A TEI Project

Interview of Mario Gerla

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1.1. Session One (December 3, 2013)

MR. FIDLER
: This is an interview with Mario Gerla. I am Brad Fidler and it is the morning of December 3, 2013. How did you first become interested in computing?

DR. GERLA
: That's an interesting question, but I was a student at Politecnico di Milano in the early 60s, and a program — and the first two years are common to all the students. By the third year we had the choice of choosing a specialization, and I — a new field had just opened up two years earlier, which was entitled Electronics and Computation, you know? So I decided to go into that after consulting my friends. Computing was then becoming known to people, let's say in the early 60s. Not popular, but people understood the potentials, and that's how I got into computing, you know? When I was in my third year at the Politecnico di Milano.

MR. FIDLER
: At that point were you aware of any of the very early work that was done attempting or thinking about network computing?

DR. GERLA
: I think there was absolutely no notion on networking at that time, you know, let's be frank, and [chuckles] I still remember I was walking through the corridors of my institute, and I would see these big machines, you know, these computers like, ah, I would say refrigerator size, but closets and so on, two or three meters tall, lots of bulbs in them. So just the idea of them working solo was a major advance, you know, a major novelty. Connecting them as a network was a bit remote. Although I have to say that once I finished at the Politecnico, the notion of connecting to the computer remotely using modem was already coming up, so centralized computer and connections to it in a [STAR] fashion, yeah.

MR. FIDLER
: Was that a time-shared system then that you —

DR. GERLA
: Time share system, you know.

MR. FIDLER

Were you affected by the politics at the time? I understand that there was a massive increase in enrollment, and increasing political unrest in the 60s.

DR. GERLA

Oh, yeah, we are talking about the late 60s. There was student protests. Student protests in Europe. In the States it was, of course, reinforced by the Vietnam War, and so those things went hand in hand, but in Italy for sure. It happened after I graduated, because I graduated in 66. I then did my military service. I was in the Navy for two years, and after that I came — and as I was in the Navy, actually I would still collaborate in the Politecnico. I remember that in 67, when I came back to spend the summer doing research at Politecnico, I was given the key to the lab and since I also worked on weekends, I was recommended to be super careful not to let anyone in! Yeah, those were really tough times, you know? There were protests everywhere in Italy, in Milano, by — I would say actually, interesting enough, that there was — the engineering student culture was even then quite conservative, so we were — and this is anecdotal but I'll tell you anyway. The Politecnico di Milano had two departments. One was engineering, the other one architecture. The architects were the most, of course, unrestful, and they would participate in these demonstrations. The engineers would sort of sit back. But we actually had a number of interesting meetings, you know, faculty and students who discuss the future of, you know, university education and which was at stake then, and I think many, many reforms were made. Some didn't last much long, some were more permanent. I think only know that it was a wakening, an awakening of the student population and sensitivity for student rights, and some good things came out of it. Fortunately I came to the States [laughs], then I got the U.S. version of it, and again I have to say that the engineering students were very conservative on campus. I think this is — probably you don't remember — but in 69 and 70, I remember we had classes here, you know, and some of the professors say, "Okay, well, there is a demonstration on campus, I don't feel like lecturing, you know. Let's us go around the classroom and see what you feel about it," and there were actually students that were working at aerospace at that time, and they were totally against the protests, and younger students like me coming from Europe and saw it before, they saw the possible good things of it. But, anyway, no, the student protests [didn't actually] have an impact on our education in those years.

MR. FIDLER

And despite having a conservative engineer — a more conservative engineering culture, during your undergraduate degree you mentioned that you still had to be careful to lock the lab door. Was there any kind of sense — was computing, for example, something that activism was paying attention to?

DR. GERLA

Ah, well, I don't think it ever came to that, but there were some acts of vandalism on some campuses, you know. Well, that was also — you may not remember, but that was also the time of the Red Brigades in Italy, and the Green whatever, the similar movements over Europe. And those are not just basic student protests. There was a much more fundamental rebellion, you know, to the society, and so if those elements, if they got into departments, they could have destroyed everything. So there was concern.

MR. FIDLER

Was there any personal attack for you, besides locking the lab door?

DR. GERLA

[laughs]

MR. FIDLER

Did it affect you in any other ways?

DR. GERLA

I would say it did not, you know, because I didn't see any change around me, and so also I was working for the Navy, and I was just visiting Politecnico for the summer. And after my military service, I went to work for a company and so I was a bit isolated from the student protests at that point.

MR. FIDLER

Was your undergraduate work something that carried over either into your time with the Navy or that company?

DR. GERLA

Oh, yeah, definitely, because my — actually undergraduate, call it "undergraduate", but the program at the Politecnico was actually — was labeled as a Doctorate, but it was a five-year program. I would say equivalent of a Master's program. And it was probably more advanced than a Master's program, because, I mean, we started early to work on technical matters, but, yes, I had worked on communications, in particular [inaudible] communications, and in the Navy I carried over because I worked on a naval — on a military satellite project, one of these satellites that were launched by the U.S. and various institutes in Italy and all over, actually all over the world followed the satellite. I built an antenna together with a company, you know, in Milano. So with this major antenna, we would monitor the satellite signals and the propagation effects, and so it was a UHF satellite.

MR. FIDLER

Can you say anything more about the purpose or function of the satellites that you were —

DR. GERLA

Well, actually, at that time satellite communications were very experimental, so — for data and for tactical, and so the purpose was to study the propagation effects. There was also a voice channel that would allow us to communicate with other researchers, and so there were similar groups and Germany and in France and also in the — I mean, the NATO countries as well as in US following it, so it was a connection to the research world in the U.S.

MR. FIDLER

Can you tell me about the process by which you moved from Italy to study in the United States?

DR. GERLA

Ah, it was actually a bit accidental, let's put it this way, because I came across a Fulbright program, and there was an opportunity to apply to it, so I decided to — on the spur of the moment to apply, because I thought it was actually probably interesting to come to the U.S. for one year. It was actually a limited, one-year MS program, so I think the application took me no more than half a day, and including letters of recommendation which were prepared by my colleagues, you know, in the department. So all that was shipped out, and then a positive answer came back then, you know? And I was actually — I was asking for three possible sites — MIT, Los Angeles UCLA, and UCSD. UCLA actually was probably my favorite, because Professor [Andrew] Viterbi was then a

professor at UCLA, and he had lectured at the Politecnico di Milano. He was a good friend of Professor [Carasa], who was then my instructor there. So I listed UCLA as the first choice, and I, I got it! So, and as you know, Fulbright is quite generous. They pay your trip and a one-year fellowship, so I — actually coming was not easy because I told my company, I said, well, you're leaving so for a year, so sure, this is actually not very good for us, but at the same time, you know, to consider because you go to the U.S. in one year you probably do not get that much done. If you stay for a year, you're advanced in the career, so they were a bit — not totally supportive, anyway, but they didn't say no. They agreed to take me back when I returned. And so I did, and I — that's how I came to the U.S.

MR. FIDLER

When and how were you introduced to the ARPANET research at UCLA?

DR. GERLA

Well, actually I really was introduced to it by a course I took — the first course I took here was in queueing theory. Of course, I didn't know what queueing theory was, not even — the name sounded strange, you know, very new then. But Professor Viterbi, my advisor, said, well, this is a popular course in computer science. I mean, by the way, at that time there was no computer science. There was just the Department of Engineering, so, you know, so, well, "This is a popular course, you may as well take it." So I took the course, and of course through the course, some comments about the ARPANET emerged. But actually the first time I knew about the ARPANET was from a colleague of mine, also an ex-colleague from the Politecnico di Milano, he was more advanced than me, a Ph.D. student also, and he said, well, "These Americans are very strange, you know, look, because, can you imagine? They have a project to study arpa, you know? And the musical instrument, arpa, and this is they've got these three rooms all locked up, you know? And I can't believe it, I don't understand it." So okay, I said, what [laughs as he talks, inaudible] something strange, this arpa. Okay, then eventually we figure out what that was. But — and, yeah, and so I, at the end of the first year, I had learned what the ARPANET was because in the third quarter in the fall — in the spring quarter, I had taken a course in natural flows and ARPANET was prominent. In fact, we had already at that time put together some papers together with Kleinrock on the optimization of such networks. So I asked Kleinrock in the spring of 1970 whether he had a position for me to work as a research assistant, because my fellowship would have sent me back after one year, and I really enjoyed working in this research environment, and Kleinrock said "Yes, yes, you can work with us." It was a time when money actually was more plentiful than these days. ARPA was very generous. And that's the way I got to work on the ARPA project.

MR. FIDLER

When you started working for Leonard Kleinrock in the spring of 1970, did that quickly turned into your Ph.D.?

DR. GERLA

Pretty quickly. You know, I — after a few months I decided that would be my Ph.D. topic, and Kleinrock agreed. Now, remember also at that time, people would graduate, what? Most people would graduate with a Ph.D. faster than today, so it took me three years, and it was pretty much the norm then. Now it is longer. But, well, we had the major advantage. The major advantage is that we were traveling new grounds, you know,

traveling new grounds, nobody had done the work before, so everything was original. Besides, without the Internet, you couldn't tell what people in Russia or in China were doing, or even in Germany. So everything that was locally original was approved. Although also the Internet was so new that there was really virtually no work done on it.

MR. FIDLER

How were you introduced to the Network Measurement Center, and what was your relationship with the Center and the folks there over the course of your Ph.D.?

DR. GERLA

Yeah, the — actually the Network Measurement Center was the major —I mean, that was the purpose of the DARPA grant to UCLA. Different sites work on different things, but the main funding to UCLA came to, for this task of monitoring the performance of the ARPANET, and measuring, you know, also traffic, and so I think it happened because Kleinrock was well recognized as the father of the models for packet-switched networks, so he would have been the ideal evaluator, performance evaluator, and I actually got coupled with it because my thesis was about designing routing algorithms for the ARPANET and also developing methodologies for topology and growth for the ARPANET, but an important component of it was the performance evaluation, so I did fit right into the Center. However, I never really got involved in nitty-gritty measurements on the ARPANET. Other folks were doing that with more programming background. I was a sort of [inaudible] programmer, I was an application [writer] programmer, FORTRAN, and so I — at that time working on machine programming and systems programming was not trivial. You had to get your hands dirty.

MR. FIDLER

Can you say more about your dissertation?

DR. GERLA

Yeah, and so this topic evolved over the years, but you tend — you are being, ah, in fact you have a copier sitting over the table there, but it is the design of packet-switched networks, and the design involves various aspects, you know? The first aspect is the routing of flows, you know, traffic flows in the network, given that you have a fixed capacities set up. And then we moved on to say, well, but how about modifying the capacities, you know, if you're a fixed budget? So, and that was then the next step. Optimizing the, ah, network — the capacity location [through] links to mini — [inaudible] was then the average delay over all node pairs, so delay was a major performance target. Then beyond that we said, okay, well, but the point itself can be modified, so, and that was a very difficult step because it is totally [inaudible], very complex, you know, problem. So we develop heuristics for the topology optimization on a network. So those are the major three steps, and within each step, you know, I use the algorithms available in the literature and also developed my own, and so we wrote a number of papers, that's how we land on the subject.

MR. FIDLER

And were you sharing a computer with the other Network Measurement Center students?

DR. GERLA

Yeah, the [inaudible] computer was interesting. Actually what I had was a terminal, I never really had a computer, it didn't exist then. You know, a terminal connects you to — I think Michael [Bellas] was working with the main IBM computer of the computer center. The computers on the lab, like the IMP and other processors, were totally

dedicated to the network itself. I wouldn't use those, because my program¬ming was, application programming, say, I would use — either we developed tools that were run in the mainframe, or I would use existing tools. So.

MR. FIDLER

So you weren't on the time-sharing center at the Network Measurement Center, you were —

DR. GERLA

No, no, I was not working on the time-share system of the. [stops here]

MR. FIDLER

And at that point, what were your impressions of the future of the ARPANET? Did you expect it to grow?

DR. GERLA

[Chuckles] Everybody's asked that question, but I think this is anecdotal information, but I have to say, after spending one year here, and I worked — actually one year and a half, you know, I was already starting to work on my thesis on computer networks. I went back to Italy and I spoke with my professors there and I told them what I was doing. And I was saying, Oh, well, I'm working on computer networks. Connecting computers together. And they looked at me a bit strange and said, "Well, this sounds very interesting, but, you know? I'm not sure, as your professor, that you'll ever be able to use this technology. But, it doesn't matter, because, you know, in the U.S., you learn so much materials and so many new things, when you come back, you'll be able to use those other aspects, you know?" But he only said, "I don't think this computer network will ever go anywhere." [Chuckles] It was also the feeling of many people around us, because at that time, I remember, the operating Bell Telephone, the operating companies owned the world, you know, it was all voice - data was transmitted on these voice channels. They thought this experiment was something interesting, but not to be given much attention, you know? And we — I mean, what can I say? We actually looked at the computer network as a nice toy, you know, you optimize and we understood the implication of saving capacity for intermittent traffic. But since there was no Web, you know, there was no notion of grabbing data, you know, from somewhere, so the only thing — in fact, the first major success of the Internet was e-mail, you know? And we said, well, with the Internet, I don't have to get on the phone and talk to my friends and call them up; I use the Internet. Because e-mail didn't require people to store files, make them accessible, so it can be done peer-to-peer. That's the first application. Anyway, I hope I answered your question, but there was some initial skepticism, and then the e-mail came out, people started believing, and then, wham, when the web came, then we turn the world around, you know?

