An Interview with

PETER LYKOS

OH 214

Conducted by William Aspray

on

13 November 1990

Chicago, IL

Charles Babbage Institute
Center for the History of Information Processing
University of Minnesota, Minneapolis

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Abstract

Lykos begins by describing his work with computers in the curriculum at IIT. He discusses his work at the National Science Foundation (NSF). Topics include: the creation of the Computer Impact on Society Program; the personal pressures associated with working at NSF as a rotator; and his interaction with John Pasta, Luther Williams, and Frederick Weingarten. He also discusses ARPANET.

PETER LYKOS INTERVIEW

DATE: 13 November 1990 INTERVIEWER: William Aspray

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ASPRAY: This is an interview with Peter Lykos at Illinois Institute of Technology in Chicago. Can we begin the interview by having you recount briefly your educational background and career before you came to the Foundation?

LYKOS: I will be glad to do that. I got my Ph.D. in 1955 in theoretical chemistry, and that involved doing extensive calculations using a mechanical desk-top calculator. In fact, I sat before one for six months and using one finger actually damaged the nail so that even today, if I find myself in a period of stress for a long period of time, it gets angry and sore. You can imagine, therefore, how quickly I seized on the opportunity of the electronic digital computer. When IBM announced the System 360 they had a market prediction of maybe 200 sales - ended up selling 1800. I had an opportunity to learn from Alan Perlis at Carnegie Mellon where I returned for my first summer after coming here to fill in for my research advisor, who was going on a lecture tour. When I returned to Chicago I contacted the IBM office, I found out there was a 650 being used by the accountants at Argonne National Laboratory. I went and visited him; he gave me a pass to the Lab and a key, and I could use that machine on weekends. And here was this huge room filled with cabinets with punch cards, and I had access to something that practicing scientists there did not have. And so I toured the city with my car, picked up my students and so on.

ASPRAY: [laugh]

LYKOS: And one thing led to another. I introduced the computer to undergraduate physical chemistry - the first time a computer use was part of a required course in a curriculum ever. This is 1959. [laugh] And then I incorporated it in my research and I created the Department of Computer Science, which, over a five-year period, doubled every year in enrollments. And I think what caught the attention of the people at the Foundation out of the computer effort was the fact that I had made an outreach to high school students in the greater Chicago area. And over a ten-year period some 15,000 of them came to our campus, were introduced to programming, actually did programming, and had

programs run on a computer.

Within a year of that starting, I got phone calls from teachers, because the students were now coming into their classes with jargon and knowledge and awarenesses that the teachers, of course, had never had. And so I started a Saturday program for teachers and the only thing I did right with the first one (pretty much right) was to include at the end of the day a pause and reflect session where we sat down and said, "Look, you're professionals; we're professionals; we're plowing new ground. Nobody has ever done this before, so let's make sure that we get feedback in order that we can improve what we are doing later on." We started then to give courses for credit to teachers and eventually created the first Master of Science for teachers in computer science here in 1968. This is an Institute of Technology, right?

So that's sort of how I got started with computing as relevant to my background. That's theoretical chemistry, which was much enhanced by the access to the computer, and while doing that the spinoff was to bring this into the academic program here, and the spinoff on that was to bring it into the high school community. And the momentum just kept going. I mean, can you imagine a chemist moving the College Board to create an advanced placement in computer science? I tried to do two things. I tried to get them to also get an advanced placement course in information systems - one of the reasons being to bring some polarization into the high schools so that trustees and deans and students and parents would know it's not just computing, but there is something which is narrow and deep, which we call computer science, and then there's something broader, which affects a much larger segment of our society. The College Board is an elitist organization, so the computer science thing they could see, but the information science thing, no, that was too close to the business program and vocational, and so on.

So I think this is what got the attention of the people at the NSF. At that time Arthur Melmed was interested in having universities, which had already given some interest in outreach, an opportunity to reach out to local colleges. And I came up with a proposal, which was... I missed the point here. We had gotten an IBM 360; I had a really sharp systems person here. We used the fact that there was a DOS that preceded OS 360 and had a partition where one could communicate interactively with the IBM 360. So what we did was we created a remote job entry system so that

high schools could rent teletypewriters from the phone company, off line generate punch paper tape and corresponding hard copy, and then periodically dial up our machine, feed it one tape after another, ten minutes later, call. The programs were compiled and executed. We also created a language called PITRAN, which was written by a man who worked with Ken Iverson on APL, and also was on a committee to define PL-1.

ASPRAY: What was his name?

LYKOS: His name as William Worley and he got a man named Ron Hopsbrauch [?], who was one of our students at that time, to work with him and then subsequently a man named Robert Doer, who was getting his Ph.D. at the University of Chicago in crystallography, which gets one involved with computers, had heard about him, was able to get him to come to IIT as an assistant professor in computer science. After some years, and he had a great impact on the program here, he went to New York University as chairman of the department of computer science.

So we had some real talent here. And ITRAN, as I called the program, was unusual. The FORTRAN, which was just coming to be used, of that day was intended to be used by quite sophisticated and experienced programmers. So the error messages were highly codified and sparse. The objective of the programming for them was to create the FORTRAN program, and so it had to be a tightly written code. In a student application it's a very different situation. The diagnostics had to be extremely explicit. And once the program runs successfully there's no further interest in it generally. So what ITRAN did was it had built in code that would scan each line of code the student would submit and would find errors in the use of ITRAN itself. And the program would be echoed back to the student with an arrow pointing to each place and each statement where an error had been found, and then they list the first error, the second one, and so on. In addition, a common error that students had was, if they had several parentheses where they were grouping variables, almost invariably the right hand side would be where they would accumulate. And the program would count the number of left hand parentheses and the number of right hand parentheses so they were equal, and see if they would parse. And if they didn't match, adjust the number of right hand parentheses, go ahead and compile and execute it, but give a message to the student that this is what had been done in the event that that was not what the problem was. So these are the things that we were doing at that time.

ASPRAY: And was this used beyond IIT?

LYKOS: A few places. I tried to have this redone in a professional manner. We had a technical manual written to support it and we also had a self-instruction program text for students to use. It was not a standard language. A few other places picked it up. In fact, I think it would be an interesting study to make sometime to find out how many students were touched by ITRAN, and this early introduction, what did it do for them, because all the students who came through our Saturday program, at least the last eight years of a ten-year effort, would have had this.

So this is what drew us to the attention of the people at the NSF. So when the NSF decided to use colleges, universities as local outreach places they came to us. But we were already working with a remote job entry system and so we didn't have to piddle around with that level. And instead, our proposal was to recruit faculty from colleges and universities in seven different disciplines who were willing to look at their undergraduate program and see what enhancements would be possible given convenient and easy access to a computer. So we did this in math and physics and chemistry and economics and so on. I couldn't find anybody in economics here to be the group leader at IIT, but I heard about a guy at the University of Chicago. And I went over, knocked on the door to his office, went in, introduced myself. I said, "Hey, I am willing to pay your salary for three summers and half your salary for the two included academic years to be a group leader and bring the computer into business." And he said, "That sounds great!" So he came and did it. As a consequence of that experience he went back to the University of Chicago, brought the Hewlett-Packard interactive computer into the business school. And today he is the associate provost at the University of Chicago for computing. In other words this was a pioneering effort and we did influence a lot of people.

ASPRAY: What year did you go to the Foundation at this point?

LYKOS: I went to the Foundation in 1971, and the reason I went was because by that time I had built up a tremendous program here - 18 undergraduate courses, 17 graduate courses, each one going each year by going, I

mean with sufficient enrollment that by the rules of the University it would be offered. I did this with part-time people. The number of student semester hours earned doubled every year for a series of five years, but I had mostly part-time people. And in part I was using the fact that the University of Chicago had made an abortive attempt to get a graduate attempt to get a graduate program in computer science going. They admitted students to it and they took all the exams and courses and so on, but the oversight committee was made up of physicists, mathematicians. There is no engineering school at the University of Chicago so the attitude, "Well, so this is applied and that's applied." So they had these graduate students milling around, and I picked them off and hired them as instructors and they were really first-rate people.

