An Interview with

MICHAEL L. DERTOUZOS

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Abstract

Dertouzos begins by discussing his research in computer science at the Massachusetts Institute of Technology and Project MAC's change under his direction to the Laboratory for Computer Science. The bulk of the interview concerns MIT's relationship with the Defense Advanced Research Projects Agency (DARPA) and its Information Processing Techniques Office (IPTO). Topics include: time-sharing, distributive systems, networking, multiprocessing, the ARPANET, and Robert Kahn's directorship of IPTO.

MICHAEL L. DERTOUZOS INTERVIEW

DATE: 20 April 1989 INTERVIEWER: Arthur L. Norberg

LOCATION: Cambridge, MA

NORBERG: Today is April 20, 1989. I am in the offices of Professor Michael L. Dertouzos of the Laboratory for Computer Science at the Massachusetts Institute of Technology for an interview on the development of the laboratory and its relationship with the Department of Defense in the Advanced Research Projects Agency. The way, I think, to begin is for me to ask you if you would tell me something about your range of activities in, say, 1970. Pick any date around 1970. What sort of research were you involved in? Who were your colleagues? How much of it was in...

DERTOUZOS: You mean the Laboratory now, or...?

NORBERG: ... Project MAC, or other parts of the MIT campus?

DERTOUZOS: At the time I was not living here. I was living across the rails, as we say. I was doing research in...

NORBERG: Living here, meaning 545 Technology Square?

DERTOUZOS: Yes, I was not on 545. I was doing research on computer-aided circuit design, which had started with Project MAC, of course, because a lot of my work -- in fact, both the things I did were concerned with it. My doctoral thesis was on threshold logic in order (?), sort of a neural macro (?) thing. I was one of the first people to use Project MAC for my book. My book that came out in 1965, which I have here, had all the tables done by Project MAC time-shared system. This was CTSS, in fact. You might be interested to know that I never learned how to program on the older systems. That was my first system, so I never knew how things got better. The other piece of research I did, closer to the 1970 period, was on analyzing circuits. I had worked on programs that, if you gave the computer a description of the circuit, a linear circuit with transistors, with resistors, capacitors, then the programs would analyze

this and give me the performance of a circuit in time, in various other parameters, various other ways of expressing it. Then you could analyze them and vary things and gain an understanding. It was CAD -- one of the early examples of CAD. It used to be called CIRCAL. That was what I was doing. I was using, of course, a lot of the MAC resources. I remember the agony of going from CTSS to Multics, which would have been just about then. I remember first having great difficulty using it and then moving everything to Multics and basically having a lot of good stuff there.

NORBERG: Now, wasn't Multics in full operation by 1970?

DERTOUZOS: Yes, I believe so.

NORBERG: What other activities were going on in Project MAC at that time?

DERTOUZOS: Well, around the 1970 to 1974 period, I do not remember the time exactly, when automatic programming grew here. There was a sense, if I remember correctly, that timesharing was now reaching its apex, and this place better do something new. So the idea came out of somewhere -- I do not know where, that the next big thing is automatic programming. Fredkin was director at the time, and you should talk to him about it. There was a big brouhaha. Lots of people were brought in. Bob Balzer was involved from ISI, and here the late Bill Martin was involved. But there were other people as well. I think it did not pan out, as you probably know.

NORBERG: Which did not pan out?

DERTOUZOS: Automatic programming.

NORBERG: Why not?

DERTOUZOS: Well, I think it was too ambitious to hope that you could go that high up. For example, in the case of

Martin, he looked at inventory control systems and he was hoping to describe the inventory control system in a hundred lines and then generate COBOL -- lots and lots of COBOL, hundreds of pages. It was just that the inventory systems varied too much, and the power of computing and software was not yet up. Even today you find some of this, but it is very, very rare. I could give you the name of a product today that does automatic programming very well. It designs interfaces for the Macintosh. You draw the interfaces, the windows and all that, and it generates 200 pages of PASCAL code. But the applications are not narrow enough to invite this, and it failed. It did not go very far.

NORBERG: What happened within the Laboratory then to break it down into reasonable projects to do?

DERTOUZOS: Fredkin is the first one who, I think, instituted in the very early 1970s a division of the Laboratory into what he called at the time three or four major divisions. That, I think, you will corroborate if you look at the record. One was the Automatic Programming Division, I seem to remember. And there were other things that I do not recall.

NORBERG: Fundamental studies, computer systems research, programming technology.

DERTOUZOS: See, there you go. Now, of course, when I took over later I divided things a little bit differently. That is the division we have today. But already these things were beginning. Keep in mind the Laboratory was very, very much into timesharing, and very, very much into the issues of those systems. The activity in automatic programming was not very big. There was fundamental activity beginning, the theory, but even that was not very big. When I took over in 1974 we were more than 70-75% DARPA funded. The Laboratory was still very, very heavily into timesharing and related systems.

