

A CONVERSATION WITH STEVE JOBS

NeXT, Inc. President and CEO Steve Jobs (left), and VP of Sales and Marketing, Dan'l Lewin, discuss the goals of the new company, and the NeXT Computer System itself.

with PETER J. DENNING and KAREN A. FRENKEL

The following interview took place last December on NeXT, Inc.'s premises in Palo Alto, California. Topics discussed include Jobs' leadership and management philosophies—from attracting and cultivating the best engineers to creating the most interesting projects for them to tackle; how NeXT listened to prospective users; why NeXT chose the Mach operating system; the role of its Academic Advisory Board; the automated factory; the future of interactive technologies like Digital Video Interactive and Compact-Disc Interactive; the digital library WORMs and computer security; and finally, the common interests of NeXT and IBM.

PJD I've been very impressed with what you have done to integrate different types of software and hardware functions inside one box. There's a technological problem in doing that, but there's also an organizational problem. You've had to convince seven or eight companies to join in with you as partners. How you did that intrigues me.

SJ That's what happens when you start a company. There's so much happening that you have to have very strong relationships with other companies because you can't do everything yourself. However, these relationships take a lot of time. If they're going to bear fruit, they take a lot of investment. And, therefore, you can't have very many of them. So you have to pick and choose very carefully, a number you can maybe count on one hand at the most. These relationships aren't the kind where you just go buy things from other compa-

nies—you can't be competitive that way. What you have to do is joint research and development with them, and help define products with them, and then do some of the engineering with them. And that requires a set of skills that isn't just engineering. For example, setting interface specifications correctly so that both sides can go work independently, across an ocean potentially. We accomplished just that with our optical disk. We did the entire controller system. We put it on a VLSI chip, and did all the software. We had to define some very clean interfaces. When we got our first VLSI controller chip back and our first disk drive, we plugged it together and we had it running that afternoon.

PJD Where did you get the idea that this was the way you wanted to go?

SJ Well, you can go backwards. Look at the LaserWriter. The LaserWriter was a combination of four things. The first was the Canon laser printer engine, which was just starting to come into being. The second was Adobe PostScript software. The third was Apple's controller technology. And the fourth was the insight to bring it all together and do it in the first place, i.e., wouldn't it be great if we could have a laser printer that only cost a few thousand dollars rather than a few tens of thousands of dollars? We had to negotiate both hardware interfaces with Canon and software interfaces with Adobe. The most perfect execution of the wrong target isn't worth too much. So you've got to figure out exactly what it is you're trying to do.

PJD You spent a lot of time on that, I take it.

SJ We spent a lot of time on it. We also talked to our market quite a bit. When we started NeXT Apple sued us during the first four to five months, which was

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unfortunate. Eventually, they dismissed it. But we couldn't get too much work done, so Dan'l just grabbed us all and we went on the road to visit our future customers and we said, "What do you want? What are your dreams?" They said a lot of things and our first reaction was, "Oh, that's impossible." But they said, "No, it isn't. As a matter of fact, we have a grad student in the back room doing it." And they gave us their best ideas. They showed us their best prototypes. They let us hire some of their best grad students. And it turns out a lot of the things they wanted weren't impossible and they were able to make our product a lot better. We had an idea but they made it a lot better.

KAF How many universities did you visit?

SJ Oh, one to two dozen.

DL And at some of them we'd stay a week.

SJ Quite seriously, we were not just going and visiting the computer czars on the campus. These were visits with the teaching faculty, the research faculty, grad students, students—really understanding what some of the neatest things out there were and what they wanted to do with computers.

PJD Did you find lots of commonality out there? Or did you find lots of diversity?

SJ We found a certain base level of commonality, but then we found a lot of diversity in terms of things like sound. The horizontal category of things were like, "I want a laser printer and I can't afford 5,000 bucks. I want one in my office. I want one on my desk and I'm tired of waiting in line down the hall." That sort of thing. Or, "I need a megapixel display. Don't give me a tiny little display." But the more vertical nature of things was "I really want to do something in the sound and music area," or "I have a scientific application and I need to hold a large data set and I need statistical analysis of this type on it." These types of issues.

KAF So you heard a mixture of very broad requests and very specific requests?