And I went to the administration at IIT and I said, "As if this had to be proven, the number one is interest in this discipline and number two, it's important in an institute of technology." We were on a peer basis with Carnegie Mellon in those days. And the president here would not see me, would not respond to my memos, wouldn't answer a phone. And I then went to the academic vice president, to whom I nominally reported and said, "Look, this is a house of cards, and if we don't convert this and take advantage of this opportunity we are just going to plateau and you're going to have a nothing activity." Well, he couldn't do anything about it so I resigned and this came to be known. I resigned my administrative position. This came to be known and that's when I got the invitation from the National Science Foundation, because they knew that I had generated all this activity here, had this experience, had this momentum, and that the institution was not supportive, at least... I mean, I think they viewed it as a cash cow. And that's how non-visionary they were. So that's how I ended up going to the NSF.

ASPRAY: What were you hired to do there?

LYKOS: That's an interesting question. The Foundation at that time had what was called the Office of Computing Activities. And in that office there was a focus on computer science as a discipline - research on it. There was Computers in Education, which was, for example, a program that had supported me for what we had done here. That was a big package, by the way. We got an $850,000 grant for a three summer, two academic year program, which in 1971 dollars is a fairly substantial amount of money. Well, I think what happened was the person in charge of

computers and research was so thorough in trying to understand what it was that he was going to support that he never did anything. And when I got there John Pasta, who had brought me there, said, "Well, of course, we don't have this new section that you were brought here to create, but while you are doing that, while you are in the process we are going to make you a program director in this computer applications and research section." Don Aufencamp was running that at that time. Well, this seemed to make some sense.

ASPRAY: Let me clarify. You had thought you were being brought in to run a program that did what?

LYKOS: To create a section called Computer Impact on Society. That's what attracted me. And Pasta also told me. He says, "Of course, something like that you are not going to get going in one year," which was the normal term for a rotator. "We would like you to come for two years." So I agreed. I got there in August. It was then that I was told that, "Well, you are going to report to Don Aufencamp until you get this other thing going," and then Pasta was not particularly discrete. So when he got irritated some conversations took place out in the open. And doors were open; people could hear. And it was clear that he was really ticked off with Aufencamp. And so he told Aufencamp what to tell me, and what Aufencamp told me was, "You have got $1.4 million to spend in this computer applications research thing." I had no real orientation to the Foundation, but what I came to understand was... Here I was now by now sitting on the end of September - Thanksgiving not very far away, and between Thanksgiving and Christmas and New Years there's not much time. Then universities, which are the group you deal with, the semester's ending; a new semester is going to start. And I was told that by March 1 or some such date this money had to be spent.

Well, it's not trivial. First you have to define a program. You have to get the word out. People have to write proposals. You have to line up reviewers. You have to evaluate them, and so on. So I in essence had no time. So in thinking about how I might do this I hit on the word hierarchical. And I hit on the word hierarchical - I am a chemist; chemistry is an experimental science - and hierarchical I discovered was a magic word. A lot of people can't pronounce it correctly, and even fewer can spell it correctly. So I made little signs that I put all over the Office of Computing Activities that said, "Think hierarchical." Okay, 'think' being sort of take-off on the IBM thing. And I let the word out that what hierarchical meant was people in experimental science already were gathering data in PDP-8s

and related machines, but those machines were pretty primitive in terms of data reduction or modeling.

And so I felt that these successively more sophisticated functions already were being done on distinct machines. So there was a PDP-8 on-line data logging device where maybe some preliminary processing could be done. Then there would be a mini-computer, which might be accommodating an entire department or an entire lab, and so those would be interfaced. And then the campus machine, or maybe a machine that wasn't even on the campus, which would be a supercomputer by the standards of that day could then be used for sophisticated modeling. And so the basic issue that I saw was how does one reconcile the fact that their machines have different power, different operating systems and things of this nature; how does one get into telecommunications? All of those issues. So that's what I meant by hierarchical computing. And with that I made about - I don't know; you would have to look it up - four or five grants of maybe several hundred thousand dollars each in areas where I thought that something interesting would come. And by the magnitude of those grants I made, these were site-visited in addition to being reviewed by reviewer staff.

ASPRAY: Can you give me a couple of examples of grants you made?

LYKOS: Yes, one was to a chemist - really sharp guy; still there, I think - at the University of California San Diego. His name is Kent Wilson. To show you how creative and imaginative he was he made a physical model of the methane molecule and connected it by cables to touch sensitive winches. So one had a graphics terminal (and graphics was not terribly sophisticated then). He had a graphics terminal and here was this carbon atom in this methane. And you could reach out and move that thing around and see the corresponding image displayed on the screen - you didn't have to be looking at it. And you could tell by feeling whether you were trying to move it in the direction to which there was a lot of resistance (therefore, energy was rising rapidly) or to an area where there was less resistance. He called this "touchy-feely" and I thought that was kind of peachy-keen.

He also had gotten into some sophisticated data collection kinds of things. He tried to have a total approach where in his laboratory everything stayed into the machine up until the printing of the paper, which came out on a printer that was part of their local network. So I thought that was kind of a neat place.

Another one went to the University of Kansas; another went to the University of Chicago. The guy at the University of Chicago, Bob Ashenherst... That was not a chemistry community focus, but he was sort of the cutting edge researcher in computer science at the University of Chicago, out of the business school. There were two faculty brought to the business school who were quantitative in their background. Ashenherst was part of the... Who was the guy at Harvard with the...

ASPRAY: Howard Aiken.

LYKOS: Aiken, right. Ashenherst was one of the 30 or 35 students who have had such an influence in computing across the country. The problem with Bob Ashenherst was he was a little too cutesy. You know, he talked about this computer being mom and that computer being dad, and it got a little wild. I don't know whether or not anything exportable ever really got out of that.

The one at Kansas - an interesting component there was that the supercomputer equivalent of that day was at a physically different location. So they had to wrestle with a cross the state communication link, and even more demanding, people couldn't conveniently talk to each other. So the operating system for that part of the hierarchical layered structure had to be sufficiently transparent that one could use it from a physically remote site. You couldn't just walk over and talk to somebody conveniently.

Anyway, while I was doing that I also began the process of defining what I saw as computer impact on society. We had a little contest at that time within the Foundation. I have forgotten the acronym they used, but there was a program put in place where grant money - not the operating budget but the grant budget of the NSF - could be used to pay the salary and travel costs of someone to come to the Foundation and work for a year or two because they were in some state or community-supported activity. It was sort of a way of providing exchange between tax-supported agencies. There was an acronym; I can't remember it. Anyway, so there was going to be a contest for the one that was going to come to our division. And so I wrote a prospectus as to what I would do if I had such a

person, and I won the prize, or at least that's what I thought. I came to realize later on that as a rotator I was viewed as a negative kind of thing by the permanent people there. You know, their noses got a little out of joint. They viewed us as coming in, as naive and not knowing what it's all about, and a negative sort of thing to be put up with. The view I took was these guys have been here too long and they need somebody to goose them, and I did a lot of goosing when I was there.

ASPRAY: And how was this manifest in the day-to-day operations? In doing your business on a day-to-day basis?

LYKOS: How was what manifested?

ASPRAY: This - maybe it's too strong to call it resentment - from the long-timers.