MR. FIDLER

So despite not having much initial enthusiasm for the spread of the ARPANET, did you eventually have a role in spreading interest or applications of network computing in Italy, for example? Later on?

DR. GERLA

I think I may have had an impact, because — well, in many different ways. See, I had been going back to Italy often to lecture, and maybe not so much of an impact on the faculty. I mean, they were — but the students, the young students really liked what I said. Many of them, maybe motivated by what I told them, eventually started to come to the

States and then they — so and these are the people — I mean, some people of course came to the States and stayed, but the majority returned and then they became professors, so they got exposed to — I think I had an impact that way. Just to motivate the students to come to the States, to get more of it and go back, you know. So I think it's a story common to most of the European countries, where the youngsters returning from the U.S. spread the word! Against would be the older folks who were a bit conservative, as you can expect.

MR. FIDLER

You mentioned using e-mail early on. Can you characterize your use of the ARPANET during the 1970s for things other than your dissertation research, for example?

DR. GERLA

Yeah, I think the first use was e-mail, no question about that. There was of course the file transfer. You get papers from your colleagues through the Internet so that was popular. But painful, I would say; not easy at the beginning. And so it built up. I should also say that after I finished the Ph.D., I went to work for Network Analysis Corporation, so there was a company that had to make a living by selling networks, so we had to tell people what they could use a network for. So we sold networks to government agencies like the National Security Agency, you know, they were very interested in networking already then. But Post Office, you know, Department of Transportation, we were actually submitting proposals to all of these companies. One thing that I remember, we also proposed a system to the border, to the Customs and Immigration Service. We took field trips to San Diego and Tijuana to check — yeah, they were interested, for instance, at that time, to document all the traffic coming through the border, read the license plates. Modern set ups, you know? And so to automate the inspection process. So that was actually useful, because although my main use of the ARPANET was e-mail, I was actually proposing, writing proposals to these [various] agencies on how to use the ARPANET. So essentially, we didn't have the web, they was probably naïve uses, but still quite significant.

MR. FIDLER

Just briefly before we go to NAC [Network Analysis Corporation], were you using the SRI online system for anything?

DR. GERLA

I was not, actually, I was not using that, no.

MR. FIDLER

So there wasn't so much of other, the specialized facilities at other nodes —

DR. GERLA

No, I mean, not for my part. Maybe — I would say that maybe researchers after me here started using those facilities for their theses, you know, for finding references and so, ah, we did — at NAC, you know, we were more pragmatic [chuckles], and I think my — I would say also the major issue at NAC was to save customers' communication lines. At that point, remember, people are using point-to-point lines and low-speed, expensive. So replacing the sys — so we will keep the same application, replacing though point-to-point lines, time shared systems, with a packet-switch network who proved to be advantageous.

MR. FIDLER

So while at NAC, were you working with BBN on these projects? I know, for example, you mentioned the NSA. They were doing —

DR. GERLA

Oh, yeah, definitely. I was — actually, I was — one of the projects that NAC had been tasked — you see, NAC was really — the initial support of NAC came from DARPA, you know, and it was an agreement. DARPA would fund NAC to maintain the DARPA topology, you know, and that was a big chunk of money coming in, and of course besides that NAC developed also an industry to redesign cable TV networks for local providers, you know, or even businesses, and at that time these time sharing networks were very popular, so it was topologies and of another type, but it kept the company going. So as part of the maintenance on the ARPANET, we were working hand in hand with the BBN, of course, had the — also a contract to maintain the software, and in fact I remember we —Dave Walden would work side by side with me sometimes. We would be invited to Washington, D.C. to give presentations to the colonels about this new ARPANET, and then we would be getting different aspects. You know, how do you design the topology, and how do you install the software right. And actually I was in touch with BBN. BBN actually offered me a job, I have to say, and it was actually a nice opportunity. Another good opportunity was that I was offered a job also by Qualcomm, which was not called that way. But then eventually I decide to just go back into academia, you know?I think I really liked to teach, so that's why I came to UCLA. But, anyway, to make a long story short — Yes. BBN and NAC were working very closely.

MR. FIDLER

Do you have any observations on the different kind of organizational culture and structure between NAC, BBN and the Network Measurement Center at UCLA?

DR. GERLA

That's definitely so, you know, NAC was a small company, probably an early version of a start up, so that to struggle for money, they could go after any — BBN was a very tradition company, built on — they would be in control systems and mechanical system, and so they had plenty of money, and so they had different goals. They wanted to make sure they would, you know, do solid work and they were already thinking how to use this technology for some bigger system in the future. And, well, UCLA was an academic environment, so there was really no pressure for funding, except for to make sure that DARPA would deliver the next check, you know? And so working at UCLA as a researcher, of course, was an immense — very gratifying, because you could do all the research you wanted. And NAC, there was research to be done, but on your free time, let's say. You know, you couldn't — because you're working 20 percent of the time on proposals! [Laughs]

MR. FIDLER

So you mentioned funding as one of the main factors in how these firms operated. Was there a particular impact of DARPA funding on these different organizations?

DR. GERLA

Definitely, you know, BBN, the Internet operation was funded by DARPA, and I don't think that they really made much of an effort to pursue other commercial ventures, from BBN. And at NAC, they'd get funding from DARPA, it was maybe 50 percent, and from other companies. In fact, I know exactly that there was a major — DARPA funded major IMP. In fact, one year DARPA went through one of these periodic, ah, [inaudible] situations so that they couldn't get money from the government for six months, and NAC actually had to lay off about ten, twelve people. It had a major impact. You know, they

had to — no cash, you know [chuckles]. UCLA, I don't know what happened to UCLA, but they say they absorb — typical university is in a better shape to absorb these kind of financial set backs. But for small companies like NAC, it was a major impact.

MR. FIDLER

How did you and your colleagues at UCLA and NAC perceive DARPA? What did you think about the agency overall?

DR. GERLA

Well, remember, okay, it was an interesting time, you know, the early 70s, and there was a lot of anti-government, anti-military feelings, you know, in the students, so when I would say that I was working on this DARPA project, Defense supported people, ah, not happy. [People would] look at me in a suspicious way or even — because, you know, DARPA was part of the Defense Department, so if you — that's what may be a feeling. But, otherwise, I would say that the funding you get from DARPA was really totally research funding. None of the work would be use for military purpose for the next twenty, ten years. So I didn't personally have any problems in working on that. And the way DARPA worked then was maybe better than now in the sense that the program manager had a lot of control on the funding, so Len was lucky he had a good friend in DARPA so he kept funding him. So it was like a, a very blessed [chuckles] support, you know, and that's very different now, you know, I see how difficult it is to get funding from the Department of Defense, super competitive, and in fact nowadays you may get funded for two years but after one year the funding goes away, so they kiss you goodbye and you [inaudible] very, very suddenly. Actually it has happened, and not so, so the funding from DARPA, from the military has less reliable in that sense than from NSF these days.

MR. FIDLER

You mentioned that in the — well, at least in the early 1970s the program managers had more autonomy than they do now. Is there anything else that you can point out regarding the differences between DARPA when you were working on their projects, say, with UCLA in the early 70s, and today?

DR. GERLA

Yeah, I would say actually, aside from the fact that the program manager had more control, there was also less control exercised by DARPA on the research you did on campus. I don't recall having, you know, such strict control on publications then. Right now, you know, one of the reasons why many of the — we cannot work on many of the DARPA projects is that DARPA requires the control examination and revision of all the papers you want to submit, so that may slow you down and in some cases you're gonna publish, the University doesn't like it, and because of this is a friction in UCLA in many cases rejects DARPA funding for that. And that is actually so. In my case, I had to work on a recent DARPA project on a separate — with a separate mechanism, you know, but I have to say that it's a real requirement concern, you know? Before we present anything supported by DARPA, we have to get clearance and clearance can require a month, so it is problematic. It didn't exist then.

MR. FIDLER

What did you think about this management-style method of funding, whatnot, that you experienced with DARPA projects then versus other environments you had at least observed or maybe worked in?

DR. GERLA

At that time or? So talking about the early 70s?

MR. FIDLER

Yeah, and also now if you have observations on that as well.

DR. GERLA

Yeah, if I put myself back in the early 70s as a — when I was a manager at the Network Analysis Corporation, and, well, getting funding from companies was not easy, so let's put it this way. You had to visit them and hustle [chuckles] and besides convincing people that they really needed a network to replace their current system was not easy, so the commercial world was a very different reality than DARPA, you know? NSF was actually probably also quite generous in those days. Accepted rates for pro¬posal then was at 30 percent. Now it is probably eight or — seven or eight percent. So it was a different environment. So being funded by the government for the university was [known], but of course if you are a company, you cannot be supported by NSF, so.

MR. FIDLER

Were there differences in the way that you were supervised or evaluated as a student at UCLA compared to when you were working at NAC?

DR. GERLA

Well, let's say as a student, the evaluation process then was pretty much the same as today. You know, you evaluate students by what they produce in terms of research. Maybe at that time there was more money around, so you will keep students working on projects although they are not producing very much and they will change that. Well, going to NAC was a very different story. Now, of course, pretty quickly I was promoted to manager, so I had to evaluate other people myself, but again, you know, the evaluation process was much less generous and even more strict and more brutal in a sense that, well, if you didn't know how to program, you're gone. I mean, you have to do this. And in the company, well, the requirements there were to be able to program, be able to write proposal, be able to talk to customers, so you have to learn how to do that, and so those are the requirements then. Different from the student requirements for sure, but, ah.

MR. FIDLER

Going back to the work you did at NAC, there was topology optimization for the ARPANET. Did you have much in the way of interaction with BBN when, for example, you would propose a topology change when a new node or two came on?

DR. GERLA

Yes, we definitely would communicate to them what we discovered, and they would be aware of it, but they wouldn't really be questioning our decision unless it was something very strange we did. They would just go along with it and say okay, that's fine, and maybe we will install another node here and there. So actually changing links wouldn't probably make much of a difference. To them it was very important to install a node or where to install it or [inaudible install], because they're producing the IMPs and TIPs, yeah.

MR. FIDLER

You also said beyond working on the ARPANET at NAC, you were developing networks for other agencies [proposing inaudible] —

DR. GERLA

That's right, yeah, yeah, right.

MR. FIDLER

Can you speak about that?

DR. GERLA

Yeah, so we had a number of topology and routing design tools that we could use and then when I was at NAC of course I improved all the tools I developed at UCLA and I used the right there, you know? So the process generally would be one of getting the customer's requirement in terms of say you're talking about maybe a large bank with a main offices and branches, you know, how do you connect the whole thing? So you do your — and you have to learn from them the site locations, the traffic, and then you lay out the network, which is a combination typically of backbone and local access, so we have a number of — certainly you have tools to do that. You try and [cut] the topology, submit a proposal, they see there is a cost of action, they're happy, so we start talking [laughs].

MR. FIDLER

Would it be a different contractor that would actually implement it, such as BBN, our would NAC actually —

DR. GERLA

No, NAC wouldn't really implement. It would do the design. And in fact, that — we would work with other contractors. It wouldn't be necessary BBN, there would be TELNET and other operators then that they were also developing switches, and they would work with us. So sometimes the bids are joint bids.

MR. FIDLER

And these weren't always packet solutions, distributed networks. You mentioned STAR network —

DR. GERLA

Oh, yeah, yeah, part of it could be packet switched like in the center network connecting major centers and then you would go in a time-sharing polling. Polling was popular then the various branch office. Yeah.

MR. FIDLER

From UCLA, Fouad Tobagi and William Naylor both at different times went and worked on networks at banks, in particular ATM networks and home banking.

DR. GERLA

Um-hmm [affirmative]

MR. FIDLER

You mentioned some work at least through NAC with banks. I think you consulted —

DR. GERLA

Oh, yeah, NASDAC, we worked on a NASDAC project, and, again, that was a project where would have a backbone and local access, you know, polling lines. I did actually consult for Citicorp, while when I — let's see, when I came back to UCLA I was working as a professor so I did some consulting for these companies, yeah, on network optimization. And then a Bill Naylor actually was, I think at Citicorp, if I remember correctly.

MR. FIDLER

He was —

DR. GERLA

Now, Fouad Tobagi never really worked for a bank, he worked for a company, I think Starlight, I think it was a company that was producing wireless switches then, wireless Ethernet systems, you know.

MR. FIDLER

So this was an early case of technology transfer —

DR. GERLA

Oh, yeah, yeah. Yeah, in my case, in fact, mine was, you know, an example [inaudible] technology transfer from UCLA to NAC when we were selling the tools, expertise and so on, yeah.

