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[Music]

[Video]

Pat Gelsinger: There is no person on the planet that I would be more pleased to introduce than our next speaker. And as you come to IDF, technology, technologists, great innovation, profound insights, and who better to speak on such topics than Gordon Moore? Gordon co-founded Intel in 1968, became president and CEO in 1975, chairman in 1979, chairman emeritus in 1997. You know, he was the guy who sort of codified what we today call Moore's Law, , this insight that's become not just an insight, but the very nature of our industry's heartbeat and direction.

I remember some of my personal interactions with Gordon very early on. And one time we were struggling on the 46th compaction, so this is back when, , we were struggling to make a 1.2 million transistor chip. Myself was leading the design team for that. [Youssef A. El-Mansy] was leading the process technology for it. And we were struggling with this low-yield problem. And were running all sorts of experiments and struggling with trying to figure this out. And Gordon summons me to his office along with Youssef, , on this problem. I felt like I was going and seeing God, right, you know, walk in, the Gordon Moore, right? And Gordon started shelling us with questions. Have you run this experiment? Have you tried that? And so on.

And by this point Gordon was not a practicing technologist for quite a number of years, so we felt like we were sort of pacifying the old man,

, by answering his questions. And after a few of those, he just said, "Try this." We told him, "We already tried that." He said, "No, no, try this," and he was very specific, run this experiment, do this work. Lo and behold, we went and ran that experiment. And, you know what? He was right. So Youssef and I had to eat crow. Gordon was right, and his technology insight, his wisdom after all those years, was just profound. And for this, I have enormous credibility -- a man who's been recognized broadly by the industry, by the world, one of the nicest men in the technology industry, not only a gentleman but one of the most profound technologists of all time, ladies and gentlemen, please join me in welcoming Dr. Gordon Moore to the stage. [Applause]

Dr. Gordon Moore: Hi, Pat. Long time no see.

Pat Gelsinger: They love you, Gordon.

Dr. Gordon Moore: I love them.

Pat Gelsinger: Thank you.

Dr. Gordon Moore: I'm glad to see you guys are keeping things going.

Pat Gelsinger: Yep, we certainly are.

Dr. Gordon Moore: It's a law, you know.

Pat Gelsinger: And you predicted its death many, many years ago, Gordon.

Dr. Gordon Moore: Yeah.

Pat Gelsinger: We didn't listen to you.

Dr. Gordon Moore: Well, that's not unusual. Happens at home all the time.

Pat Gelsinger: And for our session this afternoon, what we wanted to do was have a little bit different setting for this afternoon, and rather than Gordon giving a keynote or something like that, we thought a setting where we can more informally interact, discuss technology trends for the industry, and to participate with Gordon, we're delighted to have Dr. Moira Gunn. And those of you who listen to NPR would have certainly heard her voice. She's host of Tech Nation and Bio Nation for NPR, director and member of numerous advisors and academic boards.

And I started with Intel in 1979, so I just started at Intel, and we were doing some work -- and this was in the QA department, as a quality and reliability technician at the time. I was a little bit of a renegade, young guy, not really knowing what to do. Moira comes in, this experienced professional software developer, and we didn't like each other, to start with. And had some interesting interactions as she was trying to work on some projects together. But, literally, my first few months at Intel, got to meet Dr. Moira Gunn, and since then, a very, very acclaimed success in the industry., Tremendous influence -- influencing the hearts and minds of both technologists and legislators across the globe. Please join me in welcoming Dr. Moira Gunn.

Moira Gunn: Hi. It's been a long time.

Pat Gelsinger: It certainly has been.

Moira Gunn: And you didn't like me?

Pat Gelsinger: Those first interactions, those were a little bit tense, Moira.

Moira Gunn: They were a little tense. Good to see you, Gordon. It's good to see you. But I do have to tell you a little story about Pat, because he was green. I mean, we were Silicon Valley, we were just hip with it, and here was this young guy in the lab -- the new guy -- he used to come to work in jeans, and he had these cowboy shirts, you know, with the pearl buttons? Do you remember that?

Pat Gelsinger: It was pretty raunchy.

Moira Gunn: Do you still wear that stuff?

Pat Gelsinger: No, my wife has fixed my entire wardrobe since then, Moira.

Moira Gunn: That's good. Marriage has been good to you. But it's good to see you again, Pat. You've done well. You've done very well.

Pat Gelsinger: Oh, thank you. And you have as well, Moira.

Moira Gunn: That's great. So shall we get going?

Pat Gelsinger: What's up?

Moira Gunn: I don't know.

Dr. Gordon Moore: Okay.

Moira Gunn: From San Francisco, I'm Moira Gunn, and this is Tech Nation. Come on, Gordon, you're in the hot seat.

Well, Gordon, I have to tell you. My first really big thrill is as you know -- shows like this, you have to do a lot of work to get ready for them, and I said, "Gordon and I should probably talk first." So they said, "Sure. We'll arrange a telephone conference. That'll be good." And it was really kind of fun because it was Gordon and me and I think six other people on the line. I didn't know; there could have been 10 for all I know. And I got around to my second casual question and I said to Gordon, "I didn't know if you know my background," because I wanted to make sure he knew I was an engineer, so that we could really talk a little technology. And he goes, "Oh, oh, oh." He goes, "I Googled you." I can die happy. Gordon Moore Googled me! Going straight to the resume, I'm telling you now.

But let's just start back with -- as an undergraduate, your degree was in chemistry and your Ph.D. is in chemistry and physics, not in engineering. And we were reminded earlier that the transistor was invented by John Bardeen, Walter Brattain, and William Shockley, and while they didn't reap enormous financial rewards for this invention, they did win the 1956 Nobel Prize in physics. And it was William Shockley who actually recruited you.

Dr. Gordon Moore: Absolutely.

Moira Gunn: He didn't send you an e-mail, though. It was a little early.

Dr. Gordon Moore: There was hardly any e-mail in those days, I'm afraid. We had telephones, however. The kind you put your finger in and run through the -- no, Shockley got my name from a place I'd interviewed out here in California. I'm a Californian trying to return home, and I was looking to change jobs. I was getting tired of the research I was doing, wondering if the taxpayer was getting their money's worth at $5 a word in the publications that were coming out and wondering if anybody was reading them. So I thought I'd get close to something more practical.

So I was interviewing. I turned down a job in one place out here and Shockley got permission to go through their files of the people to whom they'd made offers and that had turned them down. He got my name. He had chemists back at Bell Laboratories and found out they did some useful things and thought he needed one in his new company, and I guess I was about the first one he called. He was right out here, you know, five miles from where I grew up. So location was perfect, and it was an attempt to make a silicon double-diffused transistor, which sounded like an interesting and potentially practical idea.

Moira Gunn: It's worked out well. It's worked out. You couldn't tell at the time, but it --

Dr. Gordon Moore: Not there, but it worked out eventually.

Moira Gunn: Well, that's true. It is not there. You and -- you seem like such a mild-mannered guy, but you and seven other people left Shockley's organization to go found Fairchild. In fact, you were one of the "Traitorous Eight."

Dr. Gordon Moore: That's what we were referred to someplace along the way. I think it was Shockley's wife who actually came up with that term.

Moira Gunn: Well, it was you and Bob Noyce and who else? Who's the merry band? What was the arc of the expertise?

Dr. Gordon Moore: Oh, besides the two of us, Jean Hoerni, inventor of the planar structure later on. Jay Last, who ran the first integrated circuit project at Fairchild. Sheldon Roberts, a metallurgist. Julius Blank, an engineer, mechanical engineer type. Gene Kleiner, you probably know him more from Kleiner and Perkins. I'm sure a lot of you have heard of them. Well, Gene was one of the first of that group. And Vic Grinich, the only real electrical engineer in the crowd. He was a Ph.D./EE out of Stanford. It was a different era then. Engineers weren't trained in any of the semiconductor stuff because it didn't exist. Stanford actually had to send a young assistant professor to Shockley's lab to learn something about semiconductors so he could go back and set up a program at Stanford. That young guy was Jim Gibbons, who eventually became Dean of Engineering.

Moira Gunn: Well, there were only about 15 people in all of Silicon Valley. But it wasn't even called Silicon Valley then, was it?

Dr. Gordon Moore: No, no, that came later. That came when Don Hefler, who used to write an article for Electronic News, then wrote a little semiconductor scandal sheet of his own, named it Silicon Valley one time, and the name really stuck. That was, I guess, in the mid-'60s before that really happened.

Moira Gunn: Well, you know, it was in the mid-'60s. You were still at Fairchild when you wrote the seminal 1965 article of electronics, which is sort of the first public demonstration, if you will, of Moore's Law, although it wasn't called Moore's Law. And you write, "Such programs as Apollo for man moon-flights have demonstrated the reliability of integrated circuits by showing the complete circuit functions are as free from failure as the best individual transistors." Was there a question?

Dr. Gordon Moore: Well, there were a lot of questions about integrated circuits in the early days. There were all kinds of arguments why they didn't make sense. One of the principle ones was yield. People knew that on transistors, we only got yields of maybe 20 percent on a wafer in those days. And if you put eight transistors on a circuit, people thought you took 0.2 to the eighth power, and that was the yield you were going to get, which wouldn't make them very inexpensive.

And so, the idea that in fact you got yields in integrated circuits comparable to what you got in individual transistors was something that took some selling. Also, people thought that these things couldn't possibly be reliable, because they couldn't go in and measure the parameters of the individual transistors and resistors. They were used to doing math. The resistors were kind of funny with big temperature coefficients. Nothing like the circuits they were making out of discreet components.