LYKOS: Oh, the way this manifested itself was there was the in group and the out group - inside group and the outside group. There were no staff meetings in this division. I asked for them. I said, "How come we don't have staff meetings?" I said, "I like to know what my colleagues are doing. I'm new here; I would like some calibration. I would like to know something more about what is going on." I did not have a mentor. This guy that I was reporting to resented me because it was clear that I was put in there because he couldn't do his job. But then after I started to succeed with this computer impact on society thing he tried to grab it as an administrative entity to stay under his jurisdiction. After all, I was only temporary, right? [laugh]

So anyway, well, let's go off on this other about interacting with the Foundation and being a rotator. See, all the things I am describing for you are logically the right thing to do, but as you know, you can lead a horse to water but you can't make him drink. And one of the things the Foundation did in those days was they would keep track of hires after a certain point in time and then they would come to a two-month later period, and they had hired a secretary or a mail clerk or a program director or whatever - they are all lumped together. And then we would go through a series of meetings where a series of directors of directorates would meet one at a time with this group and would describe what their directorate does. And that was part of our orientation and I thought that was peachy-

keen. It also put them in a spot where they had to learn how to communicate the essence of what it was they were doing. That was also important, because the Foundation is in a politically sensitive area. It serves the taxpayer; it serves people who get grants. There are people who get their nose out of joint because they didn't get a grant. They complain to their congressman and all these sorts. Well, the guy who was in charge of the education directorate met with us. And he went through his spiel and he had a three pyramid structure, and so on, and, you know, he was obviously kind of tired of doing this. And it came to the end, "Does anybody have any questions?" And here I am sitting next to a secretary and whatever and I am full of piss and vinegar, and I am a creative person. I have initiative; I raise my hand and I said, "Well, yes, I have a question." And he says, "Well, what is it?" I says, "Well, I know that completing one's formal education doesn't mean that one is set for life. Times are to change. New knowledge is being created at such a rate that contain education. However you want to interpret those words is an essential part of staying abreast of what's going on. And I am surprised there's not a fourth pyramid." And he got all flustered, because apparently this issue had been brought up to him before and I guess continuing education has a bad smell associated with her, or at least it did in those days.

So I went back to my office and I wrote a memo. And things are done through channels. So if I wanted to send this to the director of the NSF it had to have a list of people. The director was the last one on the list. And then there was the deputy director and then there was the assistant director and then there was the division head and so on. Well, by God, I did that. And this eventually came back to me with some notes on it. And at that time was there a Mackle...?

ASPRAY: Mackleroy.

LYKOS: Mackleroy was the director and he had put a note on there. He had just come back from some sort of a briefing session where it had been made clear to him how many people there were who had a need for this kind of thing and "Gee, this is a great idea," and so on and so on. But it died. Okay? Then we met with the administrative directorate. And again, the same thing. And this was kind of a low level person who was in charge. By low level I meant he was not a visionary; he was not an intellectual. He had a basic job to do.

I kind of had the feeling at the Foundation that the program directors are really the kings. At least it was at that time in the environment in which I moved and everything else was just there to sort of support them. I also got the feeling that this GS rating system where one agency would be compared with another was done in such a way that they got the very best people they could to be program directors and therefore the rating would have been very high but to offset that all the support people were at very low levels. And I think that from the contacts I have had with the Foundation in the more recent past I feel that's been exacerbated, because if I call and I get one of these clerks... How can I put this? Not only is the person I am talking to incapable of dealing with me but that person absolutely insists on being treated on a peer basis with me. Now, the words aren't coming out exactly right here, but that person is a support person. They could be better off having telephone answering machines rather than putting that human being who has not to say "Have a nice day," and "How are you?" and all this crap. I didn't call that person to exchange pleasantries. My time is valuable and to have to channel myself, "Well, he's not in," which leads to another issue.

I tried to get in the Foundation a hot line. I said, "The responsibility of this Foundation I think is to find the very best brains in the United States of America who might be able to address the missions of each of the programs that have money behind them. And therefore, I think that there are lesser institutions and there are people that are just starting out that are somewhat naive and they need help. I think there ought to be a hot line. I think furthermore that that hot line ought to be manned by one program director every day, and cycled through all the program directors - somebody who has some sense of what the Foundation is and what it does and who is a professional who handles these things. Furthermore," I said, "I have noticed that there's a telephone directory printed, bound, and it had two parts." I said, "In one part is an alphabetical listing of all the staff. The other part has the Foundation by structure and then the name of each person at every node in the structure." I said, "What I have discovered is there's supposed to be a Foundation rule that this is for internal use only, but I know this is being passed out at the higher level. Maybe these are higher level NSF people who know they are going to be cycled out of their job in a few years and they are trying to incur the favor of somebody who is going to hire them as dean of the graduate school, or whatever. But for whatever reason, I know they're out." I said, "Turn this thing around." I said, "Take the structural part of that - not

the alphabetical but the structural part. Publish that separately." You know what? They did it. Now you know why. Have you ever seen them?

ASPRAY: Yes, I have a copy in my office.

LYKOS: Okay, now you know how it came to pass. Also in this administrative directed orientation I said, "I'm active in research, and the nature of my research is such that I would be supported by the NIH or the NSF - theoretical chemistry." And I said I had given up with the NSF. "I get my support from the National Institutes of Health." I said, "Why do I do that?" The National Institutes of Health was a packet structure. There are a set of directions how to proceed. There are a set of sheets with carbon paper. There are boxes with labels. And all the information is provided or asked for in a highly structured manner. "What's your address? What's your social security number? What is the title? What's an abstract of what it is you want to do?" And so on. "Now, in anticipation that some people are going to complain that they feel restricted," I said, "there are continuation pages, but you know that it's more difficult to express your thoughts in a small number of words than it is in a large number of words. And you also know from your own experience as referees the longer it is the less likely it's going to be read, or at least read critically." I said, "Furthermore, here's the great National Science Foundation with a computing directorate and they have got a crummy management information system."

I told this to the guy who was running this thing, and by way of putting teeth in that and reviewing the files in the Office of Computing Activities I found out that there had been a major grant, or maybe a series of grants, made to two guys at Columbia University to develop an information systems that involved a fourth level language. They didn't call them that at that time. The whole idea was to eliminate the programmer analyst. You are the person who is going to create this database; you know how you want it structured; you know what language you want to use to pull things out, and so on. Now, as a chemist I was already fairly well-known in computing and chemistry. And at the National Science Foundation the chemists there knew me. In fact, some of the grants I made I did collaboratively with the people in chemistry.

So I called these folks at Columbia University, found out what they were doing, already knew a good bit of what they were doing by reading the files. I went to the guy who was acting director of the chemistry division and they have a lady, Elizabeth... I've forgotten... She was married, divorced and married, so her last name has changed. Anyway, she's one of these people who in our culture happen to be female and happen to have been around for a long time, and they are one of the pillars on which the whole structure stands. She, I don't think finished college. So the acting director and this lady went to Columbia University and visited for three days at my say-so - okay, that was the impact I had - and took with them a set of proposals that were complementary in some way. And they came back and she was overjoyed, because she had learned how to use the system, she had learned how to get the key data in, and she had learned how to search that file according to whatever the key words she wanted to use.

Well, this was sort of an embarrassment for the management information people. So then began the process, and then they started looking at possible systems, and they got people from computer science to help evaluate this. But that was pure bullshit, because what we're talking about is data processing, which is a quasi-vocational kind of thing. And people in computer science are way out in left field and are talking about step theory and all this jazz, and it was absolutely insane. But nevertheless the administration at the Foundation suffered from the same malaise that everybody else suffered from in those days. Because I was deeply into computing I would find it easy to strike up a conversation with anybody, because every profession was being touched. And so I would start a discussion with somebody, next to them on a plane or whatever, and somehow bring the computer into the conversation, immediately get a response from the person. But the common malaise was that they assumed because I was "an expert in computing" I knew everything about their discipline where it was touched by the computer.

ASPRAY: [laugh]

LYKOS: So that was a kind of crazy attitude which existed in the Foundation in those days. Well, while I was getting this computer impact of society thing going I also looked around and I said, "Well, there's a general phenomenon, and that is the ubiquitous computer is touching everybody, and what the Foundation should be doing is being a point man in this regard. With regard to all the kinds of research it's supporting it ought to try and do something

about making sure that the folks who are getting grants are at least sensitized to how the computer might enhance what it is they're doing in the way of research." So I evolved a structure. I said, "Well, here we have the Office of Computing Activities, and it has three parts - Computer Impact on Society, and that's where some cooperation ought to be going on between this office and the research directors. And here's Computers in Education, and there was an education focus within the NSF and so that's what that ought to be. It ought to be building bridges, and helping them understand where things are and working with them." And the third one was the one I was going to create, which was Computer Impact on Society. And in those days they had research applied to the nation's needs.

And so, I saw a very natural kind of structure, and I saw a very natural role for the Office of Computing Activities to play. And I felt that the program directors here should not be supporting, except for computer science... I'm sorry, computer science is up here and then there were these other three. Computer science should be supporting people doing research on computer science, but the other three I felt should be restricted to joint funding of proposals, in order to outreach, to build bridges and that kind of thing.