SJ Exactly. For example, a broad request was, "I need to make a program for my class next Tuesday and to write that program on any other computer will take me four to five months and I don't have four to five months. And I don't have the money to pay somebody for four to five months. So I need it by next Tuesday and a grad student and I have to do it and we can invest about two days in it." That was a broad request. These are the kinds of problems that were presented to us to solve if we really wanted to make a breakthrough.

PJD Did you form the academic advisory group at that same time?

SJ Yes, Dan'l pulled that together. There were originally 16 members.

DL We built upon some history—people that we knew. There were a dozen or so in our first session, and we had another session and expanded it. There are about 25 people involved now.

SJ And it's a working session. It's not just a marketing gimmick. People really help us and we listen. We've had several advisory board meetings where they've suggested a change or a new feature that they really wanted to see. And by the end of the two-day meeting, that change was investigated—we did the feasibility study. In some cases it was even engineered. We could actually show it. We said, You're right, and here it is."

KAF How did you decide on the Mach operating system? Was that something that came before the advisory board was formed?

SJ No, we decided to use UNIX mostly because there's no choice. If you want a good multi-tasking operating system with a mature development environment, with good communications, you've got two alternatives: roll your own, which will take five years—I think OS/2 is going to be a painful reminder of how long it really takes—or adopt UNIX. And increasingly, people are saying, "We'd rather spend our energy adding value at higher levels than the operating system. So let's use UNIX and save ourselves all that energy and then we'll build competitive advantage on top of UNIX." Because you might have an operating system that's 10 percent smaller, 10 percent faster, but that's not the competitive advantage people are looking for. People are looking for things like Interface Builder. They're looking for things at a much higher level, which will allow them to have real breakthroughs of weeks and months, not running 10 percent faster in the operating system. We were going to go out with System 5 UNIX but our market handed us our head and they said, "No, no, you don't understand. We want Berkeley UNIX." So we looked at Berkeley UNIX and what some other companies had done with it and we realized that there is a fundamental problem with some of the UNIX architectures out there. UNIX started off as this nice little kernel, very simple, fairly small, fairly fast. But as people started to add functionality such as communications, TCP/IP and NFS would be examples, and they started to add better file systems—the current UNIX file system—they put them in the kernel to achieve the performance that they wanted. This has led to a very fat, bloated kernel.

There are a few consequences that are quite serious. Number one, it's very difficult to maintain UNIX. You have to be a kernel guru, because once you're in the kernel, which is an unprotected memory space, and you do something in one area, it can affect something in very different areas. It can bring down your operating system. To extend UNIX is another example where you have to be one of these kernel gurus. And we felt that that was not the best approach. There are not a lot

of these kernel gurus, and they're hard to find. That's not the right way to go about maintaining and extending an operating system. The promise of Mach is that it lifts up UNIX and puts a very elegant kernel under it again with a very fast interprocess communication, almost an order of magnitude faster than UNIX, which allows you to take things out of the kernel and put them in user processes like communications, like the file system.

Now, why would somebody want to do that? Well number one, if you're not using NFS (Network File System) it would be nice not to use the quarter megabyte of memory. That's a simple one. But more important, people are going to want to experiment with the OSI networking protocols. It'd be nice if they could just flip a user process. Another example: the world needs a wide-area file system. And people are going to do a lot of experimentation. It's going to happen a lot faster, it's going to happen a lot more reliably, if people are using user processes without having to have this ever-expanding kernel. So the reason that we chose Mach was that we became aware of it, of course, through our relationship with CMU, and it offers the promise of the dekernelization of UNIX, which is very, very important.

We're not religious about the surface level flavor of UNIX. We couldn't care less which one wins. We'll go with the flow. And we think people that argue about that layer do so because they have nothing better to talk about. They don't have good toolkits, they don't have good user interfaces. They don't have Interface Builders. Whatever it is that is much more interesting, they don't have it, so they end up arguing endlessly about the 10 percent variations in UNIX.

PJD So in a sense, the initial premise of the Open Software Foundation, an argument about UNIX, doesn't matter in the long run?

