things happen at the pins. And now you develop a product that's not completely compatible. And then, of course, today the competitive products even use different IO structures, memory access structures, bus timing, and certainly different packages and pins so that today if you buy a product from AMD it doesn't fit in the printed circuit board for the Intel product. You've got to design a whole new motherboard for the AMD product separate from the motherboard from the Intel product. It's a different product. It just is software compatible.

Jarrett: Let's go back to the internal discussion that was taking place within the company, do we or don't we second source? What were the kind of arguments, pro and con? And was this a casual thing? Or was it pretty heated?

House: Well, it was extremely heated. And the big discussions were about the AMD exchange, and do we take product? And were we committed to take product? And what's the value of the products? And I had very heated discussions with Tony Holbrook in person. And we brought our whole team. Ted would be there with his people and we'd have a full delegation and he had a full delegation on his side. We had a number of regular phone calls, where I'd have some of my team, and he'd have some of his team, and we're trying to figure out how to go forward, and how to make this thing work. And, of course, there were claims that we were just being resistant to accepting their products, they we really perfect products was the position, and we were just not wanting to give them anything in exchange. And on the other hand, the position from our side was that these things are worthless. [And from their side],"you guys got NIH, not-invented-here syndrome, and you're just resisting taking the product because you didn't design them, and they're not your products, and you really should take them." And so there were big …

Carsten: Dave, as I think about, I think there was a flaw in that agreement, in the sense that we set up these complexity factors and things to exchange but there wasn't any mechanism for Intel to approve what the specs would be of a product that we wanted to accept in return for our products.

House: We were allowed to comment. And we commented often.

Carsten: There wasn't any requirement for a mutual agreement. And hence, when they gave us something, it just became a big argument about whether it was acceptable or not because they were highly motivated due to the way these complexity factors were figured.

House: Ted, you and your team were …

Carsten: They wanted to produce as complicated and as large a die and as big a monster as possible to give them as many complexity factors as they could and that was the opposite from what we wanted.

Jenkins: Yes, that was an issue. I think if you go back to the original design of the agreement, I think, the basic flaw is we're a pretty good sized company with a lot of design resources and architecture resources and they're quite a bit smaller. And you look at everything that they have, and we've either already done something that's kind of like that, or we're going off in this direction or whatever that, it's really hard for them to (over in the corner) kind of make a contribution, I think, is what it turned out to be.

Carsten: I have a different perspective on that because when I was running the business in the earlier days, one of the big problems we had was that we couldn't get any decent designers to work on peripherals. Peripherals-- because they had to interface directly to mechanical systems in the real world and serial IO and disk drives and various things-- were tough to design. And yet, there wasn't any ISSCC paper. There wasn't any great architectural miracle. This wasn't the magic of the PC. This was just some dirty, gritty [design] business. And so one of the reasons(from my perspective) that we did as much licensed second sourcing was to gain access to peripherals that (frankly) the Intel designers just kept breaking their pick on. We were continuing to lose people in that sector, and everybody wanted to work on the processors. They either wanted to go up to Oregon or they wanted to work in MPU and so forth. So perhaps we had a lot of designers and resources, but an awful lot of peripherals were, in fact, designed by our second sources.

House: Another important thing happened, between the time that the deal was first negotiated and the time that we're talking about of the 386 and no second sourcing on the 386, the IBM PC happened. And what the IBM PC did was it created a standard at the IO level, and the chips that were used in the IO had to be binary compatible with the chips in the IBM PC and in the Compaq PC. And the industry standard architecture as it's become now known as. And a lot of …

Jenkins: And we had seven chips.

House: And we had those chips …

Jenkins: And half of them were developed by others.

House: Well, no, no, the 51, 53, 55, 57 …

Jenkins: 8275.

House: Well, although that [the 8275] wasn't in the PC, the 8275 wasn't particularly successful, but those five we had developed, and they were all- in fact, [in the PC] I don't know that we got any product …

Jenkins: Those were 85 peripherals, actually.

House: Right, they were. Actually 8080 before that. I don't think there were any peripherals that we got from anybody else that were ever commercially successful. We got a floppy disk controller from NEC, remember and 8272 was it?

Jenkins: Right.

Carsten: And we got the 8237 too.

House: And we sold some of that product. An 8237 from was that AMD?

Jenkins: I don't remember.