And that's what my colleague Bob Noyce made another major contribution to the industry beyond inventing the practical integrated circuit. He says, "We'll see you the integrated circuits for less than the sum of the costs of the individual components." That really changed the economics of the industry. Of course, it was considerably less than the cost they used to make them in those days, but that's not unusual in the semiconductor industries.

Moira Gunn: Going to make it up on volume?

Dr. Gordon Moore: Absolutely. Literally, that's what happens! As the volume increases and things improve, the costs go down. Eventually, you do get ahead of the curve.

Moira Gunn: Well, in 1968, you and Bob Noyce went on to found Intel. Employee number four, you tell me, was Andy Grove. Employee number three was some guy he hired before he was even hired?

Dr. Gordon Moore: That's right.

Moira Gunn: That's Andy. And Bob, of course, unfortunately is no longer with us. But he was certainly a larger than life personality. Andy is certainly an original, far more than being his self-described paranoid. There's a real entrepreneurial spirit in everyone here and everyone listening.

And whenever you found a new venture, there's more than the overlap of the essential technical skills and sometimes scientific expertise. There's also the chemistry between the founders, and what the founders bring as a group. What were the essential elements? What were the key elements that brought you guys together that enabled you to start such a phenomenal operation?

Dr. Gordon Moore: Well, a variety of things do go into that. The first thing is kind of the negative push that got us leaving Fairchild. Fairchild had gotten rid of two chief executive officers within a six-month period, and Bob Noyce was a logical internal candidate, and he was clearly being passed over. So, he got concerned about that. When I heard that Bob was leaving, I said, "Uh! They're going to be somebody that's going to change things." I was like, "Okay, I'll leave too."

[Laughter]

Dr. Gordon Moore: And that was really the main motivation. We saw an opportunity changing the economics. In those days, it had gotten to the point where it was hard to define a complex circuit that got used in volume. It became unique when you got very many gates together. And there were only about 10,000 computers a year being made, so it was hard to find a function that could take advantage of the ability to make a complex circuit. And we saw semiconductor memory as perhaps a place where you could do that, and a good place to get started. And change the economics of the industry from the advantages of large, low-cost assembly plants in Southeast Asia to one where you could put good processing back to the center of the stage.

So, we had an opportunity, we had a push, and we got started. We were really lucky. You know, luck plays a significant role in any of these things. But we started out pursuing three different technologies to try to make semiconductor memory. We had a new twist on bipolar transistors that made nice fast memories, but it turns out it was a twist in the technology that worked so easily that the established companies like Texas Instruments and Fairchild copied it immediately, and we didn't have an advantage for very long. We tried another approach, which was a multiple chip assembly of MOS memory chips and bipolar drivers. And that turned out to be so darned complex I think we'd still be working on it today and not have our first product out if we hadn't abandoned it.

But we also tried a third one, which was the silicon gate MOS. Silicon gate was an idea that Bell Labs had made a transistor on, and we thought it offered some real advantages. And it turned out to be just right. I call this our Goldilocks strategy, you know? One was too easy, one was too hard. Silicon Gate MOS turned out to be just right. When we were focused on it, we got by the couple of difficult problems reasonably well. But the other companies didn't put the focused effort on it that we did, so we actually had a monopoly for seven years on silicon gate technology. And that really allowed us to get established. But if that had been significantly more difficult, we would have run out of money first. If it had been significantly easier, we would have had competition a lot quicker. So it was one of those very lucky choices that just worked out very well for the company.

Moira Gunn: Now, while you did write that seminal article in '65, and you can see all the seeds of Moore's Law in it, it wasn't until you were at Intel about 10 years later that it actually started being called Moore's Law. When was it -- you didn't name it. When was the first recollection you have of it being called Moore's Law?

Dr. Gordon Moore: My best information on that was a friend of mine, Carver Mead, who was a professor at Cal Tech at the time, ended up calling it Moore's Law. And for some reason the name stuck. For decades, I couldn't even say the words, but I've finally gotten used to it.

Moira Gunn: Do you ever regret that it got called Moore's Law? Does it follow you around?

Dr. Gordon Moore: No, I guess I don't now.

[laughter]

Moira Gunn: Well, I was thinking you could give me some advice, because there's Moore's Law. And then later on, there's Metcalf's Law about the value of a network. So I thought, you know, sticking with the Ms I could do Moira's law.

Dr. Gordon Moore: Okay.

Moira Gunn: You could give me some advice on that.

Dr. Gordon Moore: Well, what's your law?

Moira Gunn: Oh, I haven't got that yet. [laughs] It just seems like a good idea. I'll come up with the law, and you can give me the advice, how's that?

Now Silicon Valley is famous for a number of things, not just innovation, but also for what I call cubicles and crazy hours. And it was Intel who shocked the corporate world when it led the way on cubicles. Now, what do you remember about the genesis of cubicles?

Dr. Gordon Moore: Well, I remember we had just acquired a big building, Santa Clara 4 for those of you who have visited Intel, and it's a building, you know, roughly square, so it had huge floor areas, a lot of inside space. And we started looking at what was going to happen as we brought in a lot of engineers. And you could see you were going to have hallways lined up with both sides with doors with offices in them, no windows. It was going to look like a, I don't know, a prison block or something. So we said, "That doesn't make sense." And the alternative was leaving the space a lot more open. So we went ahead and did it with the cubicles that were available at the time. And then we thought, "Gee whiz, we've got these guys in cubicles. We've got some other people in offices." That didn't make sense, so we put everybody in cubicles. I still have the largest cubicle at Intel, I think. I got that because I had a big round table, and it wouldn't fit in the small ones. I kept that table, therefore I kept my cubicle.

[laughter]

Moira Gunn: There's nothing like experience, you know? That's really good. Now, we do have people live on the Internet asking questions. And if you've got your laptops out and you are wirelessly hooked up, you may be able to get your question in as well. And the first one is a familiar question. It says, "Is there an end state to Moore's Law?" I mean, we've been tweaking, you know, definitions for a while now keeping Moore's Law going at some times, and other times it seems to reveal itself. What do you think? Is there an end?

Dr. Gordon Moore: There is. Any physical quantity that's growing exponentially predicts a disaster. You know, it comes to some kind of an end. You can't go beyond the certain major limits.

When Stephen Hawking was through here once, he was asked that -- essentially that question -- what are the fundamental limitations to microelectronics? And he typed out his answer, and he says the speed of light and the atomic nature of matter. And we're not far from that. Before we had our hafnium breakthrough, we were down to the point where we were five molecular layers of insulator in the gate structure in these transistors. Well, you clearly can't go below one. In fact, you really can't go below five. You get into other kinds of problems. So there really are some fundamental limits. But it's been amazing to me how the technologists have been able to keep pushing those out ahead of us.

About as long as I can remember, the fundamental limits [minus] two or three generations out. So far we've been around to get around them, but I think in another decade, decade and a half or something, we'll hit something that is fairly fundamental.

Moira Gunn: Well, speaking of time, I think time is something that's -- on the inside you're one thing and on the outside you look around and say, well, gee, I guess time has passed here. And back when you founded Intel in '68, you said, okay, you can be on the board of directors until you're 72 and then you've got to get off. How do you feel about that now, Gordon?

Gordon Moore: Well, fortunately, there are other companies who don't have the requirement, so I can still sit on a board of directors. I think 72 is probably a very conservative choice of numbers in this day and age. A lot of people are still very productive at that advanced age.

Moira Gunn: But you still held on to your cubicle.

Gordon Moore: Yeah.

Moira Gunn: That's good. Yeah. I think actually if you had to give up your cubicle and stay on the board, I think that would be the wrong result. Now, we have another question from the Internet, and I'm not sure if you really feel like answering it, but can other scientific disciplines innovate as fast as the computer industry?

Gordon Moore: Oh, I don't see why not. I think if you look at the rate of innovation going on now in the life sciences, it may be difficult to plot a Moore's Law type curve, but the rate of innovation is just phenomenal. And the number of companies and the number of good researchers that are working on it is large and very bright people. I think that's one area that's moving as fast, and we have an opportunity to even go faster, if you can measure it. You probably know more about that than I do.

Moira Gunn: Well, I might, but I would hesitate to say I know more than anything about -- than Gordon Moore. That would be a real loser of a decision. But I do want to say that you pointed out something yesterday; because I said, gee, you know, what would you advise people to go and study now? You know, now that you have this [grid]. [You say, well gee, I can't go back and study chemistry and -- there's so much -- the technology that you've helped develop has changed the nature of science and how we do science.

Gordon Moore: Well, it certainly has. If I were going back today, starting school again, I'd probably look something more in the biological end of things. I think the most important things -- the most exciting things are usually at the interfaces. And the interface between computers and biology right now I think is a very productive area, dealing with extremely complex things, doing things that would not be possible without computers. You walk into a biology lab -- I happened to do this yesterday, I visited a friend at Berkeley who's in the biology thing --

every lab I went into had several computers there as well as the bottles and vials and such. Without the computers, they just couldn't do what they're doing today. So I think this industry is a fundamental enabler for most of the rest of the science and engineering getting done today. In fact, a good portion of all of [society's stuff].

I see a question here that came in: what would the world look like without the integrated circuit?

Moira Gunn: I guess you're the perfect person to ask.

Dr. Gordon Moore: Yeah. I guess the one way to look at that is, when we were making individual transistors, before we thought about integrated circuits, the people at Western Electric, the manufacturing arm of AT&T, did one of their time-in-motion studies, looking at materials and everything to see how a transistor ought to cost eventually. And it was, I think, 68 cents is what they imagined. You could eventually get a transistor down to 68 cents. You buy them for 10 picobucks today.