NORBERG: I see. I did not guess that from the number of people who were listed as being the staff of Project MAC at the time.

DERTOUZOS: We were still very much involved, in spirit, in the research and everything. People were reluctant to

shift away. Now, I will make corrections to that. The theoretical side, like I say, was beginning to grow, but it was still very small. People like Jack Dennis were beginning to think of data flow, and parallel computing, but it was very much like a germ of an idea. The bulk of the Laboratory was still in the systems area, and was worrying about the basic things that go with a timesharing system.

NORBERG: Do you remember during this period of the early 1970s what your interaction was with DARPA people, if any?

DERTOUZOS: Yes. I very well remember meetings of DARPA people coming here. And I remember Fredkin and them disagreeing with each other.

NORBERG: Disagreeing about what?

DERTOUZOS: Fundamentally they were fighting about who tells whom what to do. I remember Fredkin felt that DARPA was trying to dictate too much to him at the lab's review. Later, I never found that to be a serious problem. To this day, DARPA is extremely interested and open to creative suggestions from the field. Sometimes they have their own suggestions, which are very good; for example, Morse Code. We took that suggestion right out of DARPA and worked on it.

NORBERG: I see. I did not realize that.

DERTOUZOS: Yes, and they have always, and to this date they are open to suggestions from the field.

NORBERG: Was Fredkin reticent to approach the DARPA people, where you seem not to be?

DERTOUZOS: I don't know about that. I do know that I embraced them and they embraced me. We have had our differences over the years, but we have been able to work together as an extremely good team.

NORBERG: When you took over in 1974, the organization was still called Project MAC.

DERTOUZOS: Yes, I renamed it.

NORBERG: Yes, I gathered that. But do you recall how much of the Laboratory's activities were consistent with the overall program of DARPA at the time? We are speaking of 1974 now.

DERTOUZOS: There was no such thing as a strong DARPA driven component.

NORBERG: Here or there?

DERTOUZOS: Here or there. I remember one of the first things I did was to visit DARPA. At the time Licklider was in charge, and I said...

NORBERG: This would be his second time.

DERTOUZOS: Yes. So I am going to be director of the Lab. I want to understand what it is that DARPA does. So I went and got a tour, and a show, and an exhibition, and a discussion of what they were after. I remember finding things very, very vague at that time. I asked them, "What does ONR do?" because ONR seemed to be in the picture. I found that two or three people there had great difficulty explaining to me what ONR did [Laugh] because ONR was a contractual monitor, of course. Later, as time went on, I began to understand how DARPA operates. Smart people within DARPA and smart people from outside keep formulating a changing pattern of ideas, and you find almost no differences. You will find that these outside and inside people have their ideas gel at about the same time. And I think part of it is they influence each other. They coalesce in these new directions, and I can go back and pinpoint them for you.

NORBERG: Be my guest.

DERTOUZOS: Sure. Well, let me start back at one of the first discussions I had. I remember being at the roof of the George Washington Hotel right next to DARPA, around 1976. I was with Al Vezza and Joel Moses, who was then Associate Director of the Lab. The next day we were going to visit DARPA. I said, "Look fellows, you know, the world is going to go to distributed systems." That was in 1976. That was a long time ago. Distributed systems were unknown, so you have to define them: lots of computers at different places connected by networks. You see, the ARPANET was known. But it was only known as a medium for logging onto other computers and a way of doing Telex (Faxing in today's language). Nobody thought that you would have computers all over the world that would have to interact with each other, understand the same language, and be a community of machines. In many ways that was one of my inspirational thoughts and hopes in 1976. Now, I am not going so much for the credit here, although a bit of credit is deserved too.

NORBERG: [Laugh] We'll take care of that.

DERTOUZOS: But I am really trying to explain to you the mindset at DARPA. So I went there the next day and I explained. I gave my impassioned plea and my description of where the world was going, and where we think we should take it. I talked about distributed systems, the power of networks, of machines. I talked about the information marketplace, how machines and people would trade things with each other, how it would help mail in this country, the transaction services, the rendering of legal services -- the whole bit. It was a picture that you see, even today, in the writings of futurologists. When I finished I remember the fellow in charge (I think it was Colonel Russell... maybe it wasn't) made the statement, "Look, we think all this is nonsense, but you are the director of LCS and you may be right. You have $300,000. That is what you asked for; you are going to get it. Get it started."

NORBERG: Yes. Well, can we back up just a little bit. How did this proposal of yours compare with their distributed information systems program that was going on at that time?