MR. FIDLER

Besides banking, and it sounds like some finance, what other industries did you see this UCLA research transferring to through NAC? And how would you —

DR. GERLA

Well now I need to massage my memory to see the various projects we worked on, but so I already mentioned the Immigration Service. Instrumented the Customs sites. NSA was interested in network [inaudible], and I can't say much more about that! Although it's a long time, in fact the things are vague in my memory. But other agencies, government agencies, I think the Post Office was interested in a network; even the Federal Express, all of these systems that had to deliver, you know, data to subsidiaries were very interested in this concept of a network that could make — reduce their costs, you know? As opposed to connected all up to a main center. Doing this backbone, using packet switching was interesting to them. And there was at that time, besides the ARPANET where a commercial net was coming up, like the TELNET, TYMNET, you remember those? And, NSFNET also.

MR. FIDLER

Can you say anything about the applications that you were using? I know there was one called GRINDER, topology optimization

DR. GERLA

Oh, yeah.

MR. FIDLER

Were there any other applications —

DR. GERLA

It was Graphic Interaction Network Design! [Chuckles] I think that's the way it was. Yeah. Other applications?

MR. FIDLER

And the relationship to the initial work that you did at UCLA and then where else they would have been used? You mentioned that these were used beyond just topology optimization for the ARPANET.

DR. GERLA

Oh, yeah, right, so there are all these tools. We integrated the basic packet-switch tools that designs the topology with local access tools that will design your STAR networks or a multi — all three networks. So that was — and in fact it was man-datory because most of the customers wanted to have an entire network set up, not only the back one. They say, okay, well, I've got all these thousands of branches, you know, surely you can save me money that way! Right. It had to be a full design. And then of course the protocols also, it was — they were also changing. Ethernet came out after I finished UCLA, so I

had to integrate that product, yeah. Then eventually, well, wireless LANs came around only at the end of the 90s, so that was a long way. Although packet radio was already an important project, but packet radio never, was never commercialized or nobody ever anticipated that the radio, the packet radio would have such an immense impact with [wave length]. People at that time — I remember, I worked on the packet radio project for a while when I was in NAC, but people are thinking about emergency services, ambulances, you know, convoys, but the fact that somebody would connect the mobile to the access point was remote, you know. People didn't think about that.

MR. FIDLER

In addition to packet radio, were you connected to the packet satellite work while you were at NAC?

DR. GERLA

That's right. You know, the packet satellite was an important — so DARPA had the packet radio, the package network DARPA, packet radio, packet satellite, and again UCLA was involved in all these projects. And I worked — actually when I first came here to UCLA, I started working on the packet satellite project, which requires different expertise than the background network per se because the major issue is how do you access the satellite channel, you know. Multiple access methods, so you develop many of those. In fact, through the packet satellite project, I got to visit many sites that DARPA was funding abroad, you know? DARPA was funding a group in London, Peter Kirstein. Another group in Norway, Pål Spilling. These are all satellite sites that would be connected to the [inaudible] satellite, [ARPA satellite] network. There was — yeah.

MR. FIDLER

So while you were at NAC you had a lot of contact with these other organizations that were working on —

DR. GERLA

No, NAC didn't do any satellite, packet satellite work, you know? So I did it — so I left NAC in 75, 76 probably, you know? And I joined then UCLA part time. I was also working part time for Computer Transmission Corporation, you know? It was a strange arrangement, but I think at that time, I decided I wanted to keep a foot in industry and a foot in UCLA, and Len, he liked that because I think the funding was not sufficient or — in any event the work that I was doing, packet satellite, was fine, was part-time work. Yeah. So I — all of these contacts with the satellite companies I made when I left NAC.

MR. FIDLER

You were at Computer Transmission Corporation, I believe you were a manager?

DR. GERLA

Of computer networking, yes.

MR. FIDLER

From 76 to 77. Was this another case of technology transfer —

DR. GERLA

Exactly. You know, actually Computer Transmission Corporation was quite advanced in the design of local access networks, you know, the time-sharing networks, if you want to call them, because they had come up with a concept called PACUIT, packet and circuit network, so they could establish circuits — virtual circuits on these three distribution networks, and that was quite efficient, you know? And Ray San was the director, a very flamboyant guy with great ideas. He still has ideas nowadays, but then he was even more

active. So I joined Tran you know, Computer Transmission Corporation, and I worked for a year on their PACUIT plan, how to actually implement the MESH network using PACUIT. At that time actually Tran sold the systems to Canada, you know? So it was a big success commercially for them. And I don't remember the company they sold it to, but, ah.

MR. FIDLER

Would that have been DATAPAC?

DR. GERLA

Yea, DATAPAC, yes. DATAPAC, I think. DATAPAC was packet stream between Canada, right? So they were — yeah, that they give them a system that, ah, they ran — I don't know how long they ran the — probably they eventually abandoned to move to something more modern, and in fact I left Tran after one year, you know. I kept consulting for them but I realized after all that was my — a place where I could really, ah, come up with new ideas and architecture. It was a nice place, you know, it was — that was an aggressive company, but it was tied to a very limited product, so I came back to UCLA and then I decided to move on [chuckles].

MR. FIDLER

To what extent if any was the virtual circuit work a response to design decision on the ARPANET at Computer Transmission Corporation?

DR. GERLA

Well, it's actually a good point, that there is a virtual circuit concept. Now, you may remember that it was a religious war, you know, there was a religious war in the early —

MR. FIDLER

Yes.

DR. GERLA

— 70s, you know? Between Datagram and virtual circuit believers, because — and it can be easy under — now, in retrospect I can understand what happened. You know, the operators, the telephone companies, they were used to circuit switches. They liked the idea of packet switching, but they wanted have some control on where the packets were routed. I said, well, let us do virtual packet switching, virtual circuits, so that we tell you where the data's gonna go to, you know, and since we can set up a path, you do packet switching on this path. But now we can control exactly the flows of various users. We know where they're going. And if necessary, you shut them off. So that was mentality coming from the telephone operators.And the purist packet switchers fought it — no, no, no, we don't want that because that is going to impact our performance. We can do much better by using fewer packages. So there was actually a feud going back and forth, and I think this debate has continued over the past 40 years. In fact, today, if you look at the — as the [inaudible] networks, you know, as the end concept in open flow, it is a method for setting up flows, you know, packet switched natural in a way you can control them. You can give them better performance. So the concept of virtual circuits still exists, but coming to the point, you know, PACUIT, yes, PACUIT is a form of virtual circuit, so it was in that area. I still remember, you know, ISI, remember ISI? One time I went, I just, I went with Ray Sanders, accompanied him to a talk that he gave at ISI, you know? And ISI was the hotbed of data grams, you know? And he gave a speech on circuit switching, [chuckles], and the discussion went on for ever, and it was just finally — these people were fighting! It was interesting.

MR. FIDLER

There were a couple efforts on the ARPANET. The first one was around this time, from 73 to 75 or so —

DR. GERLA

Um-hmm [affirmative]

MR. FIDLER

— or so, to institute access control, in TIPs at least, and perhaps further forms of user monitoring for accounting purposes. So there was work at BBN between 73 and 75 through TENEX and some distributed applications that would get migrated over [inaudible] —

DR. GERLA

That is right, yeah, yeah.

MR. FIDLER

Were you, you know — you mentioned virtual circuits. Were you involved in this [inaudible] —

DR. GERLA

No, actually I was not. I know about TENEX and other systems. I probably also have read the papers they wrote about controlling traffic, you know. But definitely there was an interest, a major interest from the measurement centers and traffic monitoring researchers to document this traffic, because once you know what traffic you have, you can design better networks. So from the point of view of statistical data collection, I saw the value. Now there's another aspect which you are hinting at that is the controlling access: letting some user in and not others, and that I don't remember, because I do not remember in fact any type of security being applied to the early ARPANET whatsoever, for the good or for the bad. I mean, probably they should have done it, but it was one thing about the ARPANET where it's totally open. And it was also, you need to understand, because there was nothing lost. I mean, since there was no data, okay, well, you can break [chuckles] you can screw up maybe the routing algorithms, well, then you get caught, but there was data to protect, to speak of. Which actually is certainly different if you design a network for the National Security Agency, then that would be another story. But then again, you know, remember that in those days, the — you wouldn't say — you, say, bring up the issue of security and say, oh, don't worry. We know all the security we need. We've got all the encryption algorithms and whatever you give me, we can make it as secure, you know, you don't have to worry about that. So that was the attitude of the agencies then. With encryption they would solve all the problems. We know now that that's not true, but [chuckles].

MR. FIDLER

So when you went to do, when you were doing work for government agencies, if they had requirements regarding security, they would take care of that —

DR. GERLA

Yeah.

MR. FIDLER

— maybe with BBN, but you didn't have to worry about it —

DR. GERLA

Right, right. They would not, ah, communicate to you, they did it.

MR. FIDLER

You returned to UCLA in 76.

DR. GERLA

Um-hmm [affirmative]

MR. FIDLER

You mentioned one of the reasons is that you liked teaching. Is there anything else that helped you along with that decision to return?

DR. GERLA

You know, of course, because Maggie [Margaret Phillips] was here at DCI, so that was an attraction, you know, to — because Maggie came with me to New York, but then she decided she wanted to come back to California to finish her degree, so actually there was also personal reason associated with that. For instance, I could have also gone and worked for — I could have probably gotten a job at MIT. I was offered a position at MIT to teach at Harvard as well. And it was a position at BBN, so I had other options, but I chose UCLA.

MR. FIDLER

When you returned, the Network Measurement Center was gone, and the ARPANET was under Defense Communication Agency Management. Did that mean [inaudible] —

DR. GERLA

But then the Satellite Project was on, yeah.

MR. FIDLER

So was there still work you observed in measurement carrying on the same way that it did, for example with the Network Measurement Center, or had it shifted more towards SATNET, for example?

DR. GERLA

The type of measurements that we did, and in fact I remember the first year they were working on the packet radio, on the satellite project, it was Wesley Chu I think who was the PI for the project, not Kleinrock. Kleinrock had taken a break [chuckles] sort of! A break from DARPA. So there was emphasis on modeling, modeling was still important, because we felt that UCLA was the center of modeling. At that time, I should mention that effected Dick Muntz was also collaborating on DARPA. Dick Muntz is well known for his work on network queues, you know? And the network queues seemed to be a very promising tool to design both computer networks as well as satellite and PACUIT networks and so, so there was major emphasis on modeling.

MR. FIDLER

How would you characterize the Network Measurement Center’s achievements or just its place in the history of the ARPANET?

DR. GERLA

In the early days, let’s see, until 73 and 74, I think the issue there was measuring the performance in terms of delays, traffic, possible anomalies that would happen in traffic, and I think they did a great job in keeping sort of BBN honest, because otherwise nobody else would have done it. I mean, most of the users were interested in getting data from here to there, you know, just the fact [chuckles] that you got your computation going remotely was important, so we were the ones that would monitor that.And I think it was important that somebody would pay attention to performance.

MR. FIDLER

So when you say keeping BBN honest, that's referring to this special relationship between the people at UCLA and the people at BBN?

DR. GERLA

Right. There was a bit of a tension there, you know, at times, because I remember very distinctly a time when Len went to a conference, said that the BBN protocols were untenable [laughs], and that statement I still remember roaring in my ears, because he got a lot of flack from [chuckling, inaudible] They said now that's a statement, you should retract it. You should never have said — no, I mean, they were very upset, you know, that he said that, because it was looking like they didn't design their protocol carefully. See, you have to remember that that was the time when the design of protocols was in its infancy. Nobody had real understanding, you know, what a correct protocol was. It was only later in the mid — 75, 76, that these people like Carl Sunshine, you know, and [Bachman], I think, in Canada, you know, there are these — there was a movement and a big, um, effort in modeling these protocols in a formal way. Formal models for protocols. But before that, it was more seat of pants. You know, 'Sure you want me to develop this protocol? Yeah, it seems to be working, that's fine.' Nobody will sit down and prove that it's correct.

MR. FIDLER

You mentioned religious war at least a few years later. In the early 70s though it seems like there was still a lot of contestation. You have Len going and saying —

DR. GERLA

Oh, yeah, yeah!

MR. FIDLER

— it's untenable. Were there particular sides that galvanized? One of them you mentioned, packet switching and circuit switching,

DR. GERLA

Oh, yeah, yeah.

MR. FIDLER

of virtual circuits, at least.