That's what the integrated circuit brought to the industry. Without it, can you imagine paying 60-some cents for every transistor?

Moira Gunn: Now, it's very interesting, that Steve Jobs recently said, "The technology road is bumpy." He was saying that because he cut the price of the iPhone by a third, 10 minutes after he introduced it, but you know. Bumpy for who, Steve? Just asking, you know. And so, but it's true. The road for technology is bumpy, and during your tenure as CEO, we have to go back there, because it's easy to think we're just going to sit down and put our heads down and innovate, and we're just going to get faster and cheaper and better and we're going to sell things. Things happen. Life happens.

During your tenure in the early 1980s, Intel and the other chip manufacturers were innovating just like they do now, building chips all right. But for every new innovative chip, there were Japanese firms who were reverse engineering and building the chip and selling it for cheaper, and it was a real concern, you know. Intel had to immediately drop its price. The real concern of the American chip manufacturers would last in the long run. Take us back there. Was that a real question in your mind too?

Dr. Gordon Moore: Oh, that was a very interesting time. I feel partially guilty of making the Japanese competitors so strong, because we started doing memory and we did 1, 4, 16, and ah so! Up until then, the semiconductor technology had pretty much been, it looked like a random walk. There were new inventions coming up, different technologies and one thing and other, and it wasn't easy to see where it was going. The Japanese were great followers. They hadn't any experience with innovation at that time.

So they were trying to follow this essentially random walk, and couldn't see where it was going. But once they saw the progression that they could extrapolate, they put together some very formidable development activities and became very successful. They picked up leadership at the 16K DRAM era and continued it for a few generations.

And we started seeing severe competition on quality and on price. And we tried to look behind it to see what was happening, and wherever we looked, it looked like the Japanese were doing a much better job manufacturing than we were. Where we use the same equipment, theirs would be operating 98 percent of the time; ours would be operating 80 percent of the time. The throughput through every machine would be different, so we really sold at a significant disadvantage; we were very concerned what was going on.

Fortunately, in our industry, things turn over fast enough that we could recover also by focusing on it. And with some concerted effort by the industry, we actually caught back up and became competitive with the technology. And still, we're the innovators in product directions and so forth. So, but there was a period of time there where it wasn't clear that the U.S. semiconductor industry was going to survive.

Moira Gunn: Well, innovation certainly brought you out of it, and actually, there was a question that came up on the Internet. We passed, but I want to ask it. Now, it's -- clearly, innovation is the key, not just straight-line innovation, but almost surprised discreet innovation that surprises your competitors, is a really unique value add. One of the questions asked, "What innovation has surprised you over the years that came out of Intel?"

Dr. Gordon Moore: Hmm. Well, you know, a lot of them have. As I mentioned earlier in the technology, these barriers that look like they're impenetrable seem to disappear as we get closer to them and people have focused on them for a while. That has continually amazed me.

One thing that is more or less an Intel innovation, we were the first one to use it, are these huge wafers. What are they now? How many millimeters?

Voices: Three hundred.

Dr. Gordon Moore: Three hundred, okay. Thank you. I never believed wafers were going to get that big. In fact, I did a slide for a presentation in the early '70s where I was doing some of these exponential extrapolations. So I did one on wafer size, from the three-inch wafers we were using those days, and said in 2000, our wafer size is going to be 57 inches. Just to show how foolish extrapolating exponentials could be. Well, I overshot a bit, but I didn't believe we were going to see 12-inch wafers, either, 300 millimeter.

Moira Gunn: But what you don't believe certainly is a surprise when it happens.

Dr. Gordon Moore: It really is, yeah.

Moira Gunn: We'll give you that.

Dr. Gordon Moore: But the whole thing -- you know, the conventional wisdom used to be that processors were so complicated, you could neither design them nor test them. Testing was going to be the thing that was going to really be limiting because you can prove mathematically, but you can't possibly test them exhaustively. But lo and behold, we make them and we test them in a few seconds, and they seem to work just fine. It's been one of those real surprises.

Moira Gunn: That's great. That's great. Now, from the Internet, we have a question. If you had another career, what would it be?

Dr. Gordon Moore: Gosh. At this stage of the game, I really don't know. I certainly enjoyed the career I had. Being involved in this dynamic an industry is really a pleasure. I had the opportunity to get in at the beginning, when the industry was really forming, and I'd try to find another one of those, I guess.

Moira Gunn: Another one of those [a go]. All right. Now, you know, it's interesting. We do have a sense that if we just stick our heads down and we work hard enough and we innovate and we focus on the problem, that that's what drives the solution, and yet I recall reading where you had some of the epiphanies and observations that ended up being Moore's Law on one of your famous fishing trips. You like to go fishing. And that takes time, and it's kind of solitary, and there's a lot going on there. What I want to ask you is about the role of such things as fishing -- taking the time down -- does that have a role in pushing innovation forward for the individual?

Dr. Gordon Moore: I think it's a valuable thing to do to get away from it -- I could go away for two weeks and not think about anything but how to outwit a dumb fish, and, you know, I didn't have a Blackberry in those days, obviously. Went to places where there was no telephones. Completely lost contact for a kind of a period. And I found it refreshing. I'm not sure I did any great innovations in those days. Maybe a new way of rigging tackle or something, but nothing that had to do with the business.

Moira Gunn: But it's a good thing to get away.

Dr. Gordon Moore: Yeah.

Moira Gunn: Definitely. The Internet asks now, how has your role with Intel affected you personally over the years?

Dr. Gordon Moore: Well, you know, you can't go back to the other universe and see how I would be personally if I hadn't. Obviously, it's affected me financially rather significantly, opened up opportunities that I wouldn't have had otherwise. But, you know, I've still got the same wife.

Moira Gunn: Bravo! Round of applause!

Dr. Gordon Moore: Fifty-seven years.

Moira Gunn: That's great. Well, you know, asking about your role at Intel, it was your role in fishing that actually has a second career for you that figures largely in how much money you make, and that is the Moore Foundation and your interest in conservation. That's tremendous and separate from just the whole idea of developing innovative technologies.

Dr. Gordon Moore: Yeah. Well, it's been nice to be able to set up the foundation. You know, you have enough hubris to think that we can spend the money better than the government. A few areas --

Moira Gunn: There you go.

Dr. Gordon Moore: A few areas where we tried to focus quite a bit on the environment, a significant amount on science and higher education, and one of my wife's favorite programs, which is everything she can do to improve the nursing profession.

Moira Gunn: Right. But it was the fishing, as I understand it, that led you reflect on the world.

Dr. Gordon Moore: Well, that's right. The kind of fishing we typically did was deepwater fishing. It's always best in the most remote areas you could find. And we were going to places that were really remote, and going back a few years later, and finding high-rise hotels and golf courses. It seemed like some of these remote areas really deserved protecting. That really, I think, developed a good portion of our interest in conservation. And just seeing how fast the world is changing. You know, we humans are overrunning it at a tremendous rate. We're the last generation that's going to have any wild places really on Earth, I'm afraid. So, we're doing our best to protect some of it.

Moira Gunn: Well, while we've been focusing on data storage, and we've been focusing on getting processing faster, so we can do more compute problems, it used to be years ago we'd said, "Well, a computer problem was either compute-intensive, or it was I/O-intensive -- data-intensive." And, you know, since we've gotten the personal computer and the Internet and everything along those lines -- a lot of the consumer electronics, we also have this graphical user face -- the user interactive intensity of that is sort of another driver of what computer problems can be. From the Internet they ask, "How do you see humans and computers interacting in the future?"

Dr. Gordon Moore: Well, I'm a [Luddite], I actually use a keyboard and a mouse. One thing that has always seemed like it was going to happen is we're going to get to the point where we have good language recognition by a computer. So, the computer can understand in context if you mean "to" or "two" or what. And I think when we get to that point, you can have an intelligent conversation with your computer, you can start doing good translation and things. So, I think we'll get to the point where you interact with your computer pretty much the way you interact with your colleagues. And I think that'll bring a lot of people into the computer era that otherwise are not involved. And I think it'll make a major difference. But you people probably know better than I do just what the probability of something like that happening in the reasonably near future is.

Moira Gunn: From the Internet we have another question. "What do you still want to accomplish?" Get busy, Gordon. What is it?

Dr. Gordon Moore: Well, I'd like to get the paperwork in my office cleaned up.

[Laughter]

Moira Gunn: Clear the famous [people]?

Dr. Gordon Moore: But, you know, I think I want to have my foundation be successful to accomplish some of things it's tackled. I'd like to be around long enough to see a lot of the things that are being developed now actually come to fruition. You know, it's an exciting time. Things are changing so fast. You just want to be around. I'd love to come back 100 years from now and see what had happened in the meantime. We're living in just a fantastic time period.

Moira Gunn: You started in chemistry and physics, which are, you know, pretty much your pure sciences there. And you wanted to implement -- you were drawn to implementation, which makes you an engineer. It doesn't matter whether you take engineering or not. I can tell you the engineers are all taking sciences just to get their degrees.

But so, at the same time, if we look at that -- learning and developing as an engineer, no one is a static engineer. You develop over time. And from the Internet, we have a question I think that feeds into that. "What advice do you have for new engineers, people who've just started in engineering and are just starting to build and innovate?"