DERTOUZOS: There was no perception of distributed systems as I just described them. They viewed distributed systems as entirely different things. I mean, they were thinking of sensors in the field. They were thinking of fusion of information from various places. They did not think of distributed systems as powerful equal entities, that would negotiate in some form of open ended fashion. The image I presented to them was much like that of people in society, much like offices and stores, and entities like our own selves. We do not give each other all the details we have. We just do enough to communicate so as to achieve our goals. I said, "We need to understand the semantics of the languages and the systems that are going to do all of this." That was what led to our work on ARGUS, and later to TRIX, and more recently to MERCURY. Of course, DARPA did not think that this vision would play. Yet, there was this belief, this sense that if there is a group of smart people at MIT who want to go that route, damn it, we are going to let them go.

So that is one example. A second one is multiprocessing. We talked about multiprocessing. There was a time, believe it or not, when DARPA did not want to hear about multiprocessing, about several machines working on the same thing. I could not get them to fund Jack Dennis. Slowly, slowly we came to the point where they not only espoused the whole multiprocessing notion, but to where strategic computing was formed with multiprocessing as its core. Now this takes us to a period that is quite a bit later, and starts around 1979. Arvind came from Japan. He brought the fifth generation plan with him. I got on the horn and started screaming. I wrote to our computer corporation presidents. I went to visit the Defense Science Board. I started working with Cooper and with Kahn. I was not alone. There were other people around the country feeling the same way. Soon we were sitting around the table and we were putting together the key ideas behind SC -- Strategic Computing. If you try to see who started this or where it went, you will find it distributed equally within DARPA and outside. Multiprocessors fared very well in that program.

NORBERG: Who was the IPTO director at that time when the Strategic Computing program got started?

DERTOUZOS: Bob Kahn.

NORBERG: What sort of interactions did you have with Kahn?

DERTOUZOS: I remember Kahn telling me (it may have been very close to that meeting): "You guys have had a pretty good record over there at MIT and you, in particular, Michael, just seem to have a good common sense about where things ought to go." Then he said, "You know, on the other hand, you guys are not always right." But there was basically a respect on Kahn's part for what we had done -- in other words, an openness and respect. There was also a respect from our side for what DARPA would say. For example, near that period one of the DARPA people said, "Why don't you solve the Morse Code transcription problem?" And we said, "What do you mean? It is obvious. You know in Morse Code: dit-da=A; da-dit-dit-dit=B." They said, "Oh, no. Make me a Morse Code machine that will work with intelligence and will understand things in a noisy environment." I think you should talk to Al Vezza about that whole problem, because he took it over and solved it. This was driven initially from DARPA, yet we ended up making a very important contribution. So there was this distributed period; then there was the multiprocessor and strategic computing theory. Let's see, what program came more recently, after the strategic computing?

NORBERG: In DARPA or in MIT?

DERTOUZOS: In DARPA. We really do not have one yet. The more recent movement is Squire's movement, which has not panned out yet.

NORBERG: I guess I don't remember one in between Strategic Computing and now.

DERTOUZOS: No, there hasn't been one. There is one now. It is the one that led to the OTA study. It involves the National Research Network and things like that. We tried, at various times, to push DARPA in other directions -- for example, theory. They did not want to touch this. The only time it succeeded was with Jack Schwartz last year. For the first time he started thinking of theorizing.

NORBERG: Why do you think they did not want to do the...

DERTOUZOS: I think they felt the issue of turf. They felt that NSF ought to be supporting that. That is the basic scientific apparatus of the country. Also, it is hard to predict where theory research is going to go, and it is not quick in its results. Whereas at DARPA, a young manager would get an idea, "Hey, let's have a project," and that gave the agency a lot of strength. They had no peer reviews, nothing to worry about, a lot of things that could guarantee bad quality under other circumstances, but as long as the people on both sides were good it worked. You see, in a way, this is why DARPA people were very good, and the field was very good in those days. I mean, they only dealt with MIT, Carnegie, Stanford, where, by the mechanisms that these institutions had, there were only good people there. If any one of these factors were gone -- bad people in DARPA, or bad people in the field, this could have been the scenario for disaster.

NORBERG: Yes, it occurs to me to ask whether or not there was any effect of technology in all of this?

DERTOUZOS: Any effect?

NORBERG: Yes, was there some sort of fortuitous development, say, in semi-conductors, or materials, or somewhere else, that made certain things possible that might not have been possible otherwise...

DERTOUZOS: Yes.

NORBERG: ... and so you were able to capitalize on that as well.