DR. GERLA

That's right. That was — but that was a contention between the researchers and then the operators. I mean, the operators then owned the world. I mean AT&T, Bell Labs and so, how can you do anything against them? They couldn't talk to them. They — well, they looked at your experiment and say okay, that's fine, and whatever pushed, ah, eventually you had to buy their lines anyway. But then the same type of contestation happened when the ATM came out, you know? And there have been different phases where the phone companies came out of solution. Actually they came out also the, ah, ISO SI stack. The famous seven-layer stack. You probably, if you go back in history, you remember there was a period there it was the ARPA stack, which was a short stack, very simple development, and the ISO SI stack, seven layer. And interesting enough, people, even the ARPA researcher, even Danny Cohen, who is really very vocal supporter of ARPA, he said, well, eventually we'll have to transition to the seven-layer architecture. It was given as a, as a fait accompli that it would be a seven-layer — the researchers. And then what happened is the industry found it too difficult, you know, and if there is something which the industry doesn't like, and doesn't implement, it doesn't happen. So it never happened that way [laughs].

MR. FIDLER

Did you see much conflict within what we might call the packet community in the early 70s, or was more of it coming in like the middle, mid and late?

DR. GERLA

I mean, between packet switches and against themselves? I don't think there were very — well, maybe there were difference opinions about what protocols you should use, maybe is at the DARPANET protocol or some other — there could have been conference between, I would say, the DARPA community and the French community. At that time you had Pouzin, you know, and Transpac, you know, and in England the National Physics Laboratory Network, I believe. So and of course these were early centers of packet-switch-protocol development, you know? DARPA maybe the first one, but it follows shortly after, so. And of course there are different cultures. They sometimes have different opinions, no question about that. I don't remember any major wars between groups in the US and France or England.

MR. FIDLER

Speaking of France and England, did the Datagram work in France or the MARK networks in England, did those influence your thinking or work much during the 1970s?

DR. GERLA

Well, I'm sure that the French network, you know, had a major influence on the way the networking culture developed in France, because — and which is a strong culture, support [inaudible] and so forth, you know, and there was also a matter of pride, the French saying, okay, we've got Transpac, if you know, you are — so it's like [Inaudible] here. It works, you know, so they can claim that, you know, research then poured into the field. I don't recall a seeing a network in Germany. I think they had other projects to work on at that time. But they came much later. So France definitely was the avant-garde, and also England, yeah.

MR. FIDLER

You mentioned a change between the DARPA that you knew, say, in 1970, and today. Were those changes underway by the time you returned to UCLA in 76?

DR. GERLA

76. In part, yes, but I think that it was still a very friendly environment that DARPA was maintaining, you know? Because I remember, I — we got a grant from DARPA for the supercomputer, supernet, you know? It was a grant; I applied to it together with Len, and other researchers. It was about an optical network. So we sent in a proposal, you know, with no big fanfare. You know, it was — I don't even know if it was in response to the quote for proposal, it was just maybe unsolicited. And then the — what was the name of the? — the ARPA managers, and in fact the name — the name escapes me — the guy that invented DNS, what is his name now? You should know, that's a good question for you! [Laughs]

MR. FIDLER

I should, I'm blanking.

DR. GERLA

But that's okay. So, you know, the name will come. So he said he was going to come and visit us, we didn't know why he was coming, so he comes in and then he started asking questions about the proposal, and then you realize that here's the one way to evaluate! So we talked to him about that, you know, and then he went back and said at the end of the

meeting "okay, yes, we decide to fund your proposal." So there was a very informal kind of support, and that was actually, you know, several million dollars. That was not a little thing, and it was done very informally. You know, it reminded me of times when Larry Roberts would just meet with Len and call him up and say "Hey, time to send the next half-page proposal, and they would fund it, so, you know, it went like that for a while. But things change very dramatically, I think, in the 90s, you know? When DARPA decided, well, we have to produce things that are useful for the forces, you know, and then they came up with the idea that you fund it for three year, but after the first year you're evaluated, they down select, so it became much more brutal! [Chuckles] If I may give you an idea of what's going on, yeah.

MR. FIDLER

Were you aware of changing research priorities at, for example, the office level at DARPA or broader political shifts that would impact the way it funded projects such as the Mansfield Amendment?

DR. GERLA

No, it didn't happen until much later. In fact, I think, as I said, it happened in the — there were some program managers who were totally — who said, Okay, well, DARPA, you know, we don't care that much about university work, we want to go after industry. So universities could collaborate only with industries, and for very targeted missions. That's when some researchers like, I think David [inaudible] and others decided, that's it. We don't want to [phone rings] get funded by DARPA any more. Let's take a break here.

MR. FIDLER

Sure. [after a moment] You mentioned you would be getting funding with a short meeting and a half-page proposal. One of the observations that's been made about DARPA funding strategies during the time and even ways people were motivated, is that researchers would be accountable to their peer groups for the work they did, not just DARPA. And there's also talk that professional networks would allow a degree of trust where someone could in fact take a half-page proposal and a half-an-hour conversation and use that as the basis for funding millions of dollars. Can you speak to those professional networks? ¬

DR. GERLA

Yeah, actually I was living in that era at that time, and I have to say that if you receive the grant from DARPA, you're — as you said, it's very correct you felt obligated not only to DARPA to deliver, but also to your team, you have to deliver credible research and papers to your colleagues, to the peers. So it would be a major embarrassment if you got, I don't know, a $4 million grant and then after three years you didn't do anything. That would be a black mark on you. Well, nowadays, these things are a bit different. I think they are more cynical maybe because research, there are so many researchers beating for funding, and you try to get funding even if you don't know for sure that you can deliver. Whatever comes in, comes in. So you are committed to the agency, and but once you deliver the report, you think you are done. And then, if you graduate your students, fine, you know. Even if nothing gets done, honestly, and sometimes nothing gets really done on some of these projects. They will not really come back and bug you, because this kind of tightly knit network is a bit dissolved, you know, and too many people are there that, ah, you don't keep track of. You can — disappear, sort of [chuckles], you know, with the money.

MR. FIDLER

You mentioned numbers as one of the reasons these networks would dissipate or dissolve. Is there anything else that you saw happening over the decades that disrupted that old system?

DR. GERLA

Ah, well, there are social networks. There's social, scientific networking communities, you know. Different communities though congregate around different — I would say different conferences. I would say SIGCOMM is a community and people like to see each other there. This is hardcore, the Internet-type community, who then move to Web, [inaudible] networks and whatever, you know? Whatever makes sense around the Internet. Then there is another community of people that develop communication systems, maybe satellite systems, and that would be the ICC, GLOBECOM, the community of [Acora] developers, the [Acora] communication conference, so there are different communities, and I think if you're in a community, you're comfortable, you know everyone. But if you get out of it — so in fact sometimes, I'm frequenting the MobiCom community, mobility, you know? Okay, there is a mobility community and a traditional Internet community, so there are two different communities. I've been frequenting MobiCom in New York, and then if I go to SIGCOMM, people are surprised. They say, "Mario! What are you doing here?" They say, okay, well, I work in this community, too. So because I'm better known in the other communities, they look at you as an outsider, you know? [Chuckles]. Yeah. It's interesting. So there are communities where they are multiple and separated, you know.

MR. FIDLER

And that's something today, but is that also —

DR. GERLA

It didn't happen.

MR. FIDLER

Did not happen.

DR. GERLA

No. At that time there was just one community, you know, that everyone knew each other. I would say until the early 90s, yeah.

MR. FIDLER

How do you think the cynicism that you mentioned is generated today?

DR. GERLA

Well, in part it's generated by the fact that these grants are so difficult to get, and seven percent, so you write proposal after proposal, you know, then you get tired, and then you feel that you exhaust yourself, so when you get the money, you say, huh, okay. But you keep going trying to get more money, probably. So the goal becomes — so the effort is put not so much in performing well on a project so that you can build on — this is us for the next project, it's sort of spent in trying to get funding no matter what, you know? And because then, well, when you write your resume, you have to put down how may million dollars you got, you know? That's the figure that people remember. Instead of saying, okay, I developed these systems here and there, and I want be remembered for those instead of the money, so the money becomes an important. So number is very important. For instance, another number we were talking about today is the references, you know? The citations. So I want to know what is your H number, how much money have you

made the past ten years? How many papers have you — so these things — and then you get classified that way, you know?Instead of saying, okay, well, you are the first one to develop this system that so many people are using. Well, that is important, too, but there are only a very few people that can claim that, so the others get classified based on these numbers, you know?

MR. FIDLER

And is this the new accountability to the peer group then?

DR. GERLA

I would say so, you know, I mean, because the peer groups evaluate — as I said, in H numbers, funding, numbers that people can easily relate to.

MR. FIDLER

And this sounds like —

DR. GERLA

Because, see, the system, I mean, if you look at the Internet, there are so many areas you can work on, and probably if a colleague comes here and tells you he's done this and done that, most likely I know nothing about the area that he has been working on. But I know the value of the funding and the value of the H number, so [chuckles].

MR. FIDLER

So in addition to the changing structure of DARPA, there's also the way that these fields have altered, and then there's almost technological determinism of the infrastructure you're dealing with being so vast. Do you see a particular relationship between these changes? So there's a change in the field, there's a change in DARPA —

DR. GERLA

Probably there is. Probably there is. But there is also another very important aspect that you have to now add to it certainly, and that is the fact that when the Web was invented in 92, then that was the start of the commercialization. So until, I would say until the late 80s — the researchers in the Internet didn't make any money. They were pioneers. They were good researchers, and including Len. I mean, look: how much money can you get from your Internet knowledge? And then after the work came around, you know, people understood the importance commercially, and then all that happened, you know? And the people understood that they could monetize the ARPANET and their knowledge and then they went to different directions and definitely that changed the culture in a major way. I think even now, I mean, if you are starting a career on the Internet, you study networking because you hope in the future you are able to make money! So the idea is to come up with some brilliant concept and patent that you can do your start up on. That concept didn't exist in the early days.

MR. FIDLER

And having a goal as, for example, an application on the Internet that would be a commercial success, versus having a goal, say, in 1970 for making something new that would be recognized by your peers, do those differences mean different kinds of goals for the technology that you'd be trying to develop?

DR. GERLA

They meant a lot to the speed with which the technology will be developed and accepted, because, say, for instance, Tomlinson, I think he was the guy that came out with the main protocol, you know? Okay, he developed this main protocol and people built on top of that, and it was accepted. I don't think he made any money out of it. But people agreed,

and then that was the protocol, you know? Nowadays, suppose that happened today? You know, you would come up with a protocol, immediately someone else would say "No, that's no good. I got my patents back." So the people start — because they understand immediately the potential value of such patents, so they put — so they optimize the scheme for the second consideration or even the idea that we can all agree on a standard and make progress second to making money out of it, you know? Quite bluntly. Slow down — it slows down the developing in a sense, but at the same time the money fuels the research, so it goes back, you know.

MR. FIDLER

Today at UCLA if you want to submit a DARPA grant, for example, you go through an Office of Contracts and Grants Administration.

DR. GERLA

Right.

MR. FIDLER

Does that represent a significant shift from the 1970s, or was it always something like that —

DR. GERLA

Ah, there are something like that as well, but I think in the 1970s the agreement was done ahead of time and then use the paperwork, you know? Nowadays, everything is very structured, you know? And actually submitting these grants has become a major pain, because you have to be careful at every comma, you know? The proper paragraph must be placed, otherwise this will not be accepted. So the Office has become very bureaucratic. I mean, they have the rules and enforce them. They're paid to do that. And maybe it's good to do that, but, it's a different spirit. You have totally removed from the program manager, you know.

MR. FIDLER

So it sounds like you'd include these change in the structure of the university along with for example the change in DARPA, the change in the way peer groups function —

DR. GERLA

Yeah, maybe so, maybe so, I think so. Yeah.

MR. FIDLER

And speaking of this changing environment, one of the things that's frequently said about the strengths in DARPA's research is that failure is accepted more than other places. You spoke a bit about failure and how that works into accountability with peer groups before. Can you speak to how failure is understood and if that changed over time?

DR. GERLA

Well, this is a matter of debate when people compare the system in Europe or Italy, say, and the system in the U.S. In the U.S., if you want funding, the investor will ask you how many times that you failed, you know? If you didn't fail ever, then, no. In Italy, you cannot fail. If you fail, then you're black marked, you know? [Chuckles] You know, that's the way it is. So failure, so the failures, we understand, you know, in this country the importance of risking, you know, the risk, taking a risk and failing is important. Yeah, in the beginning sure, you know, there was, people would try different architectures, they failed, they reported on that, they moved on. And the fact that they failed and reported it was important so no one else will do the same thing or at least it was useful in a sense. Nowadays, of course, at that time there was — society was more forgiving in a sense that

the competition is not as fierce as today. You know, the competition is very tough because there are so many Ph.D.s out there, so — and if you failed in a company, you know, I don't think the co — there are another nine people sitting there waiting to take your job! So in the old days, it was not like that. So I think the competition is probably teaching people to be more cautious, you know. If you are taking too many risks, it may work, it may work against you, you know? Unfortunately. That's the way I feel. Although we still have to risk, you know, it's important, but you have to keep — document how you're risking and why and so forth [chuckles].

MR. FIDLER

With the benefit of hindsight, what would you say about the strengths and weaknesses of DARPA's approach to research, both early on and today? We've talked about this a bit, but overall, what would you say?