Dr. Gordon Moore: Well, remember the fundamentals that you learned in school, and apply them regularly. In my experience, the things that were most often needed were not the esoteric nonlinear differential equations you learn, one thing and another. It was just those very basic things -- to make those really a part of what you do, so you stay really grounded in your work. I don't know exactly what a new engineer might be tackling, but certainly focusing on their problems and looking for innovative solutions has to be what engineering is all about.

Moira Gunn: You know, this -- we're here at the Intel Developers' Forum. First of all let me ask you, a show of hands, how many people were here 10 years ago and saw Gordon at the first one? Oh, we have returnees. We have returnees, yes. You know, this is the Intel Developers' Forum. This could have been Bob and Gordon's Developer Forum. What were the alternatives to the Intel name?

Dr. Gordon Moore: Well, we went through a lot of them. I can't imagine how difficult it is for a company today. In those days even we went through a bunch of them. We were originally incorporated just to get through the papers as Moore Noyce Electronics -- no, MN Electronics. Bob's daughter said we ought to call it Moore Noyce Electronics. We didn't think that sounded very good. But we had a list of, you know, oh, 15 or 20 names that we tried to get them approved. Typically you tried to get the thing cleared in California and then New York, and then you'd be okay in the rest of the country. And we had four or five rejected before we finally got Intel approved. Then we ended up having to buy the name Intel from a motel company in the Midwest.

[laughter]

Moira Gunn: Boy, are they sorry. [laughs] Well, this is sort of my last question in terms of, you know, what your experience speaks to. We've talked a little bit about, you know, all the various incarnations that you went through. We've talked about the road can be bumpy. We've talked about being in science and engineering. What do you go to when you have to make the tough decisions, you know? It's like do we do this or don't we do it? Do we, you know, what's going on out in the marketplace. It's a risk. Do we invest all of this in how we implement technology because it might not work? What do you go to? How do you make those decisions as an individual?

Dr. Gordon Moore: What?

Moira Gunn: Don't you love it when I ask a question that doesn't under -- Well, what I'm saying is that we're in the middle of these decisions. We just don't build the technology. We have to make a decision as both a businessperson, as someone who's an engineer and a scientist. Where do you go in yourself when you finally come down to the end of the day and say, "We've got to decide whether to go with this technology or not, or to build this"? These are hard decisions because you're investing a lot of money. How do you make those decisions?

Dr. Gordon Moore: You have to make them one way or the other. So the worst decision is not deciding anything at all. You know, the tougher the decision, it means the less difference there is between the two choices. So a tough decision you almost flip a coin on. It's the easy decisions you've got to be careful you do right.

[laughter]

Moira Gunn: Yes, let's hear it for the easy decisions.

[Applause]

Moira Gunn: Watch out for them. Watch out for the easy ones. Well, Gordon, I don't do this very often, but I have to say that you are certainly deserving of this. I'm giving you a Tech Nation refrigerator magnet which says, "If God didn't make it, it's technology." Ladies and gentlemen, Gordon Moore.

[Applause]

Moira Gunn: Thank you so much. That's terrific, great. Why don't we come right over here?

[Music]

Pat Gelsinger: Thank you very much. I just love being here. I look forward to the opportunity to talk to you a bit more today about the tick-tock digital enterprise. But, boy, what a hard act to follow. Right, not only is it a hard act to follow, but I don't want to. I just feel like sort of sitting down here, crossing my legs, and sitting at Gordon's feet, and just talking to him for a while. What a great man. And also what do you think? The latest in geek attire, Team Hafnium? Right, what are you thinking? Yeah. I think every one of you -- we'll make sure we'll put them on sale in back. What do you think, [Jeff]? We'll do something like that. So welcome to Team Hafnium.

So today we're going to talk about the tick-tock model, how it's unique to the semiconductor industry. In Paul's keynote this morning, he briefly touched on the relationship with Boeing and the work and the 747, and how we have this very powerful engine, Moore's Law, this cadence that keeps changing technology that uniquely applies and has been magic for our industry. And I thought just for fun, what if we actually could apply Moore's Law to the aerospace industry? And what might it look like?

Right about the time of the invention of the 4004, the microprocessor, was the maiden flight of the Boeing 747 from JFK to London. The 747 has unquestionably been one of the most successful programs of the aerospace industry. An engineering marvel, and many, many firsts in the aerospace industry -- 1,387 of these planes have been built, many of them -- most of them still flying today. If we could apply Moore's Law, how might it look?

And this is just taking and comparing what 747 did versus the Dreamliner or the 787 in terms of some of the key metrics, you know, people you could get onboard, cargo that you could carry, fuel efficiency, how long does it take to load and unload such a plane. And the aerospace industry is limited by mass, by drag, by the material structure. They haven't had this powerful 2X. It has many, many challenges and limitations. And, ultimately, things like passenger comfort and things like that as well have limited the industry.

But if we could apply Moore's Law, this 200,000X improvement over that period of time, and we just picked one dimension and stretched it out over that period of time, well, a single plane could carry 118 million people. Right? We could carry all of the West Coast with room to spare. Load and unload time of 12 milliseconds. That would be interesting. Revenue passengers per mile shipped -- just think about how powerful -- and sometimes, as we look back over our industry, we just forget how magical, how unique, how powerful this underlying capability has been. We almost forget the magic of what we do and the innovation that it's enabled. And that's really at the heart of our talk today is this tick-tock cadence looking back, looking forward, and applying that tick-tock model in the areas of platform capabilities, I/O innovation, energy-efficient performance.

And let's start by looking at platform capabilities. And in particular, we want to see how we can evolve that platform forward, the new capabilities. And when we deliver exciting and compelling new platforms that enables the markets to grow. And if we go back again and go all the way back to the 4004, the beginning of the '70s, right, we think about that PC or the Busicom calculator. How many of those are still in use today? I'm sure you all have them, right? The PC, and since then, we've realized it's not one size fits all. We need a broad range of platforms to address specific end-user needs. And if we look over that period of time, the amazing innovation that we as an industry have participated in, created, and delivered.

Let's begin by looking at three platform capabilities that we think are critical. Virtualization, a very powerful force in the industry today. We began our work in virtualization several years ago. We introduced VT into our products in 2005, and we're now in the process of replumbing the entire platform for virtualization. We're today shipping our fourth-generation of manageability technology, a key new capability for managing platforms in the enterprise. And finally, security. A top-of-mind issue -- how can I secure and manage my data center?

Last week, I spoke at VM World, and I presented our vision for virtualization. And I looked at some of the key observations around virtualization technology. And what we see is that we had a one-to-one relationship of the operating system with the underlying platform. And virtualization essentially disaggregates this relationship, thus disaggregating the traditional view of the operating system. But, and maybe more powerfully, it gives us an opportunity to reaggregate, or create, the data center-wide operating system of the future. And in that sense, we think that it opens up doors that never before were imaginable for IT value. And I wanted to look at what we call this wave of virtualization, the nascent stage of this technology that we're in today.

Two weeks ago, we introduced the [Caneland] platform. Caneland, in our perspective, is the virtualization and consolidation platform for the industry. [It] enables customers to save space, power, write administration costs. It's built on top of the [Intel®] Core™2 Duo [processor], so we're doubling the number of Cores, doubling the memory with our [FB-DIMM] memory, offering [up to] 4.5X performance improvement over our single-core and doubling the performance of our dual-core platforms, partnering with the industry, enterprise proven reliability, [RAS] and system-scaling capabilities. The choice for virtualization and consolidation.

Virtualization doesn't have well-proven benchmarks. How can you show that this one is better than that one? What this is graph is showing is V-consolidate work that Intel and others are coming together to say, "Let's develop an industry-standard way to measure virtualization performance," so V-consolidate is a new benchmark. We're running this, comparing it on a Tulsa platform or a [Intel® Xeon® [processor] 7100 versus a Xeon 7300 platform that we just launched. Each of these CSUs, one CSU, two CSU, four CSU, on here, each CSU represents five virtual machines. So a virtual machine in this would be a server-side job on mySQL, a database, a commercial mail Apache web server, and an idle machine.

So each CSU represents five, so if you go to a four-CSU, the far-most of that column, that would be representing 20 virtual machines. So the height of each column is the performance, and then what you see was you put multiple CSUs as the scale of the platform. What you see is a stunning scaling of virtualization as we move to the Caneland platform. More than 2X the capacity and on a lighter workload, about a 30 percent performance improvement on one CSU. Unquestionably a great scalability and performance,. The virtualization platform.

We believe that this is the beginning of a broad range of systems. And we view this as the virtualization wave. And today we have assembled, I think, the broadest collection of virtualization technology ever shown.

The first platform we have over here is IBM running a virtualization software from VMware, the ESX sever 3.i. It's a thin hyper-visor that's actually built into Flash, so embedded virtualization, ready to run out of the box, running our Quad-Core Xeon 7300 product. Next to that -- or on the far end of the stage we have Hitachi running the Virtage product on the Blade Symphony platform. This is the first public showing of Virtage running on the Montvale product. Also Hitachi is taking this virtualization software and releasing it for our Dual-Core Itanium as well as the Xeon product line as well. So taking that as a virtualization product line from Itanium® to Xeon as well.

We also show Lenovo's Quad-Core 7300. This box is a screamer, has the best published SPECint rate, number one in the world for four-socket IA configuration, the Lenova 630G7 [EPSD] platform. And this platform is running the beta version of Veridian, Microsoft's Longhorn virtual server platform.