DERTOUZOS: Yes, I think, first of all, the general answer to your question is absolutely so. The field was much younger and was growing more steeply. For example, the microprocessor emerged just about at that period. So when we did our work here on workstations, advanced workstations, we developed a Nu bus, which became the standard of the Macintosh II, of the Next machine, of the TI Explorers. We did that in 1979. The reason we did that is because,

as you say, the microprocessor had emerged. We wanted to build a machine that could change microprocessors like shirts as they evolved. In 1979 we foresaw that there would be little future in people who designed their own processors. We thought that Silicon Valley would eventually produce such fast standard stable commodity processors, that we had better develop mechanisms to use them. That was what drove us to the Nu bus. That was what the Nu bus was for. And it has succeeded admirably in that quest. So again, we went to DARPA with that. They did not believe very much in that, but they funded it. Then funding increased. You have the same pattern: there was first a period of incredulity and disbelief, and then a period of rising slope where it becomes popular and everybody else does it.

NORBERG: Are the budget numbers for LCS public or not?

DERTOUZOS: They are not public, but I can tell you...

NORBERG: Okay, I am not trying to get you to reveal things that are not supposed to be public.

DERTOUZOS: No, but I can tell you what the range had been. When I took over the Lab in 1974, we were in the 2 million range. Today we are in the 18 million range.

NORBERG: Now, those are very small numbers in comparison to the overall DARPA budget, certainly.

DERTOUZOS: That is right. Yet that small. If you take the budget that was allowed for pure computing for pure advanced, forward research, that number today is not much more than about 100 to 120 million.

NORBERG: I would have said 150, but...

DERTOUZOS: If you looked at it back then it was not much more than 25 to 30 million.

NORBERG: Okay, so, two to eighteen would be a considerable ratio.

DERTOUZOS: Then over 75% of that 2 million was DARPA, so you could say that we had somewhere in the area of five to six to seven percent of their money. Today, if you look at the 100 million, we have somewhere in the area of seven to eight percent. We have about nine million from DARPA.

NORBERG: So it is staying in the same percent...

DERTOUZOS: Maybe it is even rising a little. But it is a smaller proportion of the Lab now. It is now about 50 percent of our total, because we brought in industrial funding and other things.

NORBERG: Well, I noticed in reading the brochures, the reports, and the proposal made for the period 1986 to 1988 for the LCS Common System, that the ties to industry seem much...

DERTOUZOS: Well, we have been accelerating...

NORBERG: ... the ties to industry seem to be stronger than they were back in, say, the late 1960s.

DERTOUZOS: Absolutely! By design. I set a goal to bring down funding for vulnerability purposes, but more importantly, to increase industrial participation, and God, I was lucky again. I sensed that partnerships with industry were going to be where we should be. Now, of course, it has become common knowledge, and we have a leg up on that.

NORBERG: Yes. Now, is this something that one can trace back to the 1960s where people like Licklider and Fano set out to make industry change its mind about the way computing ought to be done?

DERTOUZOS: I do not think that they tried very hard. I think they...

NORBERG: Tried to do what?

DERTOUZOS: To make industry change its mind. Neither Fano, nor Licklider, nor the team of people that were in those days the gurus of the various labs -- the McCarthys of this world, the Allen Newells -- were very industrially oriented. The generation that is now running the DARPA sites, many of them are or have been corporate players, owners of companies. I started my own little company; Feigenbaum has started two or three; Nils Nilsson has started his company; Raj Reddy has started his company. You are looking at a team of people for whom industry is not so far from academic work. Now, Fano and Licklider and Corbato -- our good friends from that period -- went out and said, "Here is how you should do it." They tried to convince them, but they did not speak the language of industry, and industry said, "Goodbye, we are building the System 360. Thank you very much." And who says they were wrong? They made more money on the 360 [Laugh]. You know, timesharing lasted a good 30 years and then started giving way to personal machines. Are you a historian, incidentally?

NORBERG: Yes.

DERTOUZOS: So you can understand all these things.

NORBERG: I started out on the IBM 1620 and went on to the Philco 2000, so I go back that far. I want to again go back to the 1974 to 1976 period, because I am interested in seeing whether there are some trends here. One of the questions that occurred to me is, why did you rename the Laboratory?

DERTOUZOS: [Laugh] Well, there are three reasons. Well, first of all, MAC sounded like a hamburger.

NORBERG: At that time it would have.

DERTOUZOS: Also, "Project" was a trick that my friend Bob Fano did to get people to come here without coming

here. If he had called this a lab or a center, people would have said, "My God, I am not going to leave RLE or one of the established big centers to come to this fledgling place. So Fano, in his wisdom, said, "Project MAC. Anybody can participate in a project." However, it was untenable for me, when I was trying to build a laboratory that would be a forefront center... a forefront center for computer science research, that I would call it a project. Second, MAC was losing in meaning. It did not mean anything to people. It had some nice value in terms of tradition. But after a while, you have got to change with the times. So I put on a search, I probed. Joel Moses who was Associate Director for the lab helped. We put up a lot of names, and we chose the Lab for Computer Science. I am glad we did it.