DR. GERLA

The benefit of the DARPA versus today, quite frankly, is as I compare it with, ah — so let's — first let me digress: the NSF model operation is that four million grants at least. They give you the money and then all they expect is a report every year, you know? For the major grants, the consortia, they exercise more control, you know, like the [inaudible], the NDN, you know, they have probably quarterly meetings. But even then, you know, there is no tight control. DARPA has tight control, I would say, a real tight control on some of these fundings. Because they are just — we are now in the second year of fund grant with DARPA, and so they want us to develop a particular network which is information center network for the, for tactical networks for the infantry, and they have called regular, quarterly meetings, and they expect presentation demonstrations, and there is a schedule of things. And that why do people have to come by? Because after one year there is a down selection. They say, okay, look, you've got these three groups, after one year and down select, again down selection and then they move on, and they keep down selecting, you know? So — and that's a lot of responsibility also on the DARPA for a measure, because he has to show up at these meetings with the technical — I mean, with the commanders, you know, people, the end users, the Marine Corps, you know? They will come and judge. And actually, I have to tell you one thing, that some of my students like it because they feel more important, you know? So they work on an NSF project and they basically do their own things for two years, nobody even watches them. So these DARPA contracts, you know, so the students sort of like it because they get the thing working and they can demonstrate it, so they are proud of it. So there is some benefit in that. Although the scheme is a bit cruel because, for the down selection, and in some cases you actually can question the criteria why they down select. Maybe that you think they selected the wrong guy! But, well, the way it works with DARPA, I think this is efficient, it's — so there are benefits with it.

MR. FIDLER

Can you speak to the strengths when you were first introduced to DARPA, what did they look like then, in your opinion? So for example when you come to UCLA in 1970, how were these factors the same, how were they different?

DR. GERLA

Well, DARPA, at that time, it was a very benign kind of relationship because I think DARPA, you know, as you said, you know, DARPA trusted the PIs, the personal trust, you know, actually, let's say Larry Roberts was a personal friend of Kleinrock, so he

trusted him totally, you know? So he would call him up and say "What's going on?" So we didn't see the program manager very much and very often. Also there was a time when demonstrations were not so important. It was more important to maybe report on it, because there aren't that many conflicts, so you report on it. You develop — produce a report, you describe the experiment, that was it, you know? Nowadays, there is a big meeting, you have to go there or here, do the demo if you have time and more pressure.

MR. FIDLER

When you were comparing just now the difference between today and the early 70s, for example, you mentioned the program manager as being quite central in, for example, down selecting. When you —

DR. GERLA

Now,

MR. FIDLER

— speak now, when you go to speak about the 70s, you talk about the PI. So was there an increase in prominence in the program manager in, ah —

DR. GERLA

I think so. So the program manager — well, the program manager in those days was important because the program manager was able to get the funding, you know, through the Congress and so forth. You needed a strong program manager that could push the program with Congress, but once you got the money, it was his money and he would — nowadays, the program managers more have the role of civil servants or employees in the sense that the money they feel that — they receive money they have to distribute and account for it, and then they feel that they are the middle man between the researcher and the tactical forces and they're to deliver to them. So they feel actually more stress — I think they're more stressed, because they, you know, if they do not perform right, if — the Marines, they say, okay, this stuff is totally useless to me and so forth, they feel a bit responsible. Not that the job at DARPA is a career job; it's a short term. But still, they feel they have to deliver to someone, and that was not the case, I believe, in the old days.

MR. FIDLER

So in the old days it's more, and maybe I got this wrong, but you seem to say that even the program manager, not just the office manager or the director, they're —

DR. GERLA

Yeah, the department manager had a tough time in selling the program to the, to the organization. Once you got the man who was in charge, he was just the king, you know. Nowadays the, I think the department manager is more like the employees. They get the money and they have to make sure that things get done.

MR. FIDLER

You mentioned Congress. Would they be more directly linked with presidential or governmental initiatives? Like things that would come from DDR&E or even presidential interests? Would they be exposed to that?

DR. GERLA

Well, certainly you remember the Sputnik situation and so forth, I mean, clearly, at that time, there was a sense of community consensus that everybody, oh, you should proceed. So it was not bipartisan. Nowadays that spirit is [chuckles] maybe lost. Although I feel that the Congress and the President should still be aware of it, and the fact that — and the next war will be a cyber war anyway, and so we better keep working on this, otherwise

we are gonna be in trouble. But still, I don't think anybody can stand up and say, ah, okay! The research is — so we need to increase, double the funding to the researchers. It was possible then, but I don't think it will — I think, it seems to me that today we don't have that spirit.

MR. FIDLER

You mentioned that today program managers are accountable to the services. Are there other groups that you think that they've got on their mind when they're looking for results?

DR. GERLA

Well, in a sense they also want to make sure that the research gets published and that they have their name on that so that when they get another job, you know, they've made some contributions to the field. But it's less so than in the past, I think. I feel that many of the program managers are just interested in satisfying the services' requirements more than developing genuinely advanced research. Maybe, maybe a different program manager. And from program, you know, they are programming in theoretical computer science, where, of course, you have produce theoretical results. But, programs in networking, you have to produce tangible results for the forces, you know? Not necessarily publish your papers.

MR. FIDLER

Does this fall into the category of the shift from 6.1 to 6.2 and 6.3 —

DR. GERLA

Also, also. In a sense.

MR. FIDLER

And when you talk about these shifts, are you mostly talking about your experience with the I2O and the old IPTO as opposed to the other offices at DARPA?

DR. GERLA

Yeah, with mostly IPTO, yeah, yeah. And the other offices I didn't have much — so I didn't have that many DARPA grants, let's say. Maybe only four or five, you know, and we have seen the difference as we go on.

MR. FIDLER

Let's change gears and look at your use of the ARPANET over time. There's only a small number of people who have been online now for over four decades, and you're one of them.

DR. GERLA

[chuckles]

MR. FIDLER

Initially, you were talking about the ARPANET as something to be experimented on, to be measured.

DR. GERLA

That's right.

MR. FIDLER

You've said that a little bit later you start using to e-mail with colleagues and to use FTP for getting files back and forth.

DR. GERLA

That's right, right, yeah.

MR. FIDLER

How did your use continue to change through the years?

DR. GERLA

Actually, I would say that for a long time I didn't see much change, because once the e-mail stabilized, that was the thing. And then the skill was to be able to design, you know, distribution lists and so forth, maintaining them, how you maintain e-mail, and people said, oh, I kept all the e-mails for the past twenty years, and so there was [chuckles] some, some downloading files so that was of course very important as well. But there wasn't a notion of downloading from sites then, you know? You have to ask your friend to send you the file, that was cumbersome, very cumbersome, you know. To the point that we still prefer to keep papers, you know? You know, copies of the paper, until probably the 90s. So the major change came when, one, when the Web came out, you know, because then all these other browsers — ah! Well, then, you know, I can get the papers much easier. Okay, that's a regular thing, and then it snowballed, and then that was it. I think in the matter of a few years, you know, then people switched from the e-mail-mostly type mode to the web-browsing mode where you can actually access the data. And then of course the things have been improving, but everybody knows how that went, you know, from the mid-90s on.

MR. FIDLER

Were you one of the people that keep all of their e-mail from the beginning?

DR. GERLA

[chuckles] I think I did! Ah, but I didn't know which system it was kept on, because — I never to go back. I — yeah, probably it was kept on one of our systems here at UCLA, but too bad — unfortunately I don't have it, because it would — actually now, in retrospect, I would probably be interested in seeing what kind of things, what kind of things you did with e-mail then and now. You know, the change in style, you know? If you had the possibility of going and see what people did with e-mail — in the beginning it was just telegraphic, you know [sounds "telegraphic"], a few words, and then, what? Later on, image and files and so forth you know. But.

MR. FIDLER

Did having e-mail change — besides the ease of communicating over distance, did e-mail lead to changes in the structure of professional networks the way that you would even have access to old conversations?

DR. GERLA

Well, definitely it had a major impact on the social networking structure, because, remember, before e-mail, people had to make phone calls, and I would have to make 20, 30 phone calls a day — no, no, maybe I didn't – but it was time consuming, and that would limit your ability to network, because how many times would you do a tel-con, you know? So, you know, you would write letters, you know, you would write letters, but how many letters can you write? And then, you know, the immediacy, three days later it doesn't — kills most of the interaction! So the e-mail, the major impact on the formation of social groups, yeah, absolutely.

MR. FIDLER

You mention making a lot of telephone calls. Comparing a telephone and early e-mail, shifting over to e-mail, would that be less informal chatter than the kinds of tacit knowledge you might transmit during a phone call, or gossip, that kind of thing?

DR. GERLA

Well, I think the phone call is still important for some, for more of a feel of contact you know, and Skype is even better because you see a person, so in some situation, you need that, right. It's impersonal, but it's so efficient, you know? I mean, most of the conversations at work are just basic, you know, they require efficiency, immediacy, without the personal touch, so that's what the e-mail is ideal for, you know, and because otherwise you call a person and then he's a person, so, she's a person, so you must — you got the feeling that you are someone interesting on a personal level, where the e-mail just goes through and, right.

MR. FIDLER

What other changes have you noticed over the last four decades? There's difference with e-mail that you noted, have there been other changes with —

DR. GERLA

Due to the Internet or due to what?

MR. FIDLER

Well, the adoption of, you know, the wider adoption of the ARPANET, more people getting on line on the Internet, that you've observed over 40 years.

DR. GERLA

Well, I mean there has been — the major change is in the young folks, you know, actually I would say! [Chuckles] You know, I'm going to keep telling my daughters, you know, look, in the old days, when I was growing up, the idea was to, hey, have a fancy car, drive — you know, one of the things. The cost of a powerful car disappeared almost in the mentalities. They like to play fancy games, they like to be on top of it. They like to be connected to the Internet, the social network, the Face[book] — these are what counts. you know? Having the Porsche down the street, that is not that important any more, you know, so, I think the Internet has totally conditioned the youth, you know, and.

MR. FIDLER

I'm glad you mentioned cars, because that's my favorite change.

DR. GERLA

You like the change from cars to Internet? [Chuckles] Really? No, actually I mentioned that to my — the other day, to my wife and daughters, they laughed at me and said no, that's not true, and eventually they convinced me, but that's true, and people recognize that, huh?

MR. FIDLER

I know that Maggie, your wife, has a very strong sense of your early work and your role developing the ARPANET. Does your broader family know about that? Are your friends outside of work familiar with, you know, your unique history with the Internet?

DR. GERLA

In a sense, yes, though they — in fact, they know, you know, my family in Italy, so it's only — they see me going to Italy and deliver a speech, so they know of this activity. Not that they are particularly excited about it. You know, they think it's nice. I have to say though that my sister, my youngest sister — actually, she's older than me, she's still computer illiterate, Internet. They still do not have the Internet at home, you know? Which for me, they do not use the Internet on the phone, it's amazing, you know? Some people are resistant to that, you know? [Chuckles]

MR. FIDLER

Some people have said that when network computers were transitioned off the ARPANET and on to the NSFNET, they didn't notice. I'm wondering what your experience was with the 1989 to 1990 decommissioning of the ARPANET and transition to NSFNET and other networks, and even before that, when more networks were being plugged into the ARPANET with TCP/IP.

DR. GERLA

No, we didn't notice, that's — in fact that was a major plus, so it was a demonstration that the technology worked, there was transparency, yes. No major glitches, no, no, in fact it was perfect. It was very nice, yeah. In that sense.

MR. FIDLER

After the shift to TCP/IP in 1983, did it have any direct or indirect impacts on the way that you would use the Internet? Like, would you then be accessing networks that were connecting to the ARPANET?

DR. GERLA

That's for sure, you know, so the TCP/IP made it possible to interconnect through GS networks because it was an end-to-end protocol, and designed to — in fact, specifically designed to deal with this heterogeneity. Of course, we didn't notice because there was not much of a network to work with in the early 70s, and — well, when you extend it to packet radio and satellites, probably nobody — we were not interested in going over the stuff with satellite links to these strange sites where there was not much anyway. So initially the impact was minor, but if we were [chuckles] went back to the network control protocol today that we had in the early 70s, everything would collapse, you know, of course! So basically the tool was introduced before the resources to take advantage of it were available, you know.

MR. FIDLER

Is there anything in these topics that we've covered that you'd like to say more about, or anything that you think I've missed?

DR. GERLA

I'm sure I missed a lot of interesting topics, but it is tough for me to say which ones! Because if we start the conversation at a different angle, probably we would have gone to, in a totally different direction. But I don't know, you know, it's — one thing that I would like to comment is the — another kind of revolution that — so the transition from the fixed world to the mobile world, because that's another major paradigm shift, you know? You know, and it effected many people, you know, in different ways, and I think that's — maybe you can talk about that next time, eh? Yeah.

MR. FIDLER

Okay, great, well, next time we'll continue perhaps with the move from fixed to mobile —

DR. GERLA

Yeah, yeah, right!

MR. FIDLER

And for now, thank you for your time.