And finally, next to that, we have the Virtual Iron technology running on the HP Proliant DL580 G5 server platform -- just rolls off your tongue, doesn't it? And 2X cores, 2X the memory, 2X the performance (compared to the previous generation G4), running Virtual Iron 4.0, Virtual Iron delivering virtualization software as well as manageability software to go with it. And they're seeing with Virtual Iron in this platform 40 percent boot time reduction and as much as 35 percent performance gain as well. VI and DL580, a great virtualization platform. And next to that, is a yet-to-be-announced system from Sun. This is running Solaris XVM virtualization technology. And instead of me describing that, please join me in welcoming John [Fowler] to the stage, who heads the Sun systems division. John?

John Fowler: Pat. Really excited to be here onstage at IDF. It's kind of unusual, Sun and Intel together.

Pat Gelsinger: Yeah, let's look at this.

[Crosstalk]

Pat Gelsinger: Okay. Thanks, John. So great to have you here, and Sun as both a software as well as a hardware provider.

John Fowler: Right. We're collaborating on a whole bunch of things together. We did an agreement a while ago, and I know that you're very curious about how things are going on many fronts.

Pat Gelsinger: Absolutely.

John Fowler: Yeah. So on the software front, starting with we're doing a lot of stuff with Solaris and Java and there's Intel engineering teams together with Sun engineering teams working on the software stack. And one of the things we're doing is we're incorporating support for many Intel features, like demand-based switching and VT for virtualization and others. And these were being done in open source, in the software stack, and of course the other side of it is we're building a whole product line out of Intel products, which of course we're not going to talk about here, right? You didn't bring anything here to talk about?

Pat Gelsinger: I don't know if you did or not. So let's see what we've got. So can you demonstrate?

John Fowler: Yeah. I'd like to talk a little bit about what we're doing in Solaris. We're incorporating virtualization in Solaris using VT and other technologies, and we can virtualize Windows and other environments, so I'd like to run a quick demo if we could on a virtualized environment, if we could roll the demo. So what we have here is actually Solaris, and what we're going to do is we have Solaris and Dom0. We've optimized to use the VT technology. And we're starting up Windows. You can see there's Windows there.

Pat Gelsinger: Windows on Sun?

John Fowler: Yeah. The proof is Solitaire. That's how we actually get Solitaire on Solaris.

Pat Gelsinger: Oh, you're pretty good at that.

John Fowler: That's how we got that application there. And this is Explorer looking at Solaris -- the open Solaris.org website. And the other thing is it's interesting enough to open -- is to manage to virtualize Windows, but what we're also doing is we've taken Solaris's ability to virtualize storage volumes in very large scale, along with snapshot reset, a lot of other capabilities, and these are actually virtualized for the Windows environment. So you get Solaris's ability to do fault management and extensibility on the I/O side, basically extended to Windows, along with your ability to look at hardware.

So we're going into bringing some of these enterprise capabilities ironically enough to Windows, so those are big changes for Sun. We're doing things with Intel, we're also doing things with Windows, which is a big part of what we're doing.

So how do people get involved? And you too can get involved. All of our virtualization technology is being done in open source on the opensolaris.org website, and so you, too, can join, be an observer, put back some code if you'd like.

Pat Gelsinger: Yeah, right after IDF, I'll get to work on that.

John Fowler: Okay. You can see actually how we're taking advantage of Intel features to do virtualization. In addition to, of course, supporting VMware, supporting Xen, and then obviously running Microsoft Windows and Linux, we have a really wide-ranging platform capability now in terms of what we can do with both our software and our hardware.

Pat Gelsinger: Yeah, and, you know, like you said, we're working together with you on Solaris and Java, working together in delivering those optimizations for our platform as well as back to the open source community. It's just incredible the amount of progress we've made in such a short amount of time

John Fowler: Seven months, yes, so it is good. Get engineers together, it's amazing what happens. We've got to stay out of the way. So I know you always bug me about hardware.

Pat Gelsinger: Yeah, I am a hardware guy.

John Fowler: So you want to get a little update.

Pat Gelsinger: Yeah, absolutely

John Fowler: So we did bring a little treat for you here. So I have a yet-to-be-announced Sun system here, which I'm not sure of the model number because it's not announced yet. But what we have here is a platform designed for [Tigerton] and [Caneland]. That's a 4-Socket platform, 128 gigabytes of memory, so a full number of memory slots, full-scale I/O and all the enterprise RAS features you expect of an enterprise platform -- eight disks, raid zero through six, hot swap power, hot swap cooling, you name it, it's in that box. But you can see that it's actually a little smaller than the other ones.

Pat Gelsinger: Yeah, I did notice that as well.

John Fowler: Yeah.

Pat Gelsinger: So when can I get that cool, sleek-looking box anyway, John?

John Fowler: Yeah, so we're actually coming up and going to announce this very soon, so we're going to be doing an event coming up here. This is actually in our next-generation platform for how we're doing rack-mount servers. And the engineers were turned loose on every little design element to get something that has all the capabilities of the enterprise but in a much smaller and more efficient form factor. And you can see this is going to be a great virtualization platform, full memory, full I/O, full RAS capabilities, half the space. It's going to be a great platform. We're looking for to it.

Pat Gelsinger: Hey, John, the collaboration is going great. Thank you so much.

John Fowler: Okay, thanks. Thanks, Pat.

[Applause]

Pat Gelsinger: So we've seen the wave of virtualization on a range of servers. Now let's look at a client as well. And what I have on stage here is a demonstration of client virtualization using the Parallels software. And here I have two machines. This is a non-vPro client. and the other is a [Intel®] vPro™ client. Each of these machines is running three OSs.

So we see on stage here, we see a Ubuntu Linux*, we see a Windows Vista*, and we see a parallels, I mean, an XP* server. So each of those are running three OSs. So this is, you know, general virtualization on the client side. And we're going to run this demo from backstage, and we're going to download an application, reboot it, and that application is going to attack the virtual machine manager or parallels in its place. So let's go ahead and start the demonstration there.

So they're trying on both of those machines to download and run this hack software. And what we've done is as part of the vPro client this year, we've introduced the new capability called trusted execution technology. And the problem we're trying to address is that any user with admin rights could come in and start to attack the machine. And security software cannot ensure the integrity of the VMM itself. We need to assist that in hardware. Furthermore, the virtual machines can collide with each other and overwrite memory. And finally, a disorderly [shut down] of a VMM is another attack point where they can go and read memory and look at what they machine footprint was. And trusted virtualization is an opportunity to attack all three of these.

TXT, trusted execution, launches the VMM into a known state. It takes a hash or a signature of the VMM and thus guaranteeing the integrity of the VMM. Second, it provides hardware-based isolation between the two environments. Third, it guarantees the integrity of the VMM as well as when it shuts down. All three of these taken together solve the key attack points for virtualization machines today. So what we're trying to do is the combination of VT, virtualization technology, and TXT, trusted execution technology, not just deliver breakthrough virtualization capabilities, but also enable that with trust and security as well, and allowing a trusted, secure virtualization environment.

So now if we come back to our demonstrations, we'll see on the vPro system that in fact as it has gone and checked that hash, that downloaded EXE that we ran actually violated the integrity of the VMM. The hash has failed, so it couldn't secure the boot process from BIOS through bootloader to the VMM starting up. And it simply said, "Sorry, I cannot load this." And, of course, we have a good solution for that. We now launch AMT, advanced manageability technology, to come and remediate the system.

Now, I come over on my non-vPro system. And we saw the skull and crossbones pop up. The hacker has successfully compromised the platform, and now what you see is this device, inside of the corporate network and firewall, is now basically running rampant, releasing all of the secure, confidential corporate information -- probably my credit card, maybe Paul's as well, right? You've seen the immediate difference enabled by parallels using VT and TXT technology.

Our work in the business optimized client, and as Paul showed this morning, has been going extremely well. The response to vPro has been nothing short of fabulous. We launched it in September of last year. We upgraded the [Intel] Centrino® [Duo] product line with Pro capabilities in May of this year. And just a few weeks ago, we launched the second generation of the vPro, the Weybridge family of products. They have over 30 ISVs that have optimized software for this platform, and major IT customers are now in scale deployment of vPro platforms. And a few of those are people like 3M or Johns Hopkins or Plymouth University in the UK, who's now essentially 100 percent vPro in their environment. And customers are finding great value proposition from security, manageability, and traditional performance, energy efficiency of these platforms.

And of course, the beat goes on. With the tick-tock model, we continue that cadence into the future. In the second half of 2008, we'll be introducing the third generation of vPro called McCreary. McCreary introduces the AMT 5.0 technology, advances in virtualization. It also integrates the trusted platform module directly into the chipset, a capability that secures the secrets, making it more secure, but not enabling the physical signaling between the [TPM] and the chipset. It's also energy efficient, being Energy Star 4.0 compliant. This is also the most eco-friendly platform that has ever shipped. With a processor chipset and LAN, it's the first to the PC industry that's … lead-free, as well as halogen-free. Our 45-nanometer desktop products will begin shipping as halogen-free and lead-free, as well, next year. And we see this as a tremendous opportunity for our industry to lead with eco-friendly technology.

And while we're way excited about McCreary, the most exciting capabilities part of it is a key new technology that we call Danbury. And what Danbury does, it's new data security technology that's built directly into the chipset. And what it does is today when you run hard disk drive encryption in software -- it's the picture on your left. And with that, you know, everything is in software including problems like key management and the keys running in software so vulnerable for attack and compromise. And what we're doing with Danbury -- we're moving the most critical elements of that into hardware. And better than me describing that, let's have one of the experts in this area join me onstage. Please join me in welcoming Bob Heard, who's the President, CEO, and founder of Credant Technology, industry leader in the area of encryption technology. Bob?