Well, it turned out that was not to be. And I suppose by that time I had gotten a reputation as a boat rocker, so I am sure this is probably one of the reasons why I was never really part of the inner circle. On the other hand, people from all over the Foundation called me in whenever they had study groups, where the computer played a role, because they really felt at a loss. You know, they didn't have the background and the expertise. Didn't even know the jargon where they could deal with this kind of thing. But this part of the Foundation that I felt could have played a major leadership role along the lines I have just described never happened; never happened. And I don't know.

I put this on the board because I wanted to mention something else. One of the reasons I went to the Foundation was the National Research Council is the infrastructure for the National Academy of Science, of Engineering, and of Medicine. And it has a membership of about 5000 people. And almost all of those are members by virtue of some position they hold in a professional society. And the whole idea is to have them place a structure with people in there who are enlightened in some very specific area of engineering or science - science broadly being social science as well. So if the president or somebody from the State Department or whatever had a need to know he could very

quickly pull together a group and come up with a white paper that would be a reasonably balanced statement of where things were at that time.

Well, there's a small group of 300 members of the National Research Council. These are people who are elected. And they're elected because they have something unique about them that will enable them to play a role in what's perceived to be an important area in the National Research Council. I was elected - Computers in Chemistry within the chemistry division of the National Academy of Sciences. I was asked to create this committee. I reached out, created it, but then the National Research Council is a passive operation. You're supposed to be hovering there, quivering, waiting to be asked to do something.

Well, I am not that kind of a person. So I used that as a platform. I used the fact of that committee and the mailing list available through the division of chemistry of National Academy of Sciences to make things happen. So I started by bringing together chemists focused on specific areas of computers and chemistry. One was crystallography; another was theoretical chemistry. The theoretical chemistry one had as a consequence a strong recommendation that there be formed a national center for computation and chemistry. And I am the person who made that happen, but not many people know this, because you don't make things like that happen by standing up and saying, "Hey, I am the greatest. Follow me." Right? You try to understand the structure; you try to involve people who would be perceived as role models, and you try to identify sources of funding. And I have a paper on that, by the way, which I will share with you as well.

ASPRAY: Thank you.

LYKOS: Let's see. What else do we have here. I had a personal problem with coming to the Foundation. The personal problem was my wife is an extremely shy person and we have three kids and we spaced them five years apart. So matter what college they wanted to go to, if any, there would not be an overwhelming financial burden. I mean, committing myself to academe, you know, money is not going to [laugh] be a big deal.

ASPRAY: Certainly.

LYKOS: Well, my wife did not want to leave Oak Park and I guess I wasn't as sensitive to her feelings that I should have been. And I discovered after all the commitments were made that her house was her skin and Oak Park was her garments. And that's where she was comfortable. I wanted to find a house in Washington, DC. We had two kids who were still with us who were going to be in school. I thought, "How the hell am I going to do this?" I wrote to the provost of each of the institutions of higher learning in the greater Washington area. I said, "I'm coming to be a rotator. I need a house, and I would like the house to be roughly this size and roughly this location and so on, in case you have somebody going on sabbatical leave." Guess what? I got one response. Perfect, I thought. But there was a problem. The assessment of the school system in the district had changed since the information that I had gotten. Something called a Scally Right [?] decision had been made, and it reduced all the schools to the lowest common denominator. I had a son going into the fourth grade and a daughter going into the second year of high school. And when we got there and got into this house, which was a nice house - a great location... I could take the Wisconsin Avenue bus down to the NSF and all those things. By the way, I was also a member of the Cosmos Club, which was kind of a nice touch, because the house was too small for entertaining but we could take somebody to Sunday brunch at the Cosmos Club, which was kind of nice.

Well, the schools turned out to be awful. My son essentially lost a fourth grade. My daughter feared for her life at the Wilson High School - it was called. I went to a parent-teachers thing, and it was a horrible mess. I mean, there had been phones in the classrooms; they had obviously been ripped out. Everything was vandalized. There were no doors in the stalls in the washrooms. If my daughter tried to call home and was standing there somebody passing by would "click" and turn the thing off. So I went to this thing and the folks at the high school had made a big fuss about they weren't getting enough support, and so they were given money. And what did they do with the money? They created a gymnasium instead of focusing on the academic things.

So I went to the gymnasium and I could hardly see when I got into it. What had they done? They had put germicidal lamps - huge germicidal lamps up in the ceiling. I reached into my pocket and I took out my American Express card.

Now, in those days American Express put fluorescent dye into the card to try to avoid counterfeiting. I took out this card and I could read AM the logo EX. So I got a hold of the principal who was there showing the parents, you know, very proud. I said, "There's so much ultraviolet here that unless people are wearing glasses which will absorb most of this you could do permanent damage to people's retinas." And I don't think he either understood what he was saying or even attempted, because here I am saying something negative about something he was very proud of.

So the second year we moved into Bethesda and my son was examined in the elementary school. And they had three classes, different levels, and they examined in and they interviewed us and they said, "Look, this kid has the capability of being in the top 5th grade class but he has essentially had no 4th grade. Now, if you are willing to work with us we will work with you." So the pattern we set ourselves to was after school my wife would work on him on the fine art stuff. In the evening I would come home and work with his math and science. And he was absolutely exhausted by the end of the day. But after two or three months of this he sort of caught up and he went on. My daughter now was in Bethesda Chevy Chase High School, so freshman in Oak Park, sophomore in Wilson, junior at Bethesda Chevy Chase.

And I had an opportunity to stay at the Foundation. The guy who was head of the Complementary Office on Information System - his name was Day; he went on from there to become head of the Library of Medicine, I think. And I said, "Well, let me talk to my wife about this." My wife, by the way, was in a very deep state of depression most of the time we were there. I, on the other hand, absolutely enjoyed myself to the hilt. I had so much fun you wouldn't believe it. [laugh] Because houses are expensive the house we rented was very small. In Oak Park they tend to be big, rambling houses. So I got claustrophobia... claustrophobic. So I bought all the tourist guides. And we went out every weekend. And we went down to Monticello; we went up to Gettysburg - the whole thing. I got my family; we went off to Killington, Vermont. We learned how to ski - parallel skiing.

ASPRAY: Do you think this was a common problem for other people who were coming to the Foundation? This kind of problem of accommodating their personal lives?

LYKOS: I am sure that everybody who does this has to make an accommodation, and it depends on their commitment to the community from which they came. I know there were some people who did not move their families and maybe once a month they would go back and make a long weekend. I think some flexibility on the part of the Foundation in that regard - maybe a special travel fund and maybe accumulating leave time so that one could have a four-day weekend once a month or something like this. Also know that it's dog-eat-dog in terms of getting research grants. There are some operators, one of whom is in this department, who went to the Foundation, not because they were going to work within the research-granting framework and try to enhance the whole operation, but rather by establishing more contacts, by making friends with the people who were program directors and that kind of thing. You know, and then some people would be invited to come but would not because they would be away from their research group and the research might collapse. This intensive thing about research and my career, "I, me, mine," seeing things only in terms of "Is this is good for me or bad for me," the fact that that motivates some of these people or that's the principal motivation. You know, one can be selfless to a degree, which is unrealistic.

But it seems to me that coming to Washington with the National Science Foundation, I viewed as a privilege. And I really enjoyed it, and I tried my darndest to not only do a good job of what I was doing, but to take what I saw as a charge that a rotator has, and that is to bring in some new insights, to help them see the world they're serving through different eyes. And this may sound naive and childish to you, but I was really motivated by that. And as you can tell by some of the things I did, a lot of things I do are not politically wise if my concern were to advance myself politically within the Foundation, but that's not what was driving me.

ASPRAY: Did you or any of the other program officers in OCA have any personal research programs going on at the time?