DR. GERLA

Well, thank you very much. [Chuckles] A pleasure. Okay. [End of this interview]

1.2. Session Two (April 4, 2014)

MR. FIDLER

This is the second interview with Mario Gerla. I'm Brad Fidler and it is the morning of April 15, 2014. I'd like to revisit some areas from our last interview, and in fact I'll start with your work on the Lincoln Labs Experimental Satellite No. 6. I think you were working on this from 66 to 68?

DR. GERLA

Exactly.

MR. FIDLER

And you were an officer in the Italian Navy,

DR. GERLA

Yes.

MR. FIDLER

And this is part of a NATO program on tactical satellite communications.

DR. GERLA

That's right.

MR. FIDLER

Now, can we revisit how you came to work on it?

DR. GERLA

Actually, it is an interesting story, because when I finished the Politecnico in December 66, if I remember correctly, I was planning to join the Army, actually the Air Force, because the Air Force is a particularly privileged field, you know? [esprit de corps]. They have education in Milano and as an officer you practically live at home. But then the professor of my Politecnico di Milano, main professor advised me there was a position that he would like me to consider in the Navy, you know, academia [de oro] because he was also an ex-officer of the Navy, and he had been offered the opportunity to do research with the Navy on satellite communications, and if he had a younger researcher willing to go to [inaudible] was the location, in Livorno to work on this project, and I said, "Of course," you know. Just, I adored the professor, sure, we go there.And I didn't regret it. But it was not easy work, because at the beginning we had to build the system, the antenna and the receiver and everything, so a company in Milano was doing that, so I worked with them for — First of all, let me say, the Navy requires that you spend four months initially in the training, so you do running, things that you do to be trained as an officer, and then once you become an officer then — So at that point I went to Milano in April 67 and for three months I worked in a company. It was actually called GTE, it was a subsidiary of GTE in Milano. We built the radio receiver for this satellite. It was a UHF satellite. And then I took the antenna packet and I went to Livorno, we installed it, and started doing measurements. So the measurements went on for about I think nine months, and so this satellite was orbiting the earth, I think one — at the rate of one round a day, just about. And my task there was to measure the fluctuation in the signal at low elevation because there was a phenomenon called multipath fading. We wanted to study that, so we did that. The satellite was also used for communications initially, but for some reason the voice channel failed, so what was left of the satellite was the beacon, so we kept receiving the beacon and measuring propagation performance of the radio. Another satellite was sent up later, I think this was LLES 5, LLES 6, and I think one was used to resume communications. I was actually able to do some communication at the beginning

on the channel itself. It was exciting to be able to talk to people across the world over the satellite. But, so the experiment was mostly propagation experiments, yeah.

MR. FIDLER

The last time you mentioned the satellite provided a connection to the research world in the U.S. in some capacity.

DR. GERLA

Yeah, because there was a community that would meet to review the parameters of the satellite impactt. In fact, once the meeting was at UCLA — was at, sorry, in Livorno so we all met there and there were a few researchers connecting with the military. Another time, we had a meeting in Germany, and similar personalities from the German research division, you know? So this was an initial project, and presumably there were other meetings somewhere else in Europe, but I didn't participate in all of them.

MR. FIDLER

What can you tell me about the position of that satellite research program or its influence on communications research more generally?

DR. GERLA

Well, actually the satellite was interesting because, see, that period was one of the most glorious periods for satellite communications. Remember: everything was going through satellites. Later on, of course, the fiber, low, low tension fabric came about and satellites were replaced by the fibers under the ocean, but at the time, satellites were the thing to do. In fact, when I was in Italy and shortly after my military period, Viterbi, I believe in 67, came to Italy for a workshop, and he told us — Viterbi was the father of CDMA, you know, I told you about the use of CDMA, of satellite communications? And in fact that was — the work I did for the satellite, military satellite experimental, so they, this meeting with Viterbi sort of persuaded me to pursue this idea of Fulbright scholarship to come to the U.S., you know? And in fact I applied at the end of my military tenure, in 68, and then I got this fellowship in 69, yeah.

MR. FIDLER

Did you observe any diffusion of the technologies that you developed with those satellite experiments?

DR. GERLA

Ah, not really, I would say. It was a nice experiment, but it was one of the many experiments going on in satellite communications then. It was advancedb let's say, for Italy, because Italy of course had commercial satellites, but there was little research being done on satellite communications, so we were one of the few places. It would have been more interesting if we had the ability to communicate with voice and data, you know, but data at that time was almost nonexistent, you know? People only considered voice. But still the five — the voice channel was up, we could have done experiments with modulation and coding and so on. So instead we are doing propagation experiments, you know.

MR. FIDLER

Now let's jump to you showing up at UCLA in 1970. The last time you mentioned that you show up for a Master's degree.

DR. GERLA

Right.

MR. FIDLER

And near the end, rather than returning to Italy, you —

DR. GERLA

That's right.

MR. FIDLER

— speak with Leonard Kleinrock about getting a position as a research assistant.

DR. GERLA

Um-hmm, yeah.

MR. FIDLER

Now, is that the research assistant position that you kept until the end of your Ph.D., or did you —

DR. GERLA

It is, yeah.

MR. FIDLER

And it was the topic of that work that you did for that first year, or initially as a research assistant, that became your Ph.D.

DR. GERLA

That's right. So, yeah, we already went through that or?

MR. FIDLER

We went through it a bit,

DR. GERLA

Yeah, yeah, yeah.

MR. FIDLER

I just wanted to clarify.

DR. GERLA

Yeah, yeah, right.

MR. FIDLER

And I'm wondering if you can say a bit more about how you determined the topic for your Master's? It seems like you knew you were going to go into communications research.

DR. GERLA

Actually, the Master's degree I received even before joining the research group. I was of course working with Prof. Kleinrock then. But the Master's degree was just a matter of taking courses and passing them, and so there was no special topic. The Ph.D. degree was a different matter. In the Ph.D. degree, so, as you pointed out, I joined Kleinrock's project in the, at the end of the first year, so it was 1970. And then I, of course I considered the possibility of going for the Ph.D. I discussed with Kleinrock the topic, but since I was already working on the ARPANET project and that was a very rich area for new ideas and possibilities, we converged on the optimal routing of the Internet, the optimal design of the Internet.Actually design of the Internet included many things. Topology design, you know? And I can tell you more about the biggest problem — some problems that I worked on. At that time also, Luigi Fratto was here, I may have mentioned that before, so he was — he came here as a researcher. Luigi Fratto was a professor then at the Politecnico di Milano, so he was my classmate, but as I came to the U.S., he decided to stay instead. He was then sort of an assistant professor, a junior professor. So he came here to visit for about a year and a half, so we worked together. And on the design of the Internet, or the ARPANET then, you know.

MR. FIDLER

Can you tell me more about that work with him and also anyone else that you worked with, even as far back as your Master's degree while you were at UCLA?

DR. GERLA

I think — see, the Master's degree is usually work that you do on your own,

MR. FIDLER

Or even the —

DR. GERLA

But the Ph.D. so Luigi and I are working very closely. Then at that time there was Simon Lam also working on another aspects of satellite com -- He was working on satellite communications, Simon Lam, or at least on another project. Jack Ziegler, was an assistant science student. Actually, he was assistant student of Viterbi, and he worked on — not a networking problem, it was a message dissemination problem or something. More geared towards information theory than networking, yeah.So we were very close with him as well. Then other students came one year later, when I was already studying with Kleinrock, and those were Fouad Tobagi and Farouk Kamoun. Okay, so we are all together for — I spent three years here, you know, so the last two years I was together with them, a small group, so [I was] in touch with each other more or less, yeah.

MR. FIDLER

I saw that you — of those people you mention, I think I've seen you publish with all but Ziegler, or maybe you did as well, but besides the—

DR. GERLA

Ziegler, in fact, Ziegler, the topic was different from mine, so there was no chance we publish together.

MR. FIDLER

Besides working on papers and the collaborative research that that suggests, can you say more about your relationship with them would you — is this the kind of thing where you walk down the hall and discuss shared problems?

DR. GERLA

Something of that, but also more than that, this was almost like a family, you know? We're all working in Klein's group, and, well, the environment is very different then than now. There were few students. Most of the students were European or, Farouk, North Africa, probably some from the Middle East, you know, maybe Israel or Turkey and so, but so we were students coming from many very different countries, so, and naturally we would be curious about each other, so we are hanging together. I would speak mostly French with Farouk and Fouad, so I would say that, yeah personalities would be different because we would see people coming, say, from India or from China or from Taiwan, and Korea, and they tend to form their subgroups, you know, for the good or the bad of it, they help each other. And they tend to be cliques, to isolate themselves from the rest. So we were just thrown in there, no choice but to get together with the Austrians, the French, you know, the Tunisian and so. I think it was a very exciting time. Also, productive in terms of research because we would, of course, discuss often the project and the problems we are working on in our studies. And but then the same time socializing altogether all the time, it was like that.

MR. FIDLER

So when you say it was like a family and then also that that's different from now,

DR. GERLA

Yeah, actually let me stress the concept of family. I would say Kleinrock viewed us almost like his extended family, you know? He would invite all of us to his house, and his wife and daughters would help us. You know, I mean, you would be made like at home. Now, this is different from what happens now. I've invited the students to my place a couple of times, but I do not believe that other faculty does the same thing. I think students prefer to be on their own, mostly because you have too many of them, you know? And so that was — however, happening a lot in those days. And I think it was happening even more before, you know? The academic life, even at the beginning was really like a very intimate relationship with advisor, and this has been a big loss.

MR. FIDLER

What kind of impact on the research do you see, if any, that would come about from having more of a family structure versus a different set of social relations today? Like, would that show up in how people collaborated or what the output would be?

DR. GERLA

Um, actually, for one thing, you would actually keep an eye on what your classmates were doing in terms of progress in research. You took the exam, you didn't, um, so, information about how difficult it is. So it was — so we didn't have the Web then, you know, so you have to work with gossip [chuckles], and so, a recommendation on which course to take, you know? And — but those who feel that problem finding a reference, you would ask your friends the same way, so your friends were your extended research team, resources, you know, you tap them first, yeah. I think also we were supporting each other, you know. I think, if a student, one of us who failed an exam, the others would help him out, say, 'Look, you know, take it easy, it's gonna be better.' And probably more than what I see here now, you know. We were getting involved, you know, personal with the other students in the team.

MR. FIDLER

In addition to academics before then, you seem to talking about passive knowledge or informal knowledge that would get transmitted between people. The —

DR. GERLA

Oh, yeah.

MR. FIDLER

courses to take, the —

DR. GERLA

Yeah, and also, also help with programming tricks or — so I was actually working most in simulation, orality models, so I would talk to Fouad Farouk about what I was doing. Other people like at that time, Vint Cerf and Jon Postel Bur, [inaudible] work on the code, so they would help each other that way. We would also take courses together, you know, there — Jerry Estrin had a course on, on dissertation, your final year dissertation, so the students in their final year would take this course, and he was helping them out putting the thesis together. Actually, it was a very useful thing, because there were six or seven of us, so we could see how we would structure a Ph.D. thesis, and I think it was an incredibly useful experience. But again, it wouldn't make sense now. We have too many people, and faculty is too busy, you know, and unfortunately that doesn't get done.

MR. FIDLER

And last time you mentioned that you, if I heard you right, you put together some papers with Len Kleinrock and that was linked to your move from the Master's to the Ph.D. program. I didn't see those —

DR. GERLA

Well, the first paper we published, if I remember, was the flow deviation method. Before that we did something else. I wrote the paper with Luigi Fratto. I think Kleinrock may also be on that paper. We published the paper at a conference in Italy. I don't know if it ever got recorded. Maybe it did. So there were a few papers we wrote along the way, yeah. In retrospect, I think I published a few papers, and nowadays we publish many more papers, you know, but, see, at that time the number of conferences was limited. There were just two conferences a year. The Fall Joint Computer Conference, the Spring Joint Computer Conference, maybe another one, I don't remember, but otherwise you would publish your papers in journals.

MR. FIDLER

Let's move to your Ph.D. dissertation.

DR. GERLA

Yeah, yeah.

MR. FIDLER

In your dissertation you note that the design tools you're developing and the techniques you're developing are for the application to any store and forward communication net. Not presumably just the ARPANET. At that time did you already have a sense of which networks in particular those tools might be being applied for, or did you just expect more store and forward —

DR. GERLA

I definitely I think so. At that time we thought there was no other network but the ARPANET. In a sense, another network would be created, would be a clone, you know? I mean, it's the only example you see around, and it was far superior to the European counterparts then, you know? A least we thought so. So it was natural for us to think, okay, while we do this for the ARPANET it will be extended, you know.

MR. FIDLER

Was that — moving to the European networks for a second, was that a shared assumption, about the ARPANET being far superior to [inaudible] —

DR. GERLA

Well, far superior would be the model that all the other networks would follow, and I think that pretty much was confirmed. There were other networks proposed in France, in England, but they didn't pan out. So.