SJ Right. I think even they've realized that it's not interesting to too many people any more, so they're trying to build layers above UNIX. We're not religious about UNIX, but we do believe that the underlying implementation technology of Mach is going to allow us to grow UNIX at a much faster rate and much more reliably than any other underlying technology. So we believe in Mach because of the underlying technology, not because it's another surface level variant, which it isn't. It's totally compatible with Berkeley UNIX. And, again, Mach came from the university research communities. Another big thing about Mach is its mechanism for processes to communicate with each other, which we have extended to allow applications to communicate with each other by writing sender and listener objects. And we are doing things now with Mach that people are just dreaming about. Other multitasking operating systems are talking about doing this sometime down the road. Mach has provided us with some

real nice advantages. But we don't trumpet it because we think that's not necessarily the stage upon which the real drama takes place.

KAF Where will the real drama take place?

SJ It will take place at the user level, with applications software.

KAF Do you think that choosing Mach is the most creative direction you've gone in at NeXT? We're interested in your approach to innovation and how you make these choices from a creative point of view.

SJ Well, Mach was a risk, there is no question. But we wanted to build a really fine operating system team, and part of the way you do that is by figuring out what the best thing is, even if it's currently not quite within reach. You make a commitment to that direction, to the best thing, and that's what attracts the best people. We couldn't have built the operating system team we did if we were doing standard Berkeley UNIX like some other people.

DL The same with the factory.

SJ Yes, the factory is another good example. A modern factory does not use a lot of "traditional labor." You use machines, but you use engineers to specify those machines, to build them, to program them, to keep them operating. So your manufacturing becomes really another engineering group. Most companies look at manufacturing as a necessary evil. There's a spectrum and on one end of the spectrum is necessary evil, "We do it because we have to, but we wish we didn't." And then most companies view manufacturing as somewhat neutral. We view manufacturing all the way at the other end of the spectrum. We see manufacturing as simply an extension of the engineering process, where we can have tremendous competitive advantage. And so we built a team of engineers as our manufacturing team. And to attract a team of engineers as good as our design engineering team—peers, really—we knew we had to be pushing the state of the art in manufacturing because we're pushing it in design engineering. So if we don't push it in manufacturing why should we expect to get the best engineers? One of the major reasons we went to surface mount wasn't just because it's more reliable and it's a little denser, but because that's where the edge of the envelope is in manufacturing. That's where the state of the art is. And if we're going to get the best engineers, then we're going to have to be in surface mount technology, because that's where *they* want to be.

So there's a very clear link between the clarity of your vision and the people you can attract to make it happen. And I think people forget that. Sometimes when people think that they should be more conservative, they forget the impact that that will have on the

people that they can attract. It's almost a self-fulfilling prophecy sometimes. If you don't go for the best thing, you almost widen the gap.

PJD Is this philosophy true throughout the way you organize all your projects here, always going for the best thing?

SJ You obviously have to manage risk. But in general if you do fewer things and you focus your energies, you can take risks in the remaining areas that can be focused on, and you can hire the best people, and most likely you will succeed. That's what I have found. Also, it'll take a little longer than you think, usually.

PJD How do you get them to work all those hours in a day?

SJ You don't get them to work all those hours. You try to get them to take vacations. Very, very good people are all self-motivated. You do not need to manage them. You need to lead them and you need to give them tools to interact with the rest of the organization, which they may not be as familiar with. So our jobs as senior managers of NeXT really are to help people get very clear on the goals, to work with them on the strategy part, the focus part. Then to get the hell out of their way. And then also to keep them very connected with the rest of their company and these other very good people.

PJD How do you do that?

SJ Well, for example, at least twice a year, and usually more, we take the whole company away for three days on a retreat. Everybody, including the receptionist. Every group makes strategic presentations on what the hell they're doing and why. And what are the alternatives they could have chosen but why they chose the ones they did and where they are and what help they need from other groups. And part of the attraction of coming into NeXT is that people in engineering will learn more than they ever wanted to know about manufacturing and finance and marketing. And you really understand the whole company as an organism, not just your piece of it, you get to make inputs and ask questions and figure out ways of saving work by getting together with these other groups. It has produced enormous interaction and cross-pollination.

DL It synchronizes people's plans and ideas.

SJ Right. People make agreements about things, but then those agreements get changed by one of the parties because they discover new information. Often, they forget to tell the other party. Keeping a group of diverse areas synchronized and informed is a challenge in itself.