NORBERG: But from what you said, it sounds like it has nothing to do with program reorientation or anything of that kind.

DERTOUZOS: A lot of it was from my own brain, my own thoughts. You are looking at something driven by the director -- a sense, a need to create, both in terms of goals and in terms of name, as well as all the other things that go together in terms of personnel you hire, to create a new direction. I was not happy with the laboratory that was so predominantly DARPA-oriented and funded, and so predominantly narrow in the systems area. I wanted us to be more industrially-linked. I wanted us especially to build multiprocessors, distributed systems, to expand our theory, to start really working with the practical problems of industry, and to maintain an even greater theoretical... I really wanted to spread out and have forefront research, of course. I envisioned having, instead of one project like timesharing, two, maybe three big ones, and a whole bunch of little ones. And that is what happened.

NORBERG: How did you convey this new objective to the people who were then associated with Project MAC?

DERTOUZOS: When you run an educational institution like this, like [Bartlett] Gamatti said, "You have to run it from a medieval throne -- even in a 20th century environment." [Laugh] So you must appreciate that if I were to stand up and say, "This is what I am trying to do," I would have had a revolution. Basically, what I did was I spoke about it. I said, "This is what I feel the important interactions are." Then step by step I made the right moves. There was something very important about the laboratory's faculty: they would hear something and they would say, "No."

Then they would hear it the second time and they would fight it. And then the third time, if it had good components, it would be their idea. Now be careful. Many times I was all wet, and they would come back and clean me up, and correct the all-wetness. And I listened. So this is a bilateral thing. We have moved with a great deal of teamwork around this lab. After a while I gained credibility here, and then they trusted me. You know what I mean?

NORBERG: Yes.

DERTOUZOS: Then it was much easier. So that was how it was done.

NORBERG: I noticed an almost complete changeover in administration in 1974. The people who had been running various groups were now gone.

DERTOUZOS: That is right.

NORBERG: Where did they go? Back to other laboratories within MIT?

DERTOUZOS: I did not plan any demise. It was just that I set the directions and the people who played, played. Those who didn't like it left, or attrition took them.

NORBERG: What sort of other computing was going on around the Institute at the time then?

DERTOUZOS: There was very little. The AI Lab existed then, as you know. That was the sin of our forefathers -- Licklider and Minsky. They decided to split the labs up. In the history, there was a period there...

NORBERG: Pardon me. Was there something wrong with that split-up in your mind?

DERTOUZOS: Yes and no. First of all, in terms of what it ultimately meant, there was nothing wrong, because we

were so big that we could not have run as a single center. There are 380 people at LCS, and there are probably 250 at AI. So it would have been too big. In terms of keeping cohesiveness and keeping the community together, however, we might have stayed closer together. You see, the distinction between AI and computer science is artificial. There is no such distinction. Well, people behave like there is -- even knowledgeable people. That is one of the things I have fought since day one. We have plenty of AI in this lab. This lab and our sister lab have plenty of what you would call computer science. So it was a little bit intellectually dishonest to make that distinction. There was a point where DARPA tried to help us unite. Colonel Russell and others at DARPA were putting on a little pressure. They did not like the way the AI lab behaved. We were a little more corporate, a little more organized. The AI culture was a little more disheveled: do what you wish and this is how you get the best result. Both places were getting great results, but one was doing it IBM-style and the other one was doing it Apple-style, if you wish. DARPA did push a little, but not hard -- very gently, but that did not work out for a variety of reasons. So that is part of the history, too.

NORBERG: I am sorry I interrupted you. You were talking about the computing environment around the Institute.

DERTOUZOS: Well, yes. You see, I did a survey in 1979, which I will let you have, of the computing in the Institute. There was hardly any computing for educational purposes. I think we had maybe a couple of hundred computers around. The undergraduates and everybody else had hardly any access. There was some IBM facility over in building 26, where people did sort of routine computing. That was kind of dying away in the early days of computing. There was some activity on supercomputers going on but it was over network lines.

NORBERG: Over what? Network lines, did you say?

DERTOUZOS: What period are you talking, now?

NORBERG: Oh, I was saying about the middle 1970s, when you took over Project MAC, when you renamed it.