MR. FIDLER

Was there a particular view that would be shared, for example, amongst researchers at UCLA about CYCLADES, for example, or about MARK networks in England?

DR. GERLA

Which net [inaudible]?

MR. FIDLER

The MARK 1, for example.

DR. GERLA

MARK 1? Yeah, I think I have a very vague recollection. But CYCLADES in France was very similar in structure to the ARPANET, and actually since I was attacking the

topology design, then for me they all look the same. Certainly the software could have been different, you know? In fact it was different. But from the topological design standpoint, they're all store and forward networks, so. Yeah.

MR. FIDLER

And when you then expected that future networks would be ARPANET clones. When you say ARPANET clones, do you mean just another iteration of store and forward networks, or are you really thinking, for example, BBN would come in and build a network that had IMPs just like the other —

DR. GERLA

That's right. So that was later. In fact that BBN over the past ten years after the deployment of the ARPANET worked on the advanced switches, one that I remember dearly is the Pluribus. "Pluribus" in Latin means "for many people", but Pluribus means "multiple busses". It was a multiple-bus-ic nature. It was scale of multibus architecture. Very advanced, actually, and so it would be the precursor of the connection machine in these massive, powerful machines. I remember I met the designers, you know, that came to give a talk at Network Analysis Corporation, so these are all very [inaudible] designs. So there was clearly the concept of scaling this Internet, this ARPANET, and one of the first places to scale was the node then, because it would be the bottle neck.

MR. FIDLER

And that's interesting because even by the time the ARPANET got decommissioned in —

DR. GERLA

Yeah.

MR. FIDLER

— 1989, there — I don't think there was too many Pluribusses that would even show up.

DR. GERLA

Yeah.

MR. FIDLER

But that when you were thinking about scaling it was really the nodes that were being focused on.

DR. GERLA

Well – the nodes, yes, but the nodes had to be scaled because there were more and more nodes, so the traffic would be building up. Also, at the beginning there was no user traffic to speak of, so the traffic then started coming as, you know, people talking about video, voice. Data sharing was also an issue, but, you know, the memories were not there yet. So you have to use, as you know, disks and tapes [chuckles]. So gaining access to data from other sites and retrieving it was difficult to say the least. So the first important application of the ARPANET was the e-mail, yeah.

MR. FIDLER

In your dissertation, you identified variables and constraints for modeling networks,

DR. GERLA

Um-hmm [affirmative]

MR. FIDLER

and specifically in your dissertation, it's delay, throughput and topology as your constraints that you would then work with.

DR. GERLA

Yeah?

MR. FIDLER

And

DR. GERLA

Yeah?

MR. FIDLER

It's interesting that these are the constraints that were defined by ARPA when they put out the request for quotations for the ARPANET in 1968. They had identified those three things as being the standards by which the bids from different contractors would be —

DR. GERLA

That's right.

MR. FIDLER

— evaluated,

DR. GERLA

Um-hmm [affirmative].

MR. FIDLER

And did that have anything to do with the constraints that you ultimately chose for your dissertation?

DR. GERLA

Actually maybe it's the reverse, because while you're talking about the bid that the ARPANET, that DARPA put out before choosing BBN or, or afterwards?

MR. FIDLER

They specified a certain delay, at least from the user's perspective, they specified the speed, I think, and then also there was a general sense of what the topology would be,

DR. GERLA

Um-hmm.

MR. FIDLER

you'd have first [inaudible] then I guess up to —

DR. GERLA

Right.

MR. FIDLER

— 19 nodes in the United States.

DR. GERLA

That's right.

MR. FIDLER

And I'm curious because I think in later papers you started with slightly different [inaudible] —

DR. GERLA

But first of all, first of all I don't think at the beginning, in 69, DARPA had any idea of what constraints we faced, that we were faced with, they just looked at someone probably that had the experience in building systems like that. But then UCLA got chartered with this performance evaluation study, so lots of study came out from UCLA, and I produced some of them, showing the relationship between throughput, delay, capacities. So then, based on these results, the next, maybe Call for Proposals to redesign the ARPANET would have of course used the words people used. So delays, throughput, reliability, yeah.

MR. FIDLER

So to clarify that a bit, do you mean to say that, for example, this choice of delay, throughput and topology also was linked to practices in the field as well as being —

DR. GERLA

That's right. Yeah, absolutely, because remember that even before the ARPANET, people had to network their stuff, so they used just telephone lines basically, and they used the switch network, 2 step pass, and they measured the traffic and they decided to determine how much traffic they can [inaudible] support, you know? There were delays, so, and they were very happy if we could give them lower delays, more throughput for less money, you know?

MR. FIDLER

And with different networks that you'd work on or proposals, they start with different constraints? Like based on the needs of a —

DR. GERLA

Yeah.

MR. FIDLER

— particular network or the people, the institution that we're introducing, [inaudible] —

DR. GERLA

Absolutely, you know, I think I remember once designing the network for the stock brokers, and they told me, you know, what is delay have to be from the stockbroker to the company's records, so, and back.

MR. FIDLER

Is that NASDAQ you —

DR. GERLA

NASDAQ, yeah. We did a study for NASDAQ. We also did a study for the Customs, for actually the Customs office in San Diego connected with Immigration Service, so one — and the idea is very interesting there, because, you know, the cars would come at a certain rate, you would have to read the license plate and do all the research, figure out whether this guy's a criminal or not, in less than 200 milliseconds, so there was a real constraint there, dictated by the application. So in many cases the application dictated the performance requirements.

MR. FIDLER

In your dissertation you covered routing algorithms.

DR. GERLA

Yeah.

MR. FIDLER

And there were different views within BBN even of the, I suppose, appropriateness of the routing algorithm that was eventually implemented on the ARPANET, and at the Network Measurement Center, there was also a set of opinions about how —

DR. GERLA

Oh, yeah.

MR. FIDLER

— appropriate this was. Did you jump into any of those debates, or was your work —

DR. GERLA

Well, I was actually maybe lucky, because my work was trying to establish the optimal routing, you know? And if there is optimum routing based on some well-defined

measures, nobody can object, so — however, the drawback was at that time, this optimal routing that we obtained through the [inaudible], was not implementable because — for many reasons that I can elaborate. But, anyway, so, I could live pretty quietly in that world of optimization. I was not threatening anyone. But, you know, in practicality, people like BBN and other groups, research groups start to fight with each other say, oh, well, you do the wrong thing, you know. These are control algorithms basically, complex control algorithms, designed by computer scientists that know nothing about controls, you know. The experts in the programming [chuckling] insist and so it was an interesting discussion! Mostly based on experiments, so we say, okay, this is the way it should be done. 'Okay, prove it!' So, sit down, do the experiments. 'No, well, this was oscillates, go back and change, so we do this continually. And in many cases, the algorithm they are testing in the field, BBN, and added some three- or four-node set up and would test on that. People would come up with ideas, they would [chuckles] test on that. Yeah, remember, actually, that's the important part. Simulation then was still very slow. My friend, Gary Fultz, who did the routing in the Internet, [inaudible] empirical routing and evaluated through GPSS, I think it's called? General Purpose [Simulation System] — yeah. So it would take me, it would take him a think two or three days to generate the curve, you know? Something that maybe we do in fraction of a second now.

MR. FIDLER

You said that your work ended up with you being rather shielded from some of the debates because it wasn't something you could go and implement.

DR. GERLA

That's right.

MR. FIDLER

You said you might be able to elaborate on some of that, and also the particular challenges that you were addressing with your work. I hoping you can do that —

DR. GERLA

Yeah, eventually, we also developed some formulations that would allow us to implement this algorithm in a semi-centralized manner. Gallagher, actually at that time, Gallagher was working at MIT. Gallagher is a famous information scientist from MIT, and a good friend also of Kleinrock, or at least he knew about him because they were all associated with MIT at some point or another. And I guess he was curious to understand what we were trying to do with the Internet, you know? So in fact we got to talk and he liked very much the algorithm I developed. Actually he also took it and expanded it to another one of his students. He turned it into a distributed version, and I followed some of their work. We communicated. So that was an example of the maybe work that we inspired, but there was also work I believe at, well, at Stanford. See, Vint Cerf, after graduating from UCLA went to Stanford for about two years, although this work there was more directed to TCP/IP, you know, he worked on a performance — on an evaluation model for TCP/IP with Carl Sunshine. But to come back, you know, the theoretical work we did and also the follows up by Gallagher and others never really made it to the, to the Internet, into Internet switches. And what prevailed was a link-state protocol which was fairly trivial, but quite powerful to run and so.

MR. FIDLER

Can you tell me what you thought about the discussions and maybe even controversies about the routing algorithm, and in fact your own research on it?

DR. GERLA

Right, so when I worked on routing, and that was in I would say 1970, 71, at that time the ARPANET had only three nodes, four nodes, so routing was not that much of an issue. So — and also my algorithm was optimal, so nobody could object to what I was doing. But shortly after, with a few more nodes added to the Internet, people started becoming curious as to the possibility of using multiple paths in the Internet, so one path fills up, maybe the routing algorithm will be able to [sound effect] shift the traffic to the next path, and this is famous topic known as alternate routing. It was advertised by BBN as one of the features of the ARPANET. Well, the ARPANET eventually would be able to shift traffic to — one part to the other and the going back and forth so that it would be load balancing. So another catchy word, 'load balancing.' While all that was great, people tried it, [chuckles], it didn't work! Because the thing was oscillating and in fact was eventually crashing, you know, and that event — And so it was demonstrated and people scratched their brains for many years trying to figure out how can we stabilize the routing. It was not until probably 76, so five more years, until BBN came up with the link-state routing approach where instead of using the Bellman- Ford, the principle of total distributed routing, so the link state means that all the nodes propagate information about their state, and I collected this global information, so I construct my own map, and then [inaudible] send maps so each one of us does the optimization in the background, so — not instantly, but, you know, on average values, and that was more stable. So this was the transition from the Bellman-Ford routing algorithm to the link-state routing algorithms. So it was an important transition, and that actually stopped all [chuckles] the discussions of alternate routing, that it wouldn't really work. So in a sense that was a bit of a black eye in BBN's work, because people, you know, criticized their algorithm for not being capable of doing load balancing. Anyway.

MR. FIDLER

And is that one of the problems that you were referring to earlier when you were talking about routing algorithms on the ARPANET, you said there was a number of problems, I believe, that you or others witnessed.

DR. GERLA

That's right, you know, that was one of the problems that were caused — the, ah — what worked for the ARPANET was that traffic was pretty light. In fact before we saw real traffic building up, it would take many more years. 77, 78, when then Van Jacobson come up with a…. We'll talk about that later, but, you know. So the ARPANET was pretty lightly loaded, so the importance in doing alternate routing practically was not coming up. No, there were other problems with the ARPANET. There was a problem with the early assembly lock up, you know? There were deadlock problems. There was the famous Christmas deadlock, and then — probably you know the controversy about that. But the Christmas deadlock. Now [chuckles] discovered by some of our colleagues. I think it was Holger Opderbeck and Bill Naylor. And so they wrote a paper and Kleinrock went to the conference and said that the, he said something big, not political, I just said that, you know, this deployment of software by BBN was untenable, you know, because they would [chuckling] report bugs in networks — and then BBN came back at him furious. So I think Len had to mitigate the statement, you know? I actually was critical of Len, because at that time, you know, BBN was also pushing the technology to the government, you know, so the government clearly watched the ARPANET to see

what was happening there, so. Actually the truth was both ways. I think BBN was under a lot of pressure to deploy software, and new ideas were coming out, so they couldn't really validate everything. And in fact a validation of this protocol is so complex there is no way you can actually implement basic protocols under all the other circumstances, so implement them then they are bugs to fix. I mean we see that happen all the time. Actually, in those days, theoreticians, you know, had the impression that, well, you know, like we can prove this beautiful graph theory of problems, well you can also prove the ARPANET protocols. So.

MR. FIDLER

You mention a link with Van Jacobson and he was doing work on congestion with TCP and the mid-80s —

DR. GERLA

Yeah, Van Jacobson then was working for the Lawrence Livermore Labs, I think, and Lawrence was one of the sites of the ARPANET, so they were doing — now what happened is that Vint Cerf and Mark Kampe designed the TCP protocol, right? But they designed it with fixed window size.I mean, it's something. Well, it was a natural extension of what had been done at the link level for this reliable protocol. When fixed window site, which was I think eight packets, well, once you had, in 78 I think 30 or 40 hosts, each one pumping at TCP connection with eight packets of 70, you talk about a lot of packets, and the buffers are not very big then, so it was easy to get this buffer congestion and get the network out of kilter. So Van Jacobson came in and said, "Look, we can't use a fixed window. We have to make it adjustable," and so that's how the modern TCP was born, you know?