[Applause]

Bob Heard: Hello, Pat. Privilege to be here.

Pat Gelsinger: Great.

Bob Heard: Well, I know like you, we're very excited about the Danbury announcement, because we think it brings a very powerful technology solutions to our customers data protection requirements, as they're fighting this continuing fight to protect themselves against data breaches and data loss.

Pat Gelsinger: Well, that's fabulous, Bob. Can you tell us a little bit more about it?

Bob Heard: Sure. Well first of all, let me tell you a little bit about Credant. We were honored here just within the last week or two of being ranked number one in the Inc. 500 list of the fastest growing security software companies, which is something that our team is very proud of. And what we do is we provide a centrally-managed, policy-based capability to protect data at risk on all types of end-point computing devices ranging from desktops to laptops to notebooks -- also mobile devices like Smartphones, PDAs, and even removable media to give a customer a holistic approach to protecting data no matter, who, what, when, where it resides.

And what we're trying to accomplish here with our efforts in and around Danbury is to enable our customers with the technology that is, one, cost effective, but is also easy to deploy, manage, and use. And let me give you some specific examples in each of those areas in terms of the value add that we'll provide.

In management, we'll do a couple of key things that are important to customers, one of which is to manage the keys and to insure that the keys are always escrowed in a safe fashion. And the second thing that we'll do is to provide continuously enforced policies that are necessary for customers who have to adhere to regulatory compliance.

In the area of deployment, we utilize the vPro technology to allow customers to do a completely unintended deployment to their endpoint computing devices, thus reducing the time, the dollars, and also the complexities of deploying to endpoints. And in the area of usability, a very interesting feature with Danbury has a feature called the remote unlock capability. I know, Pat, this never happens to you, but if you happen to forget your password --

Pat Gelsinger: No, I never do that. Paul might do that, but I wouldn't.

Bob Heard: Never. Hasn't happened to me until last Friday. We will enable this remote password capability so that a customer will have a very simple way of recovering a user who has forgotten their particular password.

Pat Gelsinger: So manageability. That sounds great. Deployability. Usability. Very powerful. Now, I just want to know when can I get it?

Bob Heard: Well, it will be delivered along with Danbury in the second half of '08. Engineers are already collaborating together, and we're very excited about the opportunity to work and bring innovation.

Pat Gelsinger: Well, this is absolutely fabulous, Bob. As a leader in this industry, we sure appreciate you joining us here at IDF, and we're looking forward to our product shipping together next year.

Bob Heard: Thanks, Pat. It's been my privilege.

Pat Gelsinger: Thank you.

Bob Heard: Thank you. Have a great show.

Pat Gelsinger: Solving real IT problems today. And we're excited to be working with Credant in this area. And literally we have the industry partnering with us; all of the leaders in the technology area, of data encryption technologies have joined with us and will be delivering products to take advantage of Danbury.

Last year I spoke about the challenge of the compute models, and what we drew a picture of was the extremes. On the one side, we had thin client computing, which has certain attributes and cost -- manageability -- which were intriguing in some specific environments for customers. On the other side, we had the flexibility and the power of a full, decentralized personal computer as well. And what we saw was this was stretching or pulling or breaking, in some cases, IT departments for heterogeneous computing. And we said is there a better way? And, in light of that, we launched our SAS work, where we had the ability to stream applications to the client. And today I'm excited with the progress that we've made in this area. And to help me demonstrate that to you, today, please join me in welcoming one of the leaders in this area, the CEO of Citrix, Mark Templeton to the stage.

Mark Templeton: Hey, Pat.

Pat Gelsinger: Hey, Mark. It's an absolute pleasure here. Citrix, a leader in this area, lots of thin-client products that you've been [leading], your terminal server products. You know, just tell us a little bit about some of your work in this area and how you're delivering application streaming and OS streaming.

Mark Templeton: Well, I think Citrix has sort of set the pace here in really delivering infrastructure that creates the dynamic capability to assemble desktops, apps, and even servers in real time. So IT organizations can build solutions that flex with business.

Pat Gelsinger: Hey, that's great. Now, but can I challenge you?

Mark Templeton: Sure.

Pat Gelsinger: It took me awhile to do an XP to Vista migration at home. Can you show me how to do this in, like, you know, seconds here for our audience?

Mark Templeton: It's really easy.

Pat Gelsinger: Okay, show me.

Mark Templeton: I'm going to really show you the way here. Okay, come on, right over here.

Pat Gelsinger: Okay.

Mark Templeton: Let me show you. Right here we have a Lenova desktop with vPro technology. And basically this machine is completely stateless. It's bare metal. There's no OS installed on it.

Pat Gelsinger: Okay. So I see Windows running right now, XP, on it.

Mark Templeton: Yeah. That's because when we booted it, it actually streamed the desktop right from the data center. So the IT guys are managing the images at the data center, but users are just starting the machine up.

Pat Gelsinger: Okay. Get me to Vista, man.

Mark Templeton: Pretty simple. So we've got the IT guys in the back. We've called them up. We want a Vista upgrade. So I'm going to ask them to reboot this machine. So you see here, we're rebooting the machine after pointing the Vista image at the desktop.

Pat Gelsinger: Oh, that's fabulous. So, you know, while that's running -- this is a stateless machine -- while that's running, no apps, no OS, locally. We're going to reboot to Vista. Tell me a little bit about your view of the business landscape and how we see this playing out for IT.

Mark Templeton: Well, I think this is important because as globalization, as consolidation in the data center, as people become more mobile, IT has to be way better at delivering desktops and applications as a service. They never know where the user's going to be, and this is core technology for getting there.

Pat Gelsinger: And how is Citrix helping to do that?

Mark Templeton: Over the past few years, we've invested over $2 billion in R&D and strategic acquisitions to really make this possible. So you're seeing here, in our desktop screening technology, really changing the game. Letting the users have a powerful, rich client on the desktop. Letting IT drive that client without any compromises in performance.

Pat Gelsinger: So we're bringing up Vista here, right, and where then are the apps and OS streaming from?

Mark Templeton: Well, this desktop image is coming right out of the data center. You can see, here it is firing up. And the user has no clue that it's being streamed from the data center. And then, obviously all the applications can be delivered to it in a multiple number of ways. The key thing here is there's no compromise. Users get full use of the local resources of the Intel processors.

Pat Gelsinger: So everything, then, is running locally?

Mark Templeton: Everything running locally. You can do CAD, you can do any kind of media generation apps.

Pat Gelsinger: But what about mobile applications and services? How does this work in that environment, then, Mark?

Mark Templeton: Well, we have -- oh, we got Vista up and running.

Pat Gelsinger: Very good. Was that faster than your Vista migration at home? Right, pretty good, impressive, Mark. Good job.

Mark Templeton: Reboosted Vista. There you go. So the mobility question is a little bit different.

Pat Gelsinger: Okay.

Mark Templeton: Because we have another demo here, actually, of that. Because when users are mobile, they need to literally work untethered from the network, and the applications need to travel with them. However, what creates the problem for IT is when the applications are installed in the desktop. So our application streaming technology allows applications to run locally, but delivered over the network just like you saw here with the desktop.

Pat Gelsinger: Okay, very good. So in this case, we have no OS, no apps here.

Mark Templeton: No, this Lenovo Thinkpad*, it's got a full Vista desktop installed on it, but it doesn't have any desktop apps. Okay? So let's try to open something up. So there's a document on here, like for example, an Adobe Acrobat doc. It hasn't, Adobe Acrobat* hasn't been installed in this machine.

Pat Gelsinger: Okay.

Mark Templeton: So what we are seeing here is in real-time, Adobe Acrobat is coming right down to the desktop in a persistent way, so it stays there so that now I can, you see here, starting the application.

Pat Gelsinger: So we're loading Acrobat?

Mark Templeton: First time. And now the document can be opened. So now, when the user wants to unplug from the network, travel, all of those apps that have been streamed are fully available for them.

Pat Gelsinger: Excellent. So a full streaming model of OS and application capabilities. This is fabulous, Mark. Thank you very much.

Mark Templeton: Thank you, Pat. Appreciate it a lot, but you know, before I go -- I noticed on your Waves of Virtualization chart, you have a typo.

Pat Gelsinger: I did?

Mark Templeton: You missed the big news. About three weeks ago, we announced this big acquisition of XenSource.

Pat Gelsinger: I forgot one. Let's just fix that typo right now. Thank you very much.

Mark Templeton: Thank you, Pat.

Pat Gelsinger: We're very excited for the progress we've made in software as a service, and Citrix is one of the leaders in this area. Really excited to have them join us on stage. The next area I wanted to look at was I/O innovation. We need a balanced platform. We can't just make fast engines. We have to make the rest of the car go fast as well, or in this case, the plane. And if we could, let's just come back to our analogy for a second. Imagine the I/O capabilities of a plane., if you think about it, over the duration of Moore's law, we've done about 200,000x in the transistor count. We've done about 10,000x in the I/O. So if we apply that, we have to load the plane in milliseconds, and so we have this problem. We have a jetway and how do you possibly get past it?

So we were thinking about some of the new capabilities to be required for airplanes to increase their I/O capacity, so we probably need more I/O ports, so we need more jetways getting into it, sort of like point-to-point I/O. We need to go one-directional, so in and out can go more quickly. We also probably need byte ordering, so we need everybody to line up in their seat order before getting on the plane, right, so as they get in. Hand-carry luggage is definitely not going to work, so that's just got to go. And of course, smaller people and suction would be helpful as well, you know? If we got all of that working, we should be able to get the plane loaded in a few milliseconds. But maybe customer comfort might be a problem.