LYKOS: No, I had my own thing that I was doing, and that was the National Research Council, the Committee on Computers and Chemistry. I used that as a platform for starting us down the road to a national center for Computation and Chemistry. I also used that as a platform to get a petition mailed out whereby I was able to create a division of Computers and Chemistry in the American Chemical Society. It was both the realization of what I was

going to be able to do - I could walk over and have lunch at the National Academy of Sciences from there - and the immensely enlarged vision that I was given, because a lot of the neat people come to Washington and they come to the Foundation. Or there are briefing sessions. And I just learned so much. I mean, it just expanded my mind. It was almost an explosion. It was almost more than I could deal with, and one could operate at that level. But going back to the original question, I think people go for different reasons, and I am sure it runs the gamut from trying to establish more contact so they can...

Oh, the other thing, I made a kind of a funny and I said that the scientific literature - people either read it or contribute to it. They don't do both. And some people didn't understand me; some people said you're being arrogant. The reason I said that was if one is really active then one is visible. And so one gets papers to review; one gets invited to conferences and hears other people speak; one gets research proposals to review. So you're in a position of knowing what's going on before it ever appears in print. When it does appear in print it's sort of after the fact. "Oh, yes, I knew about that a year ago," or "Oh, yes, I knew about that two years ago." So part of being at the Foundation is to be at the crossroads of where it's at - what's current, what's choice. And it's exciting. It really is exciting. I mean, this was one of the most exciting experiences I have had in my life, and I have had a few.

TAPE 1/SIDE 2

LYKOS: What we were talking about was the adjustments that individuals have to make or considerations that weigh heavily on your decision on whether or not to be a rotator. And we were talking about the opportunity for being better plugged in on what's going on in their research areas. We talked about the danger they have of having their research efforts sink. We talk about personal things, like kids in school, or wives with jobs, or wives with... I shouldn't say wives with jobs. I'll correct myself and say gainfully employed spouses. So that's always a problem. I don't know.

Oh, the other thing, the other thing I didn't tell you. When I won the prize and I was going to be able to hire a guy I went to the personnel office and I said, "I'm now authorized to hire" - I suppose I will think of the letters, but - "one of

these people, so I want to put out a job announcement." They looked at me cross-eyed. NSF did not send out job announcements. And of course they couldn't question my wanting to send one out. This is a free country. This should be an open society, right? [laughter]

So then another challenge was coming up with a job description. And I had to circulate this through key people to get their approval. And everybody was looking at me in crazy way and handling this in a very gingerly manner. But after it went out I had six or seven applications. And Don Aufencamp, who needed somebody to replace me in his thing, wanted to skim the cream off the people that I had gotten. And one of the guys I got, who got the job, a man named Granger Morgan, was sort of an applied science person out of at that time the University of California San Diego. Since that was a state-supported institution that qualified as a tax-supported agency whereby we could have this personnel exchange thing happen. And I brought him there. Granger is an interesting personality and he's too caught up with himself for my taste. But nevertheless it was working okay. And eventually he left the Foundation and went to Carnegie Mellon to start a program on Societal Impact of Technology. It's a national program there, and you may have seen some of the stuff he has written in *Science*, for example. One of the things he did many years ago was to look at the social impact of acid rain, which goes into how many lives we would lose, or days of work, because of damage to lungs, and the forests, and all of that, doing an energy balance and materials balance and all things. Really a neat guy.

So after I got him to come, somebody from the Foundation came around - this was in the spring - saying, "Well, who wants a graduate student?" And I said, "What does that mean?" He says, "Well, what we do is for graduate students in the Washington area we will take one or two on for the summer, by way of giving us an orientation to what's going on. They might be able to be a gopher for you and help you do something." So at that time I knew a guy named Anderson who was at the University of Minnesota. And he was a sociologist. Granger Morgan, you see, was an applied physicist. And I'm trying to define this new entity, Computer Impact on Society. So I called up Anderson and I said, "Here's the deal. I can offer you what they would offer a graduate student to come here for three months for the summer. And this is really minimal bucks, but here's why I want you to come. Here's our opportunity to create an administrative focus within the National Science Foundation on Computer Impact on

Society." Well, he came. And he looked around and looked around and he found a very cheap apartment - one room - in the red light district on F and 14, wherever that is, and that's where he lived. And now, here's Granger Morgan, and here's Anderson and myself. And we start having regular meetings. What do we mean by Computer Impact on Society? Who are the key people who are working in this area? So we came up with a prospectus. And that's how the program got started.

ASPRAY: And who were the key people?

LYKOS: Oh, I can't recall; you're talking 20 years ago.

ASPRAY: Yes, I know.

LYKOS: But we got into things like... Well, the obvious ones like privacy. What are some of the others? Well, my focus was on outreach. John Pasta had a brother working at the New York Stock Exchange. And so, that kind of thing in terms of wireless transfer of funds, the timing whereby information came to be available, the whole Foundation of Arbitrage [?], for example; this business of forecasting and reporting votes on the East Coast and the polls haven't closed on the West Coast. Those were the kinds of things. We got into what can be done now that we are getting microminiaturization to help the physically disabled. It turned out on Wisconsin Boulevard there was a not-for-profit organization that was getting deeply into that. In fact, there was a deputy director at the NSF, whose name I have forgotten - Ray, I think, was his first name - and he may have had someone in his family who had a problem like that. "Have you heard about me?" And so he called me... Did he call me or come to my office? In any event, he wanted me to identify one or two other people that could go with him to visit this place, interview the guy that was running it, and see whether or not this man was up to speed in terms of what his opportunities were and how realistic he was in terms of what he was contemplating. So that was yet another area. Computers in Education would have been a major one, but we already had an education director within the Office of Computing Activities. I don't know. I don't know if that gives you enough of a flavor, but that's sort of what it was.

ASPRAY: Had the Foundation had any activities along these lines prior to your arrival?

LYKOS: I wasn't aware of any. Let me back off a little bit. I mentioned earlier that when people came to be aware that I was there and what my focus was and by this time I guess I didn't appreciate myself how much experience I had had. And because of that experience I had learned to read other people in terms of why did they think the computer was important in what they were doing? I learned how to communicate with them, to draw them out, and to form a judgement or to give them guidance. I mean, I am sort of known in the world of chemistry. I don't you noticed all the file cases outside my office. There's some more inside. If you look in my office it looks kind of chaotic, but I know where everything is. If somebody calls me, chances are that I can reach an old file and say yes, "So and So is doing this and here's his name and here's an address. This is relevant to what you're doing for this reason." So I played a broker function. Maybe that's an important concept to bring out. I was able to play a broker function by virtue of the position I had at the Foundation - part of it is my personality; part of it is my background; part of it is my creativity; part of it is I am an action-oriented person. But that would not have been as effective were it not for all the information that I got while being at the Foundation, and all the contacts that I made. Even reading reviews of a proposal... You know, once in a while a review would jump out and say, "Boy, this guy's sharp; this guy really knows... this guy's sensitive; this guy's got insight." And you remember that person. So the broker function that one can play at the Foundation, and I am not giving full play to this, I think is an important opportunity that comes from being there. Now, I don't know what else we can talk about. We haven't finished your questions.

ASPRAY: Tell me about what happened to the Computer Impact on Society Program.

LYKOS: Well, a guy named Rick Weingarten was brought in by Pasta to take over the program. Pasta did not invite me to stay and continue the program. I was a boatrocker and I didn't kiss Pasta's ass. So when Anderson left after his summer all of a sudden Weingarten shows up. Now, Weingarten is a sleaze of the first water. And he was at the Foundation for a number of years after I left and then he eventually moved over to OTA. And someone I had gotten to know pretty well, who knows the folks at OTA pretty well remarked about how recently Weingarten went to be executive director of some professional society, and, boy, were they glad to see him go. This guy was one of the

most affected individuals I have ever met. And riding the crest of this wave where, if you talk as if you know what the hell you're talking about with computers and applications, people are swept away by that, and particularly if you have the imprimatur of the NSF. That's something else. NSF is a highly-regarded organization. At least it was at the time I was associated with it. And people didn't see you, the individual, and didn't hear you, the individual, speaking. They saw you, the guy from the NSF...

ASPRAY: Right.