House: Anyway, AMD had …

Carsten: That's probably a rat hole but, I think, the issue of the products that were sort of the result of our generation of technology is what facilitated it.

Dunlap: Yes, the one thing that doesn't necessarily come through in all of this is the importance of the timing when you make the business decisions, right, because at one point-in-time, let's say in 1985, the 386 is out there, it's not very successful, we make an offer to AMD, they reject it. If they would have taken that offer things could be totally different. We had all of this litigation, when do you settle it? When do you take a product from AMD versus when you didn't take the products? All of those- the timing of all of that stuff becomes very critical. If you make it at the wrong time it's a big advantage to one side or the other.

Jarrett: Let's go through an exercise here. As we look back on this there were some central players, there was Intel, there was AMD, there was IBM, and there was Compaq, and there were our competitors. And how would these various players kind of tell this story? What would their headline be as they look back on this story?

House: I bet Compaq would say, "Compaq the leader. Compaq takes uber alles." Because Compaq really saw themselves as [taking] a very bold move forward in taking a leadership position.

Jenkins: And their timing was perfect and their execution was well done.

Carsten: Yes, at the time, if I recall, Compaq was the fastest company in the world to reach $100 million in revenue, do you remember that?

Jenkins: I have a funny vignette and we'll just put this in here. I was responsible for the IBM business including the Microprocessor business in a period of time while I was still involved in peripherals, and we had a big negotiation at IBM back in Poughkeepsie. We actually took a Compaq "luggable" with us and put all of our data and what the prices would be and our total margin and everything. We'd negotiate with the people (and they had an arm.) I mean they had, I don't know, six, eight, people there and we would be negotiating away and somebody would make a move or whatever and you'd want to reevaluate where you were. They would always retire and put the thing on their mainframe and put the new numbers in and have it grind it all up. We didn't want them to know we had a Compaq with us. We'd get it out and put it on the table and actually set up the numbers and see where we were and we were doing it like that (snaps fingers). I mean the product was innovative. It was a lot of fun.

Jarrett: So from IBM's standpoint, what was the story? How do they write this?

Carsten: IBM was going through an incredible period of disenchantment and hubris which didn't really end until Gerstner was brought in later. And, I think, they, how should I say it, sort of couldn't believe that these little upstart companies were actually threatening a part of the business (that) they felt they had a commanding position. And I don't remember the exact market share at the time, but, I think, IBM controlled maybe 60, 70 percent of the PC business at the time. They were the dominant supplier of the generation of products based on the 86 and 88. And, I think they felt sure that with all of their robotics, with the development of their own chips, with their ability to sort of "out-Microsoft" Microsoft with respect to the new operating system and applications, that they were going to--- as they had done in other generations and other product lines--- that they were going to regain control. And so the fact that this didn't happen per their game plan and they were forced to essentially conform to a "Wintel" [Microsoft-

Intel]standard was just a nerve-racking problem for them. Perhaps in the context of their overall business and profitability and their huge sales force and support organizations and so forth, it might not have been the most earth-shattering event in their history, but it certainly was one of the biggest disappointments they had.

House: Where Compaq probably would have said, "Compaq the new leader." IBM's reaction, I think, was shock and dismay. I think they were surprised and disappointed that the industry could be independent from their set direction.

Carsten: And they were very angry at Intel in this exact time period that we're talking about. They sold their entire 20 percent share of Intel causing the Intel stock to further be depressed. They cancelled a number of other technology exchange agreements they had, including the agreement to supply us CAD technology for ASIC chips and cancelled a bunch of custom chip development contracts they had with us. And in general, broke off a lot of the relationships other than the required purchasing deals with Intel. And we got into a very estranged period with IBM.

Jarrett: How about AMD? How would they look back on this?

House: They would probably say, "Oh we're screwed. Those bastards are screwing us." That would be their reaction. AMD felt, I think, betrayed. They felt that they had done what they were supposed to and they had a birthright to our processors forever.

Jenkins: I mean, and I think, they thought they had good products and that we should have taken them and add them to our product list…

House: They thought we could have made those products successful.