The way NeXT will succeed is, as you know, not on scale. We will never have as many ad dollars as the next person. We'll never have as big of an R&D budget. We'll never have as many salespersons. But we can outthink them. We can have the best products and we can have the best manufacturing and we can have the best strategy. Because that doesn't depend on scale, it depends on people, commitment, and hard work. We

The NeXT Factory: Where Machines Build the Machine

NeXT is proud of its highly automated factory in Fremont, California, yet very little information is available besides the video tape shown at the October unveiling. Only a few customers and key suppliers have been allowed to visit the factory, further underscoring its strategic importance to the company as an asset that must be protected. NeXT has concentrated on perfecting the surface mount technology process, says Dan'l Lewin, and owns the intellectual property of electronic and mechanical systems that make that process as efficient as possible. And to optimize factory operations, NeXT has lured a cadre of Ph.D.s from the Midwest and Florida, where surface mount expertise has excelled in the telecommunications industry. NeXT won't say how much the factory cost, except that it was "significantly less" than the \$20 million start-up cost of the Macintosh plant. No output figures are available for the single assembly line now in place, but we hazard a guess: The line consists of eight stations and processes one board in about 20 minutes. At that rate, the line can complete 24 boards an hour, 576 a day, or 207,364 annually. And space has been allotted for a second line.

What takes place on that line is impressive. At the first stop, an MPM robot stencils solder paste that will hold components on the board. Another robot, specially designed by NeXT, checks the height and skew of 1,700 solder pads, and the company says that keeps the defect rate 10 times lower than on any other surface mount board. Then the board passes through two pick and place stations. At the first, transistors, capacitors, and integrated circuits are placed at a rate of 150 parts per minute on solder pads that are one one hundredth of an inch high. At the second station, a pick and place robot equipped with a vision system places fine-pitched parts. To complete the surface mount process, a computer-controlled oven heats the board to 215° C, activating fluxes which dissolve oxides on the components. Pure solder and copper remain, ensuring the best quality solder joints. Seventy more parts are handled by two Chad robots. These through-hole insertion robots work together; one chooses a part and the other inserts it. Finally, after passing over a wave solder station, an "environmentally sound" cleaning system removes residue and flux. The completed board slides easily into the one-cubic-foot, sleek, black box.

—KAF

have an abundance of good people and an abundance of commitment and people work hard here. We can be very competitive in those ways and we can have the best products.

PJD You said you had some tools that help people stay in communication with one another. Are these electronic tools or are they management tools?

SJ The retreat is a good example. The whole company, of course, is connected with e-mail. We also very much value the middle management. The way we run the company is that once a week, the key middle management numbering 15-plus people, get together, and senior management and middle management run the company together in that meeting. So they're not only seeing how we work and make decisions and approach problems, they are actively running the company. And that's extremely important.

PJD Could you just go a little bit further forward now. Right now, I know your attention is focused on getting your product up. What do you see ten years down the road?

SJ I don't know.

PJD Are you looking that far?

SJ What we're really interested in is augmenting the educational process with these tools—the learning process. We believe that higher ed's a wonderful inflection point in society. You've got people that are mature enough and creative enough to really want to take advantage of these tools. Institutions have enough funds to take advantage of these tools and yet they are not at the point in their lives where they have significant investments in the way things are. They're very interested in change if change is for the better. So it's a wonderful inflection point. People take the knowledge of working with these kinds of tools with them wherever they end up. And they never want to work with anything less. Higher education is a wonderful place to help this process with tools. And that is going to take years. It's not going to happen overnight. And we're committed to helping that happen. Higher education is going to be our primary market. We're really quite serious about it.

PJD There's a discussion beginning to unfold about the possibility, with support from computers, to help students in the classroom actually begin to experience what the faculty usually calls the research process.

SJ Oh, absolutely. What we learned was that one of the most vital sources of courseware will come from the researchers. And it may not be polished and it may not be perfect but they'll bring in to their students and say, "Look at this!" And they'll be tremendously excited about it. But they will never rewrite it for another machine with less capability. They may not be able to rewrite it for that machine. And you'll choke off one of your vital sources of courseware if you make those machines different. So we realized we had to make those machines the same and pull that \$15,000 or \$20,000 research machine down into the range of affordability and have one machine. So that's an example of the kinds of things we've learned.

KAF There has been a lot of interest in interactive technologies lately, like Digital Video Interactive (DVI) and Compact Disc Interactive (CD-I). I was wondering if you see the NeXT machine as being used for that, given its huge amount of memory?