LYKOS: There is an imprimatur; there's an aura that goes with it, or at least did. Recently I was asked to serve on a panel and I got to rub elbows with some other people, and maybe it's because it was the education directorate, but I had a completely different impression. These guys were not proud of the job they were doing. They had no presence; they had no pizazz, and they were almost apologetic in terms of dealing with the reviewers who were coming in. Maybe the Foundation has changed, or maybe I have changed, or I don't know what is going on. But that's an aspect - and I don't know if that's still true - but that's an aspect of being part of the Foundation that one has to be sensitive to the fact that people see this thing off in the distance and they don't know the structure. They don't know exactly what it does, but it's perceived as being the point man for science in this country. It's a quality agency. It's at the cutting edge. People there know what's going on. And I'm not certain that it's playing that role. And I'm not certain that there's a self-perception on the part of the people who are there. I know there was a problem with level of compensation, and even though there's a GS-10, or GS-18, Step 10, we know that there was a ceiling that fell below that because that was tied to the congressmen's salary. And there's some perception that, "Gee, these sharp people are underpaid; they really should get more," and so on. I suppose that's a factor. It was not a factor for me - in part, because IIT is a third-rate institution with a very low salary range. I mean, I have forgotten if I was 15-Step 7 or a 16-Step 7. The big surprise to me came when my wife read in the paper that there's a Marine drill corps thing that happens every Friday night or something and wouldn't it be fun to go. And I said, "Well, sure, why don't you call up and get us..." You have to call up to get a ticket. And he asked her over the phone who was I. And she told him what my GS rating was. Oh, then that was equivalent to a Brigadier General, and that meant that I could sit here instead of here [laughter].

ASPRAY: One thing you could tell me about is your perceptions of the effectiveness of the various programs of OCA at the time. I will let you lead the way through it.

LYKOS: Well, I had a very strong feeling that each program director had their favorite list of people. That's sort of how it worked. Relevant to this is something I started to talk about earlier that I will bring up again. When the administrative assistant director met with us one of the things I brought up was the NIH proposal format. We didn't finish that. And the reason I brought that up was because it was highly structured and thereby lent itself to being put into machine-readable form. That's when we went off on a tangent. I brought this up, and one of the reasons I gave for making the recommendation was I thought that the request for proposals or announcements of programs were too vague, and more explicit guidance ought to be given to proposees. I found in reading proposals that each one was different. And I had to waste a lot of my time just trying to find key information. It wouldn't always be there, or not in what I would consider to be a reasonable place.

Well, guess what! It almost made it through the Foundation to do this. And I was having lunch with a guy from the Office of Computing Activities, and somebody came and leaned over his shoulder - didn't know who I was. And it turned out there was an action very likely going to be taken about this crazy idea to standardize the proposal format, and that if they didn't want this to happen they better move their ass up there and vote against it. And they did, and they squashed it. And the reason they squashed it was they wanted to leave that flexibility in there. Why? The career people there, after being brown-nosed by really sharp people, who were so sharp that they would engage the program director in conversation and sort of almost subliminally suggest a line of research so that this person could then believe that they thought it up. And they said, "Oh, what a wonderful idea! What a bright person you are! I am going to write a proposal based on this," you know. And eventually their ego got so puffed up in an artificial way that I think some of them could have qualified to be mentally ill. I mean, it was so far off-base in terms of their self-perception of how much they knew and how important they were.

And what came out with this proposal format was the following. They wanted the flexibility to shape and to mold.

Now, it could be that... and computing was different from the others because that was a new phenomenon. And so this self-perception of shaping and molding, you know, finding this nugget in this ore and working with this purpose, and by making recommendations and so on, this got so bad that... There's this hierarchical computing thing - an interesting phenomenon took place. The Department of Defense Advanced Research Projects (ARPA) had launched the ARPANET. And I looked at that and it blew my mind. I said, "Wow!" I said, "What this means that people doing research where the computer can play an important role could now do a number crunching here and use a graphics package there and an information base there. And the ARPANET is really a giant computer. And these guys that were supporting it at the NSF... But you don't have a network just to have a network; it has to have a purpose. And the NSF is the place where the purpose was, because here are the people doing fundamental research. No, you should have some research in networking and computer science, but that's not an end in itself. Okay? You should demonstrate how people are able to do more research or better research having that kind of capability."

So what tool did I have to work with? I had this hierarchical computing. In fact, you ought to interview Kent Wilson out at San Diego, because he came up, bright guy, with the idea of hierarchicaling to the ARPANET. And then I found stumbling blocks thrown in my way. "Well, the ARPANET has an IMP, an interface message processor, so you have got to buy them an IMP," and so on. And I was saying, "Well, it's only money, and we're not talking about a huge amount of money; we're talking about a concept." And so I was very careful in terms of whom I selected as reviewers. I wanted this to be absolutely bullet-proof. And then to make it further bullet-proof organize a site visit. And again, I was very careful who I selected, and backing the reports and recommendations, said, "Great idea; go with it." And I signed off and sent it to Aufencamp. Aufencamp got on a plane and he went out to San Diego and he told Kent Wilson, "We really don't have enough money to support all of this, but if you knock out the ARPANET connection we can probably swing it."

ASPRAY: [laugh]

LYKOS: I also discovered accidentally something else, and that was within the Foundation there are multi-part forms. And the different tissues are different colors. They're color-coded. Once, for some reason, something ended up in

my hands after it had left my hands - a clerk made a mistake - and I found that one of the color tissues was missing. That's another nice thing about... That's another factor that was driving me toward a machine-based database, because that means that anybody with the authority can log in and look at whatever they're authorized to look at. Plus you can collect statistics and who the reviewers were, and so on. You can begin to look for patterns; you can begin to analyze. You can begin to be an administrator. The other thing I remember was if a congressman or a senator or somebody high up in the administration took an interest in a specific proposal, it came through with one of these florescent orange tags on it and it was hand-carried from place to place. What else? I am just sort of free associating.

ASPRAY: It would be useful for me to know something about the people themselves. Tell me about Pasta as a person. I didn't get the opportunity to interview him.

LYKOS: It was curious, Pasta died; Kent Curtis died; Don Aufencamp died.

ASPRAY: Right.

LYKOS: Now, I don't know what the probability of something happening as... Oh, and... I can't remember his name now - a black guy, had cancer, which was treated, I think successfully. I think he's in the education directorate. I liked Pasta. He was basic, and he didn't take any crap. I mean, he found the limits - how far he would have to go. They kept him on a short leash. I remember once he was at the airport ready to go somewhere - a site visit. And he got a phone call over the loudspeaker and they jerked him back, because there was a discussion going on and they thought he should contribute to it. So that was a way of administering, I guess. Now, he also worked on his wife's thesis in his office. She got her thesis from George Washington University and it was a statistical analysis of this or that, and he was doing it for her. And there was this printout on his desk. Well, I thought that was kind of shabby. Aufencamp...

ASPRAY: Well, let's talk about Pasta a little bit more. How did he interact with the program officers?

LYKOS: Not much.

ASPRAY: Not much?

LYKOS: I brought up this matter of having a meeting of the office, and so we had one or two, but he would call on the section heads and they would just sit there stone-faced. They were not about to participate. Their whole modus operandi was, you know, keep it close to your chest kind of thing. And that's how they were going to control things. I remember once - I had been there maybe two and a half months - I am kind of a workaholic and it was kind of late; it was a winter night. And here I was in this sort of pseudo-room they had created for me by putting up a couple of partitions in a corridor. And so all I had was a desk lamp for illumination. You know, my desk was piled, and I was working away, and I was conscious of a figure standing there in with John, and he sat down. He wanted to chat with me. I guess in retrospect I should have been much more open with him than I was. Not that I was secretive, but I should have made more opportunities to go in and see him and talk to him about how things were going. But I had this innate feeling of structure - that is, I don't report to John; I report to this other guy, who, it turns out was sick. So I really didn't get to know Pasta that well.

ASPRAY: Was he a good people person?

LYKOS: No, I don't think so.

ASPRAY: Not at all?

LYKOS: He was a shoot from the hip... I think he terrorized people. He didn't terrorize me, because nobody does. I am who I am and that's it.

ASPRAY: And what was his vision of OCA?