All joking aside, we continue to innovate in the I/O area in a pretty fabulous way. We talked about PCI 2.0. We launched it at IDF -- doubling of the speed and the bandwidth of the PCI Express, that industry standard attach point. Today, we have seven IHVs who are working with us with nine different cards in the area of graphics, LAN, and storage, with running PCI Express 2.0. These are running on our Stoakley platform, our, you know, platform that will be launching in Q4 of this year. And being able to demonstrate that as well as the X38 chipset, which Paul demonstrated earlier today. PCI Express 2.0 going great for the industry.

But, of course, the heartbeat goes on, tick-tock continues to drive innovation. We are well underway with the industry for PCI Express 3.0. We launched a year ago Geneseo, targeting again a doubling of bandwidth for PCI Express 3.0. Full backward compatibility with PCI Express 1 and 2. Protocol extensions that expand the usage models. Protocol extensions in the area of data reuse, dynamic power management, atomic operations for improved coherence across PCI Express. We see this as opening up new capabilities for IO and attach points.

We also announced our QuickAssist initiative, where there are just some applications that are 10, 100, 1,000X more performance than what we enable today. We call these extreme workloads. And to enable those, we launched the QuickAssist initiative, where we would enable extraction, we licensed our front side bus, we would extend that to QuickPath into the future. And the first products are making great progress. And as you see by the long list of logos here, the industry's response to this has been very exciting. And we'll have our first products from our first vendors shipping before the end of this year, and we'll have several of those in the demo showcase that you can look at as well. QuickAssist, making great progress.

We also announced our directions in the area of our acceleration efforts. Paul mentioned some of our accelerators in the area of consumer electronics, but we're also doing work in the area of embedded applications. We launched our Tolapai system on a chip, an IA core, with an integrated IO controller, memory controller, as well as dedicated accelerators for security and network processing as well. We've seen up to 8X performance, [up to] a 20 percent reduction in power, and as you can see, a dramatic reduction in the footprint as we go to Tolapai acceleration and integration for the future.

One of the greatest successes of IDF was probably when we launched USB, universal serial bus. USB 1.0, 2.0. We've delivered over 6 billion devices since 2001. Since 2006, in the last year and three quarters, over 2 billion devices shipped, alone. And when we launched USB, this is the stuff we were thinking about. We were thinking about keyboards and mice and disk drives and DVD players and those kind of things. But after we did it, the industry went wild, and look at all the other things that appeared, right? Look at all the other things that appeared. There we go. Look at all of this stuff.

I'm sure all of you, for your LP collection, have the full -- you know, an LP USB device for your record collection. Here's one of my favorites. I'm going to line it up in my office -- the USB missile launcher. For Nerf wars have never been the same. You have your USB hand warmers as well, your mittens here. And every geek has got to have one of these -- you have your USB refrigerator. Of course. You have your can of Red Bull, the energy drink, for when you're working late at night. But look at the incredible innovation that was unleashed by creating an easy-to-use standard attach point for the computing industry that's now adopted by everything in consumer electronics media across the industry.

Today I'm very happy to announce the USB 3.0 promoters group. And with that, HP, NEC, Intel, Microsoft, NXP, and TI are forming and announcing today the formation of that promoters group. The target for USB 3.0 is a backward compatible cable. Here's a mockup of the 3.0 cable that we have. A goal of 10X the bandwidth, energy efficiency as we improve the operation for mobile devices, and support for both optical as well as copper. And this is a mockup of a cable that we've done where you can't actually see it here, but we have the optical connections, the laser connections built into this cable, so that we could have a compatible way of both copper and optical into a backward-compatible USB connector. The power of the industry has been carrying this compatibility forward and continuing to enable I/O innovation for the future, USB 3.0.

Also working for I/O innovation in the data center, today we have parallel infrastructure in the data center. We have the LAN infrastructure, and we have the storage infrastructure: costly, high power, hard to manage.

We've very happy with the industry progress in the area of Ethernet extensions for the data center and a new technology called fibre channel over Ethernet. The T11 has just agreed on the standardization of fibre channel over Ethernet. The standards for this are expected to be completed in the second half of next year. Intel has just announced our new LAN controller for this market, our new gigabit 82598 I/O. This is a copper version and an optical version of that product. This includes the enhancement for Ethernet in the data center. We expect that we'll be delivering a full software stack for fibre channel over Ethernet in 2008.

And as you go to look at the picture that's shown on the chart here now, you see that we have a top-of-rack switch that would then enable you to split out or connect to the traditional fibre channel infrastructure as well as LAN infrastructure while we consolidate to a single wire inside of the server itself. But, of course, our vision is a [fully converged fabric] where we're able to move to a single infrastructure for cost, size, power, and complexity. Fibre channel over Ethernet, consolidating the network in the data center of the future.

We've also launched this year our nonvolatile efforts for the mobile client. Similarly, we've seen there's an opportunity for servers and storage devices as well. And with that, we're very happy to announce that we'll be delivering nonvolatile memory-based technologies for the hard disk drive industry for servers. And what I have here is a prototype of our solid state disk drive technology, a SATA 3.0 device, three gigabytes per second, 10 to 50x the I/Os per second from this device. We see it having 4.5 times the power savings compared to a HDD, 2x the write speed performance. We'll be launching products in 2008, and like [Robson] Intel Turbo memory, bringing our secret sauce in terms of the core physics, algorithms, and policies to make it reliable, high-quality, and high-performance. Classes this week at IDF. We believe this will revolutionize the storage industry and the data center of tomorrow. Aren't you excited about that? Yeah.

[Applause]

Next, I wanted to look at energy efficiency. And, again, if we can go back to our analogy. Since 1970, the 4004 to today, we've done about 1,000x increase in the energy-efficient performance of our microprocessors. Now, if we could apply that to the airline industry, we'd go coast to coast in about eight seconds, and we'd refuel with just a few ounces rather than requiring a whole expensive truck to come by. What do you think? Do you ever want to be on that kind of plane? The incredible magic of our industry.

Sixty-five-nanometer products have had an incredible ramp. I continue to be amazed with how customers are utilizing our 65-nanometer core products. And what I wanted to do was maybe take a look at one of those. We do innovation at the chip level. We do innovation at the chipset level. We do innovation at the platform level. We do innovation at the rack level. Let's see innovation at the data center level, the data center on wheels. Let's hear from Rackable and their new ICE Cube center.

[Video plays]

Pat Gelsinger: Innovation at a new level. And the container is open. It will be across the street at the Metreon 9:30 to noon tomorrow, and 10:00 to 2:00 on Thursday. So, go take a ride.

And while 65 nanometer has been great, on to 45 nanometers. You know, Moore's Law, the incredible shrinking machine, as we move from 65 to 45, we see that the die size is about 25 percent smaller, enabling costs of manufacturing scale, but also enabling a 50 percent increase in cache size, as well as energy efficiency and new features as well.

Some of the performance results for this, and the first ever published data today -- these are all based on Harpertown. These are all measured results that we've done. We're comparing in this case a three-gigahertz Quad-Core with a 3.16-gig 1333 Harpertown to a 3.0-gig Clovertown. And we see 19 percent on SPECint rate, 25 percent on JAVA. In this case, we're looking at a workstation configuration, so a 3.2-gig Harpertown with a 1600 front side bus. And we're looking at a multi-application, or a multitasking scenario of SpecScape, SolidWorks, Fluent all running simultaneously. And we see about a 23 percent improvement.

And finally, we have leadership on a broad range of benchmarks. You know, literally every benchmark. The Intel platforms win today. But the area where competition is closest is in bandwidth-intensive and floating-point areas. And what we see here is with the improvements of the 1600 front side bus, the larger cache is 3.2 gigahertz, going from Clovertown to Harpertown, a 34 percent improvement. And what's even more impressive than that -- all measured results -- if we compare that against the best published results on shipped products that aren't even shipping yet, the 2.5 gig from our competitor, Harpertown wins on FP SPEC rate, as seen here at 89.8 on FP SPEC rate -- the fastest machines on the planet.

While the machine is the fastest, let's talk about some of the applications that are possible with this. To help me do this, I'd like to introduce Alistair Downie, manager for R&D with Paradigm. And he's going to show the application of Paradigm, and how they deliver for the oil and gas imaging capability with their product. Alistair?

[Applause]

Alistair Downie: Hi, Pat. I'm very excited to be here.

Pat Gelsinger: Thank you very much, Alistair. I can -- you know, can you tell us a little bit about Paradigm and what you do?

Alistair Downie: Paradigm is an independent software vendor who develops technical software for the oil and gas industry, and optimized for the Intel platform. Our customers use that software to help produce oil and gas reservoirs.

Pat Gelsinger: So, I can imagine that that must be enormous compute, as well as enormous working sets?

Alistair Downie: There is enormous compute and enormous working sets involved. Some of the applications that we run in the area of seismic imaging -- they produce and use terabytes of information as input and output in a single analysis. And we've taken that tenfold performance improvement you've made over the past few years, and we've used that in new algorithms such as our new common reflection angle migration, to help produce higher fidelity results for our oil and gas customers.

Pat Gelsinger: That sounds impressive. Can you show me?

Alistair Downie: Well, I can't show you the actual process of the imaging, because those applications are multithreaded. They're scalable across hundreds of applications, and they still take weeks or months to actually perform. But we can look at some of the results of this, and look at another area where Intel's platform is helping our customers on this workstation here.