DERTOUZOS: Oh, I do not think there was that much yet. The networks were not that good. That is all. I will take

that back. So there was some local computing. There was hardly any personal computing yet. Minis were beginning to sprout, so you would find maybe a single mini in aeronautics and in other places -- again, just in a research environment, no computing for the undergraduates and no computing for the instruction of education or things like that. In terms of research, there was really nothing beyond what was in this building -- AI and LCS. We were the heart. Now, there was a little bit of computer research at the Sloan School on applications -- architecture. Negroponte was beginning to build his architecture machine. That was about it. But today the picture is not very much different. I mean, now we have a big media lab which Nick pulled together, and the Sloan effort is bigger, but it is still the same players.

NORBERG: Yes, but now there is good deal more computing around.

TAPE 1/SIDE 2

NORBERG: Project Athena...

DERTOUZOS: Project Athena, which we did precisely to bring computing to the educational and instructional side of campus. So now, of course, with personal computing and with the networks around, the scene is pretty much as we had predicted in our 1979 report. Then we predicted that we would have by now, 10 years later, around 5000 machines, 4000 or 5000. We are right on target.

NORBERG: Yes. What has that meant in terms of the Laboratory's interaction with the rest of the computing community on campus? Let's stick to the Institute first, and I will speak about the nation after that.

DERTOUZOS: We have been...

[INTERRUPTION]

NORBERG: Okay, I would like to return to what we were talking about. The interruption gave me a little time to think about what you had been saying, and I want to go back to one other thing that I did not get a chance to cover as we were going along. That is, when I asked you about your interaction with the people at IPTO and at DARPA, you began to describe quite well the various interactions concerned with what sort of plans and programs were being discussed. I want to get down to a slightly lower level inside IPTO for reasons that I think will become obvious. That is, what was your experience of the running of the IPTO office? Let's take it in two ways, one of them being the procedures that you as the director of the Laboratory and any staff members who might be interested in interacting with them.

DERTOUZOS: It is obvious, and the other one?

NORBERG: Well, what do you mean it is obvious?

DERTOUZOS: One was the procedures.

NORBERG: You mean you are not going to answer me?

DERTOUZOS: No, my answer is obvious, but I was just rushing. What is the other one?

NORBERG: The other one has to do with what sort of meetings occurred in that period with either scientific personnel of the IPTO office, or in PI meetings, which had been a favorite tool of the 1960s, and how these thing were different in the later period.

DERTOUZOS: Very different. Let me give you the style. I will paint it like an impressionistic painting rather than a precise picture for you. There is a sense in my head that in those days we were able to get things done a lot more easily.

NORBERG: Those days, meaning early 1970s?

DERTOUZOS: Meaning essentially all of the 1970s. You would basically pick up the phone, have a discussion about a new idea. You would get a reading as to whether the new idea made sense. You would go down to Washington, spend a couple of hours, and it was done. Then the bureaucracy maybe took two months. Let me give you an idea. Up until 1983 or 1984, we could submit our proposals in August, and have full funding in place by the end of the year. Okay? I will trace it, but I think it goes all the way to 1985 or 1986. You would go to the PI meetings... I remember, in fact, as a young turk, taking over a meeting and discussing future directions and everybody being happy about it. A lot of things came out of this -- a sense of common language. I mean, when I am together with Feigenbaum or Raj Reddy, or Nils Nilsson, we all have a sense that we are the same community. Oh, we may disagree on small things, but you know, we feel French. All of us feel French. DARPA is French.

Now, several things have happened. Some things have changed. First, the bureaucracy that has entered that organization is much greater. Now it takes a year, even for a place like MIT to get a proposal through. The freedom of going down there with a quick idea and getting going is no longer there, because now there are all these bureaucracies set up, in the interest of fairness, for small people and big people to compete on equal terms -- all of which has a lot of validity. But then, of course, who says that you've got to be fair if you have got to be inventive. Then there is this tendency, which started for no good reason, which I call the systematic broadening and the systematic destruction of the strengths of DARPA, which was to take what was great and worked, and start chopping it up based on absolutely no rationale. So now you find 300 universities competing, or 300 contractors competing, in inky-dinky chunks. If you go to the PI meeting today, it is a big mass affair where you go hear big people speak. And there is no longer a sense of give and take, of "Let's get together; let's pull this. What do you think of that idea?" There is just too much variability between the people who attend. I am very consciously trying to not be old man with the old man syndrome of "It was good then and bad today." I am trying to be as objective as I can, because even today, good things are happening.

NORBERG: Yes, but given the ability of the Department of Defense to, it seems, act rapidly if they want to, why

should this continue to be the case once it is recognized to be a failing of the system?