LYKOS: I think the fact that he brought me there shows you that I think he was a visionary person. Now, it was also clear that Aufencamp, once I had gotten his show on the road and in addition was clearly taking a rational approach to devising this new program, I think Pasta would have let him keep it. But the Office of Computing Activities lost the Computing and Education program for some reason, so Pasta was now in the position of having an office with only one section reporting to him. So I went to him at that time. I said, "John, I think this would be a good time to push for the section on Computing Impact on Society. I think we proceed in a rational way; we have got documentation." I had already, by the way, begun to use some of the computing and research money to fund joint projects with other individuals. I said, "There's a track record and this gives you an opportunity to create a second section, so that you still have two sections."

Well, the way it worked out was - and I didn't know enough about the politics of the administrative structure at that time - but there was a section created under Tom Owen, Admiral Owen, who was head of the directorate in which the Office of Computing activities resided. But it was not a full-blown section. In other words, we didn't have the ultimate authority, whatever that was. This was sort of half-assed. Okay. And so it was created because they didn't want me around anymore, because I was raising too many issues and gaining too much support for these. It was kind of rocky, you know. But on the other hand John didn't want his whole operation to go down the tubes either. The way things work at the Foundation you always get the impression that there may be some discussions and planning going on, but it's almost like some giant hand reaches down, takes this pawn, and moves it over there. One minute you're over here administrating [?], the next night you wake up and you're over there. People who have been there for a while, of course, know that and accept it. And you have to have change in order to be able to adjust and to promote people or demote people or whatever. I think at the Foundation they have probably got that down to a fine art. Recently I sent a letter to Luther Williams. Do you know who he is?

ASPRAY: No, I don't.

LYKOS: Well, when they fired Bezan Shakashiri [?]... McGlock fired him as assistant director for education... he

promoted one of his staff - not a line position - named Luther Williams, who is also black, to be head of a revised education directorate within the Foundation. And one of the things I have done since I left the Foundation was to get into video via satellite as a form of outreach. And I am quite certain that that could be an important part of what the Foundation would be doing. So I wrote to Luther Williams and I said, "Here I am; this is my background; these are the people I know, and it seems to me this is an important area for you to develop." And you may not know this but in terms of education all the federal agencies are being formed into a consortium. That's why Jim Watkins, who is Secretary of Energy, is going around saying, "We're going to do this for education and that for education." But the Foundation is going to be the point man for each of these consortia, and Luther Williams is the man. And so I thought that a lot could be done with video via satellite. So I wrote to him volunteering my services. I probably have three to five years useful life left as a professional, and it's very much under-utilized here. So I thought that would be kind of a neat thing to do, and I didn't hear from him - not even the courtesy of a response. So what can I say?

ASPRAY: What about Kent Curtis?

LYKOS: Kent Curtis was a funny guy. He had a physical problem. He married sort of late in life - I don't know if this was his first marriage or not - and had a child. That really transformed him as a personality. I had the feeling he was a professional person. He did what he was supposed to do, did it well. Oh, this is another thing about Kent. This has to do with being in a privileged position in the Foundation. Kent did make statements and he did make pronouncements. He did gel concepts for ideas that were sort of amorphous because there was a piece here and a piece there. But he had the sense of I was going to use the word greatness; that's an exaggeration but he had the sense that there was a larger picture, and that he is in a privileged position, and when he sees something that ought to be focused on he would write it, or speak it, or whatever, and focus. So I liked Kent. He was not a warm, likable person; we were never close. But I liked him in that sense of his professionalism and his ability to see. He didn't have a Ph.D., as I recall. I don't know how much that weighed on him one way or another, but I don't know what I else I can say about him.

ASPRAY: How successful was the OCA at promoting the development in computing in the United States?

LYKOS: Well, I knew Joe Coates. I don't know if you know him or not. Joe Coates was an interesting guy. And he was one of the people who pushed for the creation of OTA and may have been the original acting director for all I know. He had been at the Foundation in this research applied for the nation's needs, and he was one of the people that involved me. Okay? You know, we were both cut from the same whatever, and I viewed OTA as an opportunity for me, because I thought, "Wow, this is the place for a guy who has had this training and experience, both what I had here locally, and also what I got from the Foundation." But it was too political and disorganized. And so it didn't happen. Joe Coates arranged for me to interview a couple of people but there were no sparks. And the people I interviewed... There was no resonance. It was as though I were talking to robots. They looked like people and they sounded like people, but there was zero communication. They had no sense, as far as I could tell, of the role that something like OTA could play.

ASPRAY: In writing about computing at the Foundation, at least from the period that you have had your closest experience with the Foundation, either as an outsider or while you were there as a rotator, what themes would you want to see highlighted and studied, examined carefully?

LYKOS: Well, remember, we are talking 20 years ago. And so much has happened since that time that it's sort of as though some of what you call themes were pulses. They came into existence; they peaked and they died because they were no longer useful. Now, whether one can do something more general than that in terms of computer-related themes that might be carried forward, I find that here I am at IIT and we are still way behind the world in terms of what's going on with computers and education. I came up with a concept; let me tell you what it is. And I have another paper, which I will share with you. [laugh] And the concept was the following - that our knowledge base and problem solving base is expanding and ever-expanding and will continue to ever-expand. And here we have bachelor's degree programs, and we have certain disciplinary focuses. And we still play the same old crappy game where there's a body of knowledges, there's an external crediting body, and you have to master this, and you have to master that. You have to have so many credit hours in humanities and so on and so on. And the Foundation tried to change that.

Oh, if you want a theme, here's something that I was aware of since I left the Foundation, but it was still a number of years ago - maybe the middle 1960s. The Foundation laid two or three million dollars on each of four universities - I have to put something on the board for you to get it - to develop innovative undergraduate engineering programs. And one was here at IIT, and it was the ideal gas [?] version. There was a project, and it was a total commitment to this way of doing things. We just threw away the regular undergraduate program. Incoming students would have two tracks. One track would be to have a series of concepts, or modules, rather, to master - each module being about one week's worth of work in class. So you take an academic year of calculus and you divide it up into one-week modules and a student would do this on a self-study basis and then take the quiz, and repeat the quiz until they mastered it on an acceptable level - B level.

In parallel with that students were organized into problem-solving teams - two from the freshmen year, two from the sophomore year, and so on. And they had two faculty advisors - hard sciences and soft sciences. Social scientists and an engineer or physicist or whatever. And the whole idea was to come up with a problem that they were going to work on and make a presentation to the entire group of what they were contemplating doing, and to try to find a problem that was neither too ambitious nor trivial, and to take a problem which had a technological foundation, but to explore solutions to that problem, recognizing thereby that there were social, legal, ethical, and so on constraints. Okay, it's called e^3 - engineering, education, and through experience. And one of the pluses, one of the reasons it was cited here was the greater Chicago area provided a context. For example, one group wanted to do something that had to do with airports. So arrangements were made and they dealt with the folks at O'Hare and so on.

Now the problem with this one was different... and all these four were different, as they should be, in this context. One of them, Worchester Poly, was sort of middle of road. It said, "Number one, we're going to make this a total institutional commitment." At IIT this project stood by itself. So, a total institutional commitment. "Furthermore, the first two years are going to be still classwork, except we're going to divide semesters into half-semesters, so we can have sort of the flexibility that comes with modules but not... And the student, prior to the junior year, could get on a self-study basis, but not necessarily if they weren't ready for it, and a total institutional commitment." Well, that

became the Worchester plan, and to some extent, I guess, it continues to this day.

The IIT e^3 plan, when the funding was over the program died. The guy who was the principal director was an old mechanical engineer, and certainly the ruts were deep before the computer was invented. He was not about to incorporate the computer into what he was doing. He was sufficiently clever that if anybody brought the computer he always had some negative anecdote that he could cite. So that was sort of his response. But he eventually drew on 60 of our faculty, on some basis or other - some more full-time; others just occasionally. And eventually he had his arm twisted to get the computer in there.

So he had to come to me. And we had a long conversation, and I said, "Okay, I am going to spend the coming summer and the coming fall on this project. I will spend the summer doing studying, evaluations, and travelling, and then in the fall I will implement a plan that I will design during this period." I said, "The way I see this is the computer can play a role at the modules and managing the project, because instead of a semester of calculus you have 15 modules. You know, just multiply that by the number of courses, that becomes a..."