SJ DVI's quality leaves a lot to be desired. It's not an interactive technology so much as a way of compressing video. And because you have to compress it off-line with a big computer taking many, many hours, all you can do is play back canned sequences. Some of that will be important, but what's going to be far more important is synthesis. In other words, I can fly through a DNA molecule, if I want to, if I synthesize the image, versus playing it off a prerecorded image where I can only fly through it in ways that the person that made the prerecorded image has thought of. The production costs of synthesis should be a lot less than with video because we can make tools to help the production costs. Automate them and put the production on the workstation versus needing expertise in video production. That doesn't mean that video is not going to be important, because it is, but synthesis is also going to be very important, I think. That's why we chose the route we did with sounds. We can store and play back perfect digital CD-quality sounds. But that's not enough. You've got to be able to synthesize. Playing back prerecorded sounds is limiting. It takes a lot of storage, number one. Whereas, if you synthesize sound, the actual score or description of those sounds or the music itself is very compact. And you synthesize it and you generate the enormous volume of information in real time so you don't have to store it. And you also have complete interactive control over that. So we think synthesis is very important, not just recorded playback, whether it be audio or video.

KAF Are your comments the same for CD-I as for DVI?

SJ Yes, CD-I is dead. When we introduced our fully erasable optical disk, CD ROM instantly became a thing of the past.

KAF When do you think what you envision as synthesis will really be available?

SJ Oh, some of it's available now. We don't have video synthesis yet, but we certainly have the highest quality audio synthesis that you can get. And because of the speed of the machine you'll see some things happening in the graphics area that are pretty impressive too.

KAF You seem to have a really strong interest in both music and literature, so I'm curious about your choice to include the complete works of Shakespeare.

SJ You know, that's interesting. The hardest thing we did was *Webster's Ninth New Collegiate® Dictionary and Thesaurus*, which is about 25 megabytes of data for both of those books. The complete works of Shakespeare is only about 5 or 6 megabytes of data. So it's actually a smaller work, and in many ways an easier work to bring into the digital domain because Webster's is full of much harder typography and pictures. But people take the dictionary for granted. And when you tell them the complete works of William Shakespeare is on-line and searchable in a few seconds, their eyes light up in an inspired way. So Shakespeare's primary purpose in being in there is: First, Shakespeare's works are the second most oft quoted in the English language behind the Bible. And the Oxford edition is, we feel, the best edition of Shakespeare available. And, second, and maybe primarily, it inspires people about what's possible. Now, it turns out Webster's is remarkable. I use the dictionary ten times a day and you can blast through it in about a second. Using the Mach interapplication communication mechanism, you can blast from any document and bring up the dictionary in a few seconds. You end up using it ten or fifteen times a day and learning many things. Having it on-line at your fingertips is a qualitatively, not just quantitatively, different experience than having it on the printed page. It's remarkable. I can't explain to you how exciting that dictionary is. You wouldn't believe it, but it is. I couldn't live without it now.

DL Being in the learning environment is really critical. That's something we learned. And having the materials and the information there. The tools have to be there all the time and integrated.

SJ And a dictionary is a very, very rugged valuable example of that. Shakespeare is a slightly more lofty example of that.

PJD It's going to explode.

SJ It's going to explode.

SJ The whole concept of digital libraries, which is predicated on searching software technology that we have, and also the mass storage opportunity that the 256 megabyte optical disk provides is going to be enormous. The average book takes under one megabyte.

PJD Could you comment on the Internet WORM attack last November? I understand that students and faculty are concerned about protecting their work stored in workstation file systems.