DERTOUZOS: The first factor is the succession of people who got into DARPA. Each one had his own agenda. Some came from the aerospace establishment. They did not understand computers, and they wanted things to go like they did in the aerospace business. So they had that agenda. Other people came in and were reluctant to go up to Congress and say, "Computing is the only thing left in this damn country. We lost steel; we lost textiles; we lost electronics. Are you going to support us?" Nobody until recently has gone to Congress and said this with this conviction. And, to be sure, there is some rationale behind this weakness. After all, why should the DOD be the Agency to mind for U.S. competitiveness? Well, it has done so and it's the only game in town. Enter now, the bad boy -- the bureaucracy and the requirements -- and everybody uses that as an excuse for all that happened.

NORBERG: Do you think something like *Made in America* will turn this around?

DERTOUZOS: I know that if one good person were to go in there, he could clean that place up in six months.

NORBERG: Well, considering the number of good people that are around, why won't people go? They had a terrible time...

DERTOUZOS: I know that...

NORBERG: ... a difficult time to get Schwartz to go.

DERTOUZOS: I can answer that for you, because I have been Chairman of the Advisory Council to DARPA for years. I have gone after people myself for the job, and others have come after me. One is a damning statement for all of us. We are not cooperative. So people like me, and people like my colleagues, will not stop doing what they are doing and go do something that is perhaps less exciting for a couple of years in the interest of helping the U.S. First, there is a component of lack of cooperation that *Made in America* brings up. Second, however, there is a very

practical component: money. I had people in the palm of my hand who were ready to take this job if I could only get up there and pay them the $150,000 that they required, or the $160,000; yet all I could get for them was $65,000. These are successful people with children. These are people making $160,000. There is no way to get them. So, you have got to be financially comfortable or independent like Bob Kahn was. Bob was one of the superb people that we were lucky to have there. But if his dad did not have a medical forms business, we would not have had Bob Kahn, and where would the computer industry be today? It is almost as fickle as that.

NORBERG: I see, because Kahn seemed to me to be a man with a mission. In some respects, at least with respect to networking.

DERTOUZOS: But what allowed him to have the mission was his financial independence. I mean, Kahn did not need anybody's money, and he was at DARPA 12 years, which was a boon to all these programs; the SC and everything else was a result of that.

NORBERG: Do you think that that was not a problem in the 1960s when people like Licklider and Sutherland went there?

DERTOUZOS: That is right.

NORBERG: The salaries were less.

DERTOUZOS: That is right, the differential between outside and inside, a) was smaller and, b) more significantly, the field was so much in its infancy. The excitement was so high that the sense of what you could achieve with the steering wheel called DARPA was much greater. Now, you know, computing is 10% of the GNP, 400 billion dollars, hardware and software combined. And you are just sitting there. Industry and everybody else control this 400 billion, and you have got a little chunk of 120 million, and another 100 million in applications. What do you think you can do now? That's the first. Then you have got a two to one ratio on salary; then you have got the bureaucratic

procedures; then you look inside and the personnel is not stellar. If you are a top notch person and you are also not very cooperative, you know this is going against several gales.

NORBERG: It strikes me that you are painting a very pessimistic picture for the future.

DERTOUZOS: I do not think it has to be pessimistic. I think...

NORBERG: Ah, but that is not what I said. I said that you were painting a pessimistic picture.

DERTOUZOS: I am an optimist; I want you to know this. But yes, I paint it pessimistic because the field is leveling out. The field is not growing as fast as it used to. It has become more mature. Computing is now accepted; it is not a fringe field. Even the kids that we get here are normal [Laugh]. They are no longer the wild geeks, the unwashed. We get normal kids [Laugh], so something is wrong. So how can I but be pessimistic? I will tell you, the one thing that...

NORBERG: Where are all the wild kids going, incidentally?

DERTOUZOS: They are sitting still now. They are waiting for the next higher technology.

NORBERG: I am sorry. I didn't mean to interrupt you.

DERTOUZOS: No, no. It is a perfectly legitimate question. Look, all they have got in this country at the peak of intellectual activity now is biotech, material science, and computer science. These are the three hot seats. And material science is not that exciting. So biotech and computer science are the queens. That is the leading edge. And biotech is not getting that many geeks either. So both fields are beginning to level out. Maybe there will be a new one -- I do not know, maybe fusion; who knows? Look, if we could spin salaries off and make it possible for people to live on them, you could find good people. I think that it is a question of survival; if you have two or three kids and

all that, you can not live on the stupid salaries they give. So if you can satisfy that, as a minimum, then I think you can find dedicated people, that will do the jump. So I am not pessimistic if we tend to it.

NORBERG: If you were in my position trying to assess the influence of the IPTO portion of DARPA on developments in computer science, what sorts of things would you focus on in order to tell this story in an adequate fashion?