Pat Gelsinger: Okay. And I think what we have here is we have a quad-core Xeon 5400, the Harpertown processor, and a workstation 1600 FSB, so this is the best hardware.

Alistair Downie: This is great, and this is the type of system that our oil and gas customers want to use on their desktops. And what we're looking at here in this demonstration is the output from one of those seismic imaging processes, and the horizontal reflections that you see here are typically associated with rock beds in the subsurface.

In this image, you can also see vertical striations, and those vertical striations are the result of faults in the subsurface, where rocks are slipping against one another. And the combination of the rock bed truncations against the faults are one of the primary sources of reservoir trapping in the subsurface.

So we look at the next illustration here. We're using these powerful workstations to run automated processes to extract that fault information from the subsurface image and present that information to the geoscientist, the interpreter, who's then able to take that information and combine it with the horizontal information, as we see next, and take that and build a digital model of the subsurface.

And the final result of this is, if we look at the next, is a full subsurface model, a volumetric model of the subsurface, where we've color-coded the rocks based on ages, so you can see how they've shifted over those fault segments. Now this type of information is used by our oil and gas customers to produce more effective and accurate drilling decisions.

And of course, this is very important to them, and very important to your customers.

Pat Gelsinger: So this is very impressive. So you're stressing our servers for all they've got, our workstations for all they got, but I think you use our software tools as well?

Alistair Downie: Yes, Pat, we use your software tools. We use your compilers and your math kernel libraries to maximize the performance we can get on both the desktop systems and on the high-performance compute nodes.

Pat Gelsinger: Take advantage of everything we've got.

Alistair Downie: And we will do so in the future as well.

Pat Gelsinger: Thank you so much. Great to have you join us here.

Alistair Downie: Thank you very much, Pat.

Pat Gelsinger: So from the most powerful workstation system available today, we've an array of, using the power of 45 nanometers, the most impressive collection of desktops ever assembled. Our high-end workstation, this is SkullTrail. This is for the extreme enthusiast. Now we didn't have a three-stage cooler like Paul had this morning, but a dual-Quad-Core, so an eight-core extreme system, 45 nanometers, 3.2 GHz, four PCI express slots so we can have quad graphics capabilities as well, and planned for the end of this year, first thing next year, chiller provided.

Next to that we have our x38 desktop systems. The high-end system available. Dual PCI Express 2.0, what I was mentioning before. This is the platform bringing PCI Express 2.0 into the mainstream platform. Next to that, we have our mainstream vPro platform. This is a Dell 755 system. We're quite excited about their recent launch supporting next generation active management, virtualization, trusted execution technology. And finally, the mainstream G35 platform. [The] Integrated graphics Paul mentioned this morning. Video quality, 7.1 HDI clear video technology, using 45-nanometer technology. An incredible range of desktop systems available today.

But the tick-tock goes on, and the next stage is the Nehalem processor. At Spring IDF in Beijing, I talked out Nehalem with a slide and gave a view of the Nehalem microarchitecture. Brand-new microarchitecture spanning mobile desktop and server products, first products in the second half of next year. We announced with it a set of new innovations. We describe new instruction-set architecture. We launched SSE 4, and with that, Penryn. Our 45-nanometer Penryn product is delivering 47 of those new instructions.

With Nehalem, we're delivering seven more new instructions that are part of it. Application-specific instructions like POP counts and CRC-32, also new streaming instructions, specifically for workloads like XML. This is our first published data on that, where we see enormous reductions in the instruction count and over 3x performance improvement on XML-like workloads. And as an old [RISC/CISC] debate guy, this is the [CISC] construction of all CISC constructions -- 256 simultaneous compares going on. Just makes my heart beat, right?

Excited. Man, this really is a powerful instruction, and as ISVs start using it, we're certain even more compelling application.

Also disclosing for the first time AES, which will be part of our Westmere products, specifically for security algorithms. We also are driving innovation at the system level. Today we're disclosing the QuickPath architecture, and this architecture provides [with Nehalem] integrated memory controller as well as the point-to-point interconnect from the processors, robust RAS features, flexibility and scalability. On the slide here, I show both the DP as well as the MP configuration of those platforms. And this technology -- QuickPath -- will be [available] across the Xeon family, high-end desktops, as well as into our Itanium family of products.

QuickPath has great acceptance by the industry. And as you see by the slide here, we have a broad range of partners who are working with us on QuickPath. These licensees include chipsets, customers who will be building it, with foundries, ASIC, test providers, a broad range of industry support for QuickPath technology.

But, of course, Paul challenged us to show off Nehalem, and could we do a little bit better? And to help me do that, I'm very happy to have [Jim Brayton], the Nehalem project manager, join me. Jim?

Jim Brayton: Hi, Pat.

Pat Gelsinger: What do you got here, Jim?

Jim Brayton: It's really great to be here representing the Nehalem team and bringing fresh 45-nanometer silicon from Nehalem -- the 45-nanometer talk.

Pat Gelsinger: Oh, this is very good, Jim. It looks like you have a chip on your shoulder, up here.

Jim Brayton: In fact I do.

Pat Gelsinger: So --

Jim Brayton: Well -- go ahead.

Pat Gelsinger: Before we start tell me about the team. What's going on here?

Jim Brayton: Well, first, let me acknowledge the team that put this together, the Nehalem [process] team. They all wanted to be here today, but unfortunately we couldn't get them up. But we took this picture Thursday, and they're actually watching this via webcast back up in Oregon.

Pat Gelsinger: Right now they're hooting and hollering in Oregon.

Jim Brayton: Absolutely.

Pat Gelsinger: Okay. So we better do a good job here, Jim. So tell me about Nehalem, how fast is it?

Jim Brayton: Well, you know, I could tell you that, but I'm not sure I could tell them that.

Pat Gelsinger: Oh.

Jim Brayton: But maybe between you and me, real fast.

Pat Gelsinger: Oh, our secret. So what else can you tell me about it, Jim?

Jim Brayton: Well, you know how Paul and Glen demonstrated Nehalem this morning for the first time?

Pat Gelsinger: Yeah, [you've had lots] of time -- four hours -- working on it.

Jim Brayton: Four hours. And Paul really challenged us. He said, hey, go back and do something a little bit more interesting for Pat. So had a lot of time, we went back in the back of the stage, and we think we've put together something that's kind of [interesting].

Pat Gelsinger: Okay.

Jim Brayton: Realize, though, this is A0 Nehalem silicon. This is A0 [Tylersberg] chipset. This is a brand new platform, and it's only three weeks old.

Pat Gelsinger: Okay, so, what can you show me?

Jim Brayton: Well, let's see -- before I show you something --

Pat Gelsinger: Oh, I've got to do [a quiz]?

Jim Brayton: You know that Nehalem is a breakthrough in scaleable computing.

Pat Gelsinger: Right, right.

Jim Brayton: And you also know it's brand new silicon, so how many threads do you think that I'd be willing to demonstrate for you today?

Pat Gelsinger: Well, so we have one core at least.

Jim Brayton: Right.

Pat Gelsinger: And it's SMT, so it should be at least two threads.

Jim Brayton: That's right.

Pat Gelsinger: Okay, two, good.

Jim Brayton: Two threads, you're right, and Nehalem does implement simultaneous multithreading. But this particular version of Nehalem happens to be a Quad-Core Processor.

Pat Gelsinger: Okay.

Jim Brayton: Why don't you guess again?

Pat Gelsinger: Okay, so two times four, we should be at eight threads of --

Jim Brayton: Eight threads. A number --

Pat Gelsinger: [Math pretty good. Binary] stuff comes to me.

Jim Brayton: Another very, very good guess, but imagine if we took two of these Quad-Core Nehalem silicon and put it in a system using QuickPath interconnect technology.

Pat Gelsinger: So you guys did it? You got the DP running?

Jim Brayton: Absolutely.

Pat Gelsinger: So can you show me?

Jim Brayton: Sixteen threads, come right over here. Hopefully [got a big] screen here. Here we go, a Nehalem Quad-Core --

Pat Gelsinger: So a Nehalem system.

Jim Brayton: A Nehalem system, SMT, Quad-Core, two processors, connected together with QuickPath technology running server-intensive applications in the foreground here, some things in the background, all brand new, three weeks old, and we're all very happy.

Pat Gelsinger: This is fabulous. So we see the graphics load, we have background work going on. You have 16 threads -- count them -- all 16 threads up here and running.

Jim Brayton: Seventeen.

Pat Gelsinger: No, 16, do the math.

Jim Brayton: Okay.

Pat Gelsinger: Right, all of those heavily loaded, incredible health --

Jim Brayton: Yeah.

Pat Gelsinger: Incredible health in [first silicon].

Jim Brayton: Yeah, we're very --

Pat Gelsinger: Jim, you guys are fabulous.

Jim Brayton: We're excited about it.

Pat Gelsinger: Wow. Woo! But of course, Jim, there's no rest in this business.

Jim Brayton: Doesn't stop.

Pat Gelsinger: And how's Westmere coming?

Jim Brayton: Coming along, development also up in Oregon and well underway.

Pat Gelsinger: And we already have the team well under way, the Israel team is well under way under SandyBridge. The tick-tock innovation engine doesn't pause. It delivers predictable, powerful, efficient performance for the industry, for Intel, and ultimately for our customers. Jim, fabulous job. Thank you very much.

Jim: Thank you, Pat.

Pat Gelsinger: Thank you.

[Applause]

[Music]

[End of recorded material]