Carsten: Well, we had loaned them CFs in the past. They felt that we needed them more than they needed us, I think, the concept that we would go by ourselves [was alien]. I mean back to this philosophical think about second sourcing. You know, Jerry Sanders and most of those people were strictly out of the old style game book that I came from. I mean, I competed with Jerry back in the TTL business in the early '60s and that was all a second sourcing business. So I don't think they could conceive of the sort of business that we've been talking about here [and] that we saw was a new generation. It was just shock and anger there.

Dunlap: I look at it as a game of chicken, right. In the 8086 AMD won the game of chicken. One-eighty-six, 286, they won. Three-eighty-six, we didn't blink. We said, "Okay, we're not going to give the 386 away. We understand there may be some customer problems. We'll build another facility. We'll work with our customers. We're going to make that work."

Jenkins: But they didn't have a 386 so they didn't do the what-ifs that Dave House did. They didn't think about the pricing. They didn't put that whole thought process together. So I don't even think they had that perspective inside their company. And so as a consequence, as Jack said, they took the old school position relative to that and I'm sure they said, "You guys figured this out from the beginning. We figured you never had any intention of taking the product, and this is the way it ends up and we helped you. You know, we were at your back for five years, and now you cut us off and send us loose." And I'm sure that's exactly what they thought.

Dunlap: That's what they testified to.

Jenkins: Well, that's what they said. And I believe their testimony.

Jarrett: How about from Intel's standpoint? How does it look back on this? What story does it tell?

Carsten: Well, Andy Grove wrote a book about it, and he has perspective, and some of us have a little different perspective of how it all might have worked out. I think the question that you have to deal with is what if the 386 had not been that popular a product. What if it had only been as popular as the 186 and 286 which were the last two products we had, which weren't that popular. The 386 was probably the best product Intel ever developed and certainly led to a lot of other things that were bigger and better. And it all sort of sprung off of that [386], and even today the 64-bit thing is just starting to happen and so the 32-bit generation was incredibly important. But it's possible that some other architecture, whether the Motorola architecture, the Power PC or something else could have grabbed the momentum and become the industry standard. Then this decision would have been a disaster.

House: I think it would have been really tough…

Carsten: I think it was unlikely. In other words, I think, once we saw the industry response to the Compaq 386 even though we didn't have IBM sort of in our camp at that point, I think, you felt that it was [a winner]. …

House: It was so obvious for me, from the day that I talked to Glen Myers about the architecture, that the 386 was going to be a phenomenal success. All we had to do is execute, that's why we threw so many resources at it.

Jenkins: My perspective is, in retrospect, because I didn't think this out at the time, but this whole scenario is playing out in the context of Gordon Moore's Law; and that is this incredible geometric compression that we're able to do. And supply ongoing generations of incrementally more complex electronics that do things that people want done. I think, what you're hearing and the reason we got a couple of brilliant business people haggling over the timing of some of this stuff is just the incredible dynamics that that technology puts behind all of this. I mean, we go from something where we're making these smaller relatively simple chips to something that's very, very complex logically; and the computer scientist saying, "Hey, this has incredible value beyond just the chip size, and just the transistor." So we had a special challenge. I think there was a special challenge there to figure out what to do with that.

House: Yes. I think one thing we should be honest about though that the 386 really laid the foundation for our next war which was the RISC versus CISC was. What we built with the 386 is a 32-bit machine with a 16-bit machine inside of it. At a time when Moore's Law didn't give us enough transistors to do everything we wanted to do and we did that with a lot of microcode. And that's a complex machine. That is the definition of Complex Instruction Set Computer. And that really gave the birth to the RISC processor. And it's at that time that IBM really kicked off what became the Power PC, their RISC processor, and MIPS got started.

Carsten: Also Sun Sparc

House: And Sun Sparc got started because of the complexity. And it wasn't until Moore's Law gave us enough transistors in the 486 to take the most frequent instructions and implement them as a RISC machine. And then, with Pentium , we really got there with being able to take all of the frequently used instructions and implementing them outside of microcode in a RISC machine. And we had enough transistors left over to maintain compatibility and put microcode in for the less used instructions that we really were able to put the RISC war to bed. But we had a whole decade of CISC versus RISC because the 386 was such a CISC machine. It was the definition of CISC.

Jarrett: If we back off from the semiconductor industry and the computer industry and look at this in a very general sense what kind of lessons can be drawn from this that are applicable to any business?