SJ The famous virus was a result of there being an old trap door into the mail program which allowed you to download something that executed in the recipient machine, which has obviously been removed at this point. So you have to have a way of getting a program into a machine and launching it. Hopefully, those ways have been taken out of the transport mechanisms, like mail. So this isn't a really serious problem. It may become a serious problem if people embed these kinds of things in programs, put the programs on bulletin boards, and when the programs are run, they in es-

Dan'l Lewin and the University Consortium Tradition

NeXT's VP of Sales and Marketing, Dan'l Lewin, has been associated with Steve Jobs since Jobs moved from his parents' garage in the late '70s. Jobs' first office was next to Sony, in Cupertino, California, where Lewin ran the business products sales office. Shortly after discussing the newly introduced Sony 3½-inch floppy, Lewin joined Apple Computer as the marketing liaison to the Lisa division. The targeted market was the Fortune 500 which, to Lewin, did not seem to be the only match. "If the software concepts embodied in the Lisa project came from the research and university community, why don't we want to turn around and take these machines to that market?" he asked. When he encountered resistance from the head of marketing, Lewin asked to try on his own and traveled first to Brown and Carnegie-Mellon, forging ties with the academic community. At the same time that the Mac was progressing, the company was recognizing that Apple II's were not penetrating the higher educational market enough. Jobs told Lewin that he wanted the Mac to reach the higher education market, so Lewin joined the Mac division and went on the road and visited 70 universities. "I flew 150,000 miles in about 12 months on one airline alone," he says, "And put together the business model that Apple now calls the consortium business." Then he built a sales channel specific to higher education which is now a large percentage—as much as \$500 million a year—of Apple's business. At that time, he was also trying to bring UNIX into the company.

Quite naturally, Lewin's role at NeXT has also been largely to coordinate ties to universities and to listen to their requirements. The university community differs greatly from other markets; it wants "a very high common denominator computer that does lots of things, but it is a 'low common denominator market' in the sense that they are more than willing to take care of themselves. They don't want \$200-an-hour technicians," he explains. That seems to be the opposite of the corporate environment, which wants training. Given these unique characteristics, Lewin says his "goal is to reach the individual's needs. Building the organization and the company's way of doing business around the university market is different from going after an industrial, engineering, scientific, or business arena," he says, "So we have a challenge on our plate."

—KAF

sence infect your operating system but don't come alive right away to let you know that. So that by the time some computers start to have problems everyone's used this program. You know, like a six-month gestation period or something like that. There will be more instances. I think we'll find our way through this.

PJD Is it basically a technological problem or a social problem?

SJ I don't think the solution is a technological solution.

PJD Are people becoming more socially aware of their responsibilities in the networking environment?

SJ I don't know what's going to happen. I think there will always be young, creative, precocious programmers who are going to delight in making something work that's cleverer than the next person. But I think we have other important pieces of technology in our society that are just as vulnerable as our networks. You know, we don't have people blowing up freeways. So I think that there are other vulnerabilities in our society that are just as exposed as our computer networks are.

PJD Oil pipelines, gas.

SJ Right, and we manage to channel people's creative energy in other directions than harming these things for the most part. And I think the same mechanisms will take over.

KAF There are all sorts of rumors about the agreement that you made with IBM. One of them is that it facilitates your getting hold of memory chips and the shortage is not, people say, going to be felt by NeXT. Is there any truth to that rumor?

SJ The relationship we have is not a public one, so it's better to keep that quiet. It turned out to be a very good relationship.

KAF People often think of Apple as having been the rebellion to IBM. So since you were Apple, what's caused you to flip flop?

SJ We want people to use really great computers and one way to do that is to make them, which we do. Another way to do that is to influence the software that

people will use on other platforms. And we saw a tremendous opportunity to do that in the IBM world. Hopefully a lot of people are going to be able to use a better computer environment because we were able to contribute to the IBM platforms. We think we have sufficient technology and innovation to be very competitive in what we're trying to do here, while at the same time maybe helping people on other platforms, such as IBM, have a better environment. And that's why we're in this business. So it seemed to make a lot of sense.

The thread that carries through, that makes it all make sense, is innovation. I think that the computer is very young. We still have a long way to go. And anybody that thinks we're anywhere near the end is blind. In this case, IBM seemed very receptive to innovation and was willing to be very open and look to where they saw the best technology.

PJD Before we close, would you like to express anything else?

SJ I think the best way to express yourself is through your work and that's what we try to do around here. We don't say a whole lot. Hopefully people using our products will understand the spirit that drives us.

KAF Do you think that will broaden outside of the university environment in the next decade?

SJ The next decade is a long time.

KAF How about five years?

SJ Our sights are focused—it turns out that higher education is a very big market and just to fulfill the demands of higher education is going to take us a while. They're our primary market and they get first access to the machines.

KAF How big is the market?

SJ It's big.

KAF Can you give me a range?

SJ It's big.

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