[INTERRUPTION]

"So you can have a management problem, and also you could use computer-assisted instruction, except there are not enough of these around that are of any use. And we certainly don't have the time within this project to even attempt anything like that." I said, "The complementary thing we can do is we can view the computer as a kind of a sandbox for these problem-solving teams. Since the problems have a technical foundation they can model the project. They can model the problem. And then they have a common framework within which they can communicate with each other. They have an operational manifestation of the abstractions that they're going to externalize in terms of how they are thinking about this problem. And furthermore, this also becomes a vehicle for communicating with other people. Because if you're presenting your solution... or solutions, because this also provides the opportunity if there's a renegade in the team that says, 'Well, I think this ought to be done differently,' you can do it differently. If you are presenting this to other people and they're having a difficult time accepting just what you are talking about

they can ask a question that you can respond to in an operational way and show them what the result would be."

Well, I found out about simulation and modeling. I visited the University of... Portland's University, I guess it's called, in Portland where they have a Ph.D. program in systems science. They were using a manuscript form, a book called *Patterns of Problem Solving*, which I then adopted as a backbone for the course that fall. That fall I found a guy at Purdue who had created something called GASP 4, which is a modeling language, written in FORTRAN, highly modular. And we had 11 sample programs in there and it turned out I had 11 students. So each student got one of these programs with a charge of, "Bring it up on our machine; design a non-trivial modification of it, and get that operational in order to make a presentation." So that was sort of what we did.

Well, now that we had the personal computer phenomenon, and I don't know if you remember this advertisement that IBM had, but I thought it was so dramatic in terms of the impact of the personal computer, why the timing of this was right for this to happen, and here within chemistry I developed why this was important. We were exposed to the phenomenon in the recent past of some schools requiring a personal computer on the part of each and every entering freshman - Drexel, for example. Macintosh struck a deal with Apple on that. In looking around I came to realize that in universities there are people who are paid to do research, and those are the ones that get all the brownie points and the big salaries, and then there are those who don't, and therefore, they teach. And what are those people doing with the computer? They're developing computer programs based on algorithms that were in operation before the computer was invented. Okay, so you are not going to get anybody turned on or excited by that.

Then gradually, I came to also appreciate that, of course, the big impact of the PC was it was a large number, large installed base, of a standard operating system. So this meant that a really thinking guy could come up with an algorithm on a corresponding program to operate in that environment that could develop a big market, and therefore could not only be motivated to do this, but motivated to do it extremely well, because number one, the potential of the market is great; number two, they're going to be competitors. So you better do it well the first time so you can grab the niche.

Well, in science and in engineering statistics is a big deal. And with the ubiquitous microprocessor you can attach these to transducers and sensors. We can collect a tremendous amount of information over a short period of time in very small samples. Now that means statistics can be used in a very sophisticated way. We could do signal analysis; we could do pattern recognition - lots of neat things. We can also do feedback control. Now, these are all words that have been in the engineering community for a long time, but I am talking about the degree - not the concept.

Well, here at IIT I came up with a suggestion, which I call the IIT plan. And the idea is the following: let's use the personal computer as a vehicle for the whole four year program in all of science and engineering. But we will start out with a starting point that's already in place here. We call it Project Hawk. It's a first-year program. Students go to the bookstore; they buy some software - I think there may be seven different components. There's a spread sheet; there's TK solver and some other things. And they get a manual; it's called a Hawk manual, and in that manual are the dos and don'ts about how do you get an account, how do you log on, how do you use electronic mail. Electronic mail is a big deal here - it's not conferencing; it's electronic mail - especially Friday afternoon kids are making arrangements for the weekend you can't even hardly log on to our machine.

I said, "Well, one of the points for doing this is to provide a common foundation for all our students so we can build," but no building was happening. So I suggested that we design a second year, which would be built on data logging, signal analysis, the physics and chemistry of transducers, and doing things in real time. Well, the objections I got were, number one, "There's not enough time to correct them, add new things." And the other objection was, "This is too expensive."

And then one day I was reading, I guess it was an editorial on science, and I realize that the automobile industry is the perfect vehicle, if you pardon the expression. Why? It's highly competitive - to try to reduce the use of fuel per mile and reduce pollution. So if you lift the hood of your car and look at the engine you see a cable coming out with a jack with nothing attached to it. Well, that's where the mechanic attaches his device, and he's part of the data flow within the system. So you're sensing nitrogen oxide; you're sensing oxygen; you're sensing carbon dioxide. You're

adjusting instantaneously - what's happening when within the engine you have anti-skid brakes. You're sensing when the wheel locks, and you can sense how frequently you should cause those to be turned on and off. And this is being massed-produced. And the chairman of our board at that time was Bob Gelman, who was chairman of the board of Motorola. And Motorola is here in Chicago. And guess what, they had an automotive, industrial electronics group.

So I wrote to Gelman and I said this and that, and I sure would like to talk to some savvy engineer to see whether or not we could use a development system, because there has to be flexibility - not the final system as it's installed in the car - as the basis for a laboratory. I said, "Furthermore, the automobile has captured people's imaginations. I mean, this is an important part of everybody's life, especially a young person. So if we are going to get into what's going on inside of these machines? And how do you control things, and how do you sense, and so on that also will provide a motivational kind of thing. More important, down the road we recognize that the personal computer is a vehicle for technology transfer. The people get application packages." And I brought up the statistic thing. A lady in our math department who is a professor of statistics came down hard on me. She said, "Well, we offer all these courses. If they want statistics they can come and get these courses." So I went through the catalog and established that for a person to get these courses in statistics one has to be a math major with a minor in statistics. I said, "So what good is that going to do somebody who is going to be an engineer or a scientist?" Well, that's not going to sway her.

But it further convinced me that this is just an example of an application package and that a service that we can provide for our students is to teach them how to become sensitized to what packages are available, how to make an evaluation as to whether or not that would be a useful tool for them, how to verify the tool does what they think it does, by whatever means, and then add that to their tool kit - that this should become a kind of training that would carry them into their functioning life as a professional. This is almost a form of continuing education, because what you are having handed to you, or what you have available to you, are problem solving tools with a range that's way beyond anything you might have learned about when you were an undergraduate, got your degree.

We could then go on to our junior and senior year and get into this group problem-solving kinds of things, because there's something else that's operating. Chemistry is a cottage industry, and chemists can afford to do that, because this is an exponentially expanding world. I mean, there are 10 million known compounds, and there are 5000 new ones being reported in the literature every week. So if you want to find your molecule family, you know, you have got it made for the rest of your life, and you don't have to be a subservient to somebody else or depend on somebody else.

Look at supercomputers and look carefully at what's going on, and you come to a position, or I came to a position that the power of these devices in terms of this active memory size and the speed with which they can do calculations is such that it is no longer possible for a single human being to come up with a model that will tax that magnitude device and do justice to all the nuances of the model. In other words, this a multi-disciplinary kind of thing that's got to be a team approach, because there's no one person that's in command in a fundamental way of all the different parts of what's going on.

A friend of mine, David Edelson, who was with Bell Labs and then quasi-retired and took a job in a chemical engineering department at Florida State University, has got a major project under way, which has to do with chemical kinetics. I just reviewed a collection of papers, and his was one of them, which is why I am sensitive to this. What's beautiful about what he is doing and his confreres is that they have laid out as an objective an important problem, which in the chemical industry is chemical reactions. And built in from ground zero is the realization that there are various specialties that are involved. And therefore, they are going to draw on individuals who are accomplished in each of these specialties. And built into the system is a meta-language that they can communicate with each other in their own language and still come up with something that's going to fit into the structure they are creating. Now, I think that's peachy-keen. I really do.

So that's sort of part of this business of functioning within a team and coming up with problems that are neither trivial nor overly ambitious, but learning that one depends on other human beings for part of the design of the solution, and one depends on other human beings once removed in the form of the problem-solving tools they make available via these programs that are now highly transportable. In that manner, one can feel free to conceive of problems and find

solutions to problems that are significant, but also learn how to work within a problem solving environment...

END OF INTERVIEW