House: Do the numbers. Look at the business case. Do the ROI. In the end it winds up being business. You've got to do what's in the best interest of your stockholders. And that winds up being measured in profit. I mean on a basic, basic level, the value of a company is the net present value of all future earnings. And you've got to look at earnings potential and what you can make, and you do what's right. And so what was right at one point in time, wasn't right at another point in time. And so basic principles of an industry need to be questioned continuously. Are they still in the best interest of the stockholders? Is the second sourcing which was so prevalent and totally understood? AMD was set up to be a second source company and so they were probably the last guys to get it that the world had changed. But you've got to get back to the basic principles of do the ROI, do the spreadsheet. Does it still make sense to follow the rules that are kind of assumed? They're just the air we breathe. They're just universal in the business. And that's the beginning of so many new businesses is breaking those well-established rules.

Dunlap: So there's a lot of industries that have the exact opposite practice that we had, which is they only do exclusive licensing. Well, at some point in time, that may not make sense. It may come a point in time where you have to do some non-exclusive licenses to really get the kind of competition to develop products that you need.

Carsten: I would observe, back to Tom's point, that in a lot of industries the key to success is understanding the relationship between licensing, proprietary rights, patents, and the ability to copy products. And one of the greatest ways to be incredibly successful is to have a proprietary solution inside of a commodity product. That's what the 386 was and is. The PC was copied broadly. All of the attempts of various kinds of bus protection and IP protection on the PC all failed and dozens of Asian manufacturers came out with clone after clone after clone. But Intel had a proprietary piece.

Let me give you another example. A company like Qualcomm that owns most of the IP for a large sector of the cell phone business has a similar kind of advantage. They have a recognized and largely protectable proprietary position on chips and architectures inside a huge commodity. They are also very successful as a result. If you misunderstand that, and you either can't maintain your proprietary position and you become commoditized, or the IP breaks down. I think you end up with a business that, unless your strength is manufacturing, you're going to have a hard time maintaining control.

House: Microsoft being the other company that's done that. Another company [is] Google, in many ways, inside the Internet has got something proprietary inside of a commodity business.

Jenkins: I want to make a different observation and, I think, it's how the culture of the company had that got us through this. I didn't quite get the appreciation for it until I heard the dialogue between Dave and Jack. I worked for all of these guys. I was on the ESM for a short time, but I wasn't there when these discussions were going on. But when you hear this banter back and forth in this exchange, one of the things that we had was constructive confrontation. But, I think, it's also the idea that where Andy said, we don't sweep our problems under the rug. We get them out. We glorify them. We work on them. And only by having this debate do we get all of the data on the table and do we really understand what all of the issues are. And do you optimize the solution? So, I think, in a way, that culture had a lot to do with how we made this transition from that to then. How we dealt with the dynamics of the technology. So, I mean, in a way, I think, this is an excellent discussion and an excellent example of how you deal with that. In spite of the fact that you can still tell that there's a little tension between these two players here. But I mean there's respect too. And that counts for a lot. And having that be acceptable, I think, is very important.

House: The decision-making process at Intel was truly unique. All of the facts got on to the table. All of the point of views got argued. It became like a college debate. You had executive staff where everybody was presenting their best data, their best case, their best logic, responding back and forth to the other person's position. And a decision was made typically by Grove if it was at that level, if it was my staff, it would be me. If it was your staff, it was you. And then everybody got behind it, and we all went and did it.

Jenkins: That was the rule, disagree and commit. We actually had a phrase, "disagree and commit." And if you did, you did. Because he said, "If everybody is running in the same direction, we'll find out if it's wrong quicker than if we don't."

House: So when Jack was second sourcing and I'm saying, "I don't understand this," obviously I was supporting it. And then later when we stopped second sourcing and Jack is saying, "We made these commitments, shouldn't we really do this?" And it was being impacted as IBM business, Jack was supporting what the decision was made because once a decision was made, we all got behind it.

House: The concept of disagree and commit, you may disagree but you must commit.

Jenkins: We selected it in and we purged it out if you weren't compatible with those principles.

House: The mode of operation.

Jenkins: Right.

Jarrett: I think that's it.

Dunlap: Great. Anything we didn't cover?

House: Yes, well it was fun.

Jenkins: Thank you.

House: And thank you Rosemary [Remacle] because this wouldn't have happened without Rosemary orchestrating the whole thing.

END OF INTERVIEW