DERTOUZOS: I would say, first of all, that if we look at the computer field as a whole, I can peg for you the major contributions in the field -- forget who did them. So I would say the microprocessor, the personal computer; I would say artificial intelligence; I would say languages like FORTRAN, compilers, LISP; I would say advanced work stations, distributed systems, the whole networking from local to broad area networks; multiprocessing; and work in theoretical advances. Then I would say, "How much of this do I credit to industry, and how much do I credit to DARPA, and to NSF?" I would credit NSF with a lot of the theoretical advances, period. Regardless of what they say, I would stop there. I would credit industry with the microprocessor, with making the computer a commodity, a staple commodity like bread that you go out there and buy. I would credit DEC with doing this with the PDP-8 in the mini era, and credit IBM with doing this with the PC. I would further credit Xerox PARC with that whole invention of the Apple Macintosh personal computer world, and then I would credit Apple with the continuation of that. I would credit our semiconductor industry for the invention of a whole bunch of other special purpose devices that have really played a major role, special purpose semiconductor circuits that have done so much. Then I would turn around and I would credit DARPA with timesharing, with the whole field of artificial intelligence, with the LISP language, with a lot of the pioneering work in distributed computing, with multiprocessing, unquestionably, and with networks. Then I would sit and weigh these two parts on a scale and say, "Look, we are all human. I may value something more than the other, but those two are not far from equal, my friend. DARPA has been responsible for half the computer field's evolution in the world."

NORBERG: Okay, how about people. People were not mentioned in this. It would seem to me that...

DERTOUZOS: This was technology so far.

NORBERG: Yes.

DERTOUZOS: Now, if I look at the people, where are the leaders today? You will find that with very few exceptions, the leaders have all passed through the DARPA school in one way or another. They have either been on the side that was funded, or they have been on the side that was funding. You look at DEC and you ask yourself, "Who was heading operations?" Visotsky, here, was in the Multics effort. Bob Taylor, out west, on the research side, was part of the early DARPA effort. I think that he was down there working then. You look at a lot of the companies that are in the forefront today, and you find people at HP -- people like Birnbaum; people like Ira Goldstein -- that have passed through this circuit. So DARPA has contributed a lot to people.

Then if you ask what we at MIT, and Stanford, and Carnegie have been able to do by educating the cream of computer scientists throughout the world, you can attribute a lot of this to DARPA. Without DARPA would we have had such strength? Would we have had this vigor? I look at this Laboratory -- 25, 26 years in existence and see steady funding. I have tried to get funding from industry. I would say that the effort and the difficulty of getting $100,000 from industry is maybe five to eight times higher than getting it from DARPA. Where would we have been if we had to get funded from industry? We may not have generated as many computer scientists, as many good people, and so forth. So I think the impact of that organization has been tremendous. They are the closest thing we have to a MITI. If I am bitching about something, it is because forces unknown are trying to change that. They are trying to change something that is working perfectly all right, or they are trying to question it by virtue of turf, you know, "Should they be doing this and all that? Isn't their function the military?" When we are working with a tool like the computer it is like pliers. Do you care if the pliers are going to be used to pull nails, or if they are going to be used on people's teeth? [Laugh] The intent is a human purpose; it is a mechanism that we are talking about. I think DARPA has a profound influence... Unquestionably, it has had a profound influence on the computer field.

NORBERG: Do you think that the DARPA influence in LCS will continue?

DERTOUZOS: I think it will continue, because LCS by now is so broad and big that it is inconceivable that it will do things that are not in line with what DARPA at any time thinks is in line. I think we still have our problems. For example, I think LCS is the only place, I repeat, the only place that is resisting doing things with as short-time horizons as DARPA is pushed and is pushing to do. Kahn predicted this. He said that LCS is going to be the only place that is going to be able to hold on because of its established record and all that. How long we can do this I do not know.

NORBERG: That is interesting. Does that mean that places that Carnegie and Stanford are giving in already?

DERTOUZOS: Oh, yes. Carnegie is working on systems that are in use today -- the MACH (?) system and all that. I have always felt that if we start working on things that are current we are dead, because we are competing with industry. We have got to stay at least ten years in the future. How long we are going to do this I do not know. But I will tell you, we are strong enough now to where if DARPA decided to go loose on us we could survive.

NORBERG: Okay, that sounds like a good stopping point. I realize you are pressed for time, but I appreciate the help.

DERTOUZOS: There is a lot there, and I have a sense that if I were to go back in my records I could probably find a lot of gems for you.

NORBERG: Let me pose some questions for you at a future time when things are not quite so pressed, and we will see whether or not those elicit further remarks. Thank you.

END OF INTERVIEW