MR. FIDLER

So when you link Van Jacobson with some of these earlier issues that showed up in the 70s, it is just thematic in terms of modifying a network to make it more effective with congestion, for example, or were there other, you know, very specific links between his work and before? You mentioned, ah, [inaudible] —

DR. GERLA

[inaudible], I think that was a natural progression, you know. I think Vint Cerf and Bob Kahn came up with the architecture, which is a thin layer that is IP, you know, is the center of the universe in every case, [have gravel] below, you know. But we shall not touch that. So TCP couldn't be touched, it was a technology, an edge technology, you know, so, and of course, you can modify whatever is at the edge, so they were consistent, Vint Cerf, Bob Kahn, you know, edge, keep all the complexity to the edge. It was a solution consistent with our plans.

MR. FIDLER

And I'm really curious about what you mean when you say "natural progression".

DR. GERLA

[laughs]

MR. FIDLER

You just spoke to the [inaudible] —

DR. GERLA

By 'natural' and 'naturally' in the nature being the nature of the man working with Internet, and the developing, deploying more and more applications, you know? So basically at that time, just file transfers, people transfer files from different sites, you

know. And with the limited link capacity that we had then, you know, I think we're still at the level of kilobits per second, below the megabit per second, if you can imagine that.

MR. FIDLER

Fifty kilobits, you mean, you're referring to that when it was at the fifty —

DR. GERLA

Well, now when we designed it was 50 kilobits per second. By the time the congestion built up in the late 70s, probably it was multiple kilobits per second in parallel, and I think we built up eventually to the megabit per second then. But it took a long time. Actually, the megabit became available in the Internet, you know, locally, and these long-distance links had to be very expensive, had to be bought from phone companies, who didn't believe the very much in the Internet then, of course [laughs]. So it didn't really want to deliver anything particularly fancy [laughs].

MR. FIDLER

And to finish up on this natural progression comment, we're talking about going from, for example, the ARPANET with the network control program to the Internet with TCP/IP, you've mentioned that this progression, one of the things that would have determined it was different uses and then more traffic, is that specifically what you mean as kind of a natural response —

DR. GERLA

That's right. There are most of these sophisticated users, so the NC protocol was very sort of primitive, you know? If we just open the sockets and there we go. So the TCP is much more sophisticated, you know? It does congestion control, flow control, [inaudible] adjustment, and so forth, you know. Right. And then later on it is seen that TCP version survive wireless links, TCP versions that allow multi — now there is — 40 years later, people are still designing, retouching TCP. It's a sort of a — it's a mobile design paradigm this one, never studied, so it keeps improving [chuckles].

MR. FIDLER

Before we move on to the next topic, which is returning to some of what we were discussing about your time at the Network Analysis Corporation between 1973 and 76, is there anything you wanted to add to our discussion of your Ph.D. research and its relationship to [inaudible] —

DR. GERLA

Well, actually — for me NAC was an interesting experience, in fact a very enviable [experience], because I was able to put to practice all of my design techniques. They said, "Look, you're the expert, you know, you're the only one who has done topology design," so you knew it, and then you tried to find the business for it! [Chuckles] So I [retouched] implemented all these papers on how to do design, and I sort of went around talking to companies about the tools we had and the beauty of this new technology. We talked to, among others, NSA, you know, we talked to all sorts of — we talked to FAA and to, you know, they were all very interested, of course, and still hesitant, you know, a bit skeptical. Didn't understand what was going on. So that was an interesting opportunity and experience for me.

MR. FIDLER

Last time when you talked about proposing networks to firms, you said that your suggested uses of these might have been a bit naïve, you said, and I'm curious how you would figure out what to propose to them. So when you'd look at — there was

NASDAQ, you mentioned banks, there was U.S. Customs and Immigration. Different firms or institutions have different needs, and how would you get a sense of what it was that you proposed that would really appeal to them?

DR. GERLA

Well, you have to understand that at that time there was no notion of the Web, and in fact, the ARPANET designers, you know, like Klaus came in with the concept of, well, we do packet switching because it doesn't make sense to have the line connected between A and B — but then, once you replace that connection between, say, A and B with a packet-switched connection, then you stop. Whereas now, you under-stand there's much more to it than just establishing a connection. To design the network you would have to understand the user requirements. You don't want to just get a connection. You have a lot of software goes with it, to take the data, render it, you know, and so when we talk to the companies, there was, it was difficult to find a common ground, you know, because we have to bring it down to the point where their requirements we formulate it as a traffic that goes from router A to router B and C and D. And they were a bit skeptical, I think, I understand now, you know? In the way they could map all that. They were used to operate with a telephone-type network, you know, where they set up direct connections and they knew exactly perhaps that this particular program can only talk to that server over there and so forth.When they made everything available, and accessible, they say, what? Wait a minute. Security and theory alone is a problem, but even putting that aside, you know, the compatibility or the software: enormous problems. But I think people understood that, well, they cannot solve everything in one shot, so I think what we did was useful because people started to think about it. It may take another ten years before they really deploy these networks and could use it efficiently.

MR. FIDLER

So a lot of places that you would propose a new network to, they wouldn't have necessarily taken it up right away, but it —

DR. GERLA

Right.

MR. FIDLER

— planted a seed, so to speak?

DR. GERLA

Probably they needed a web, you know, and the idea of the Web probably could have gotten all the contract they wanted, because that's really — but unfortunately even the computers were not there at that time to do the data management we do today, you know? But with respect so to sell the network there I should have become an expert in many areas. Database management, maybe security, maybe graphic support — and then I could have sold — this study of all the applications down, you know? I was coming in with the network level because that's what I knew best and it was tough.

MR. FIDLER

So it was tough to come in at the network level and say to somebody, look,

DR. GERLA

[chuckles]

MR. FIDLER

replace your network with a —

DR. GERLA

That's right.

MR. FIDLER

packet switched network.

DR. GERLA

That's right.

MR. FIDLER

This is providence, this is the new thing.

DR. GERLA

Yeah.

MR. FIDLER

I guess you would propose cost savings to them if you...

DR. GERLA

That's right.

MR. FIDLER

modify things, but then after starting off by just coming with the network level, you started to talk about applications.

DR. GERLA

Yeah, right. I mean, the cost savings at the network level were probably minor as compared with the cost that software costs, you know, so we should attack that as well.

MR. FIDLER

So you —

DR. GERLA

And I don't think many people did. I don't think people pushing networks at that time were capable of going after the applications. There were other people going after the applications, but specific applications and without even caring about a network.

MR. FIDLER

And the applications that NAC would eventually begin proposing to you, those were applications that would have specifically required certain kinds of networks?

DR. GERLA

At that time probably not, you know?

MR. FIDLER

No, okay.

DR. GERLA

I mean, you go after NASDAQ, you know, and they had the issue of recording all these transactions and putting together, managing the data, massive data, you know? Then the communication aspects were probably not that major, at least they had to be integrated with the application. And we actually wanted then to take it down, stream line for us, it was not easy. Eventually, you know, in our proposal we came up with something that made sense.

MR. FIDLER

Last time you mentioned that in addition to proposing packet-switch networks, you'd also talked remote time-sharing machines.

DR. GERLA

Well, that was one of the interests of Kleinrock's and there was research then on time sharing, right? That was something dependent of the network. They were sharing the computer. Just in spirit, you know? You want to — in fact, maybe the idea started from

there, you know, we've got a big computer, there are few — only four in the country, we have to share it. How do we do it efficiently so you have to make — and then, the next thing that people said, well, what about the network itself? We can also time share the network, right?

MR. FIDLER

So when NAC would approach a firm, would you be talking, for example, about replacing batch systems with time-shared systems as a precursor —

DR. GERLA

In some cases, yes. In some cases, we said look, you know, with a network, you can shift, move jobs around, you know, and so instead of having this computer perform only on the local jobs, now it can perform also remote tasks, you know, and look how much, how much more bang you can get out of the computers. So that was also the initial idea of the ARPANET: with a few computers around, they wanted to share them.

MR. FIDLER

So this link between distributed-packet networks and time-shared systems would appear in the NAC proposals then?

DR. GERLA

That's right, it would appear as well.

MR. FIDLER

Did you know that these were going to be the kind of ARPANET clones that BBN was selling for the packet-switch networks, or was it much more open ended in terms of the networks —

DR. GERLA

We didn't call them clones, you know, because they all had some special features, but they were, they were all using pretty much the same routing algorithm and several protocols similar. I don't think there was much of an issue of copying, you know, intellectual property and so in those days. In those days, people were pretty free — in fact, actually, if you discuss the early days of the ARPANET with [inaudible], he says one of the major advantage there was you had idea, you share it with your friends, got some feedback, kick it around and then come back with a better solution. Nowadays people have an idea, they do not tell anyone until they implement it and make sure they cannot make money with it, and so that has been a — well, that has been a problem. I was in ITF, which is supposed to be open. People come with their own idea, push them to make money with their own gear.

MR. FIDLER

Hmm. On that topic, was NAC ever competing with BBN? I know that you said, for example, you'd be working side by side with Dave Walden giving presentations —

DR. GERLA

Oh, no, no, no, they were totally complementary because BBN was building switches and software, you know, and we were proposing networks that would use their software and switches. So they were not trying to get into the network design and problem then.

MR. FIDLER

Okay, so —

DR. GERLA

So they were sharing side by side. In fact we would often give presentations together.

MR. FIDLER

So NAC would be proposing a certain kind of network and then, for example, BBN might be hired —

DR. GERLA

Right.

MR. FIDLER

— to implement it.

DR. GERLA

Exactly. To Dave Walden more than I would talk to the Generals. [Laughs]. We actually meeting had a meeting with them. [Chuckles]. The meeting with the Generals. Interesting.

MR. FIDLER

Can you walk me through a proposal process from start to finish?

DR. GERLA

Actually, yeah. This is something we did at NAC, not the NSF. So the NAC proposal started with perhaps a VP, you know, going and visiting or being called in by, let's say, maybe FAA or — let's say the Customs, you know, because — the Customs office, and they say, "Well, we have this issue of these border entry points, and we would like to automate it. What can you do for us?" So you get all your information, come back and then get together a meeting, a team is formed, maybe two or three people, and then we kick around the ideas. We write a pre-proposal to send over. They look at it and say, "Well, that sounds interesting. So let's do some more discussion" because then in fact it would have a meeting with [a lawyer], understand what the real problem is, and then eventually come back with a proposal, you know? So that was — and this is actually a dedicated proposal to a particular company, you know, and they would evaluate it. They typically would also pay us for the study, because they realize that NAC was a small company, you know, that couldn't survive [chuckles], so maybe they gave us 50 or 60K for the study, you know, not much, and then evaluated, and if they were interested we would come back with another study or — some company that worked out in the sense the we'd — so they would implement an initial topology, a few switches to play with, BBN switches, so they started kicking the tires of this network. Not much money for them, really, but I think it was useful.

MR. FIDLER

And the tools and techniques that you developed at UCLA and you said improved quite a bit at NAC, it sounds like those would have been a major part, or they would have played a major role I developing these proposals.

DR. GERLA

Right. There are many types of techniques. We developed analytic tools to design a network. We also provided simulation programs to simulate the performance. UCLA here when Len had developed the Network Measurement Center so they're collecting measurements, interpreting them, you know, so that was an operation by itself. I think — I'm not very familiar with how that was commercialized, if at all, you know. You may want to ask Len [chuckles] and maybe somebody — I don't think it ever was. But, anyway, that would have been also very important. I think someone else took it over, maybe BBN could have also worked on that. So the entire package eventually had to be delivered to the customer, one way or the other, yeah.

MR. FIDLER

And of those customers, last time you talked about NASDAQ, Citicorp. You mentioned banks generally, I don't know if that was just Citicorp. Federal Express, the Post Office,

DR. GERLA

Yeah, right.

MR. FIDLER

FAA. Any other group — like industries or firms or institutions that you can recall making proposals to or doing work on?

DR. GERLA

Maybe talking about SNA also. Again, these are — some of those are — typically those were paid studies, you know? They were not bids. At that time, since we were the only ones, the companies weren't ready to go out for bids, you know. They would ask us do a preliminary study, you know, and so forth. I think I pretty much mentioned most of them. If I were to go back to my notes and see if there were other companies, um. Maybe in the health — no, the health not much, because they were pretty much still not networked then, it was just single hospitals work on their own. But FAA, you know, was interested in that, being spread out, of course. I think the government was interested in building an overall network for their General Services, you know? To combine various service together. Post Office, and some other services, so definitely, and that would have been a natural. The military, of course, they were allowing us to do their own designs.

MR. FIDLER

Was the reason that people came to NAC without putting out bids is that because, as I think you suggested before, NAC was the only game in town?

DR. GERLA

Well, yeah, but also they minded other companies, proliferate, there was TELNET. And TELNET actually was selling a service. Another company came out here, in California. It was Quattron, I think? Or, yeah, a company trying to pursue the — actually this company was very interesting because they wanted to install access points in all the airports and so something with Boeing going [inaudible], you know? And then also access points in various cities on top of Quattron, I think it was? Quattron. I'll have to go back. And it was actually, in operation until 85. Then they failed, you know, and bankrupt. So many companies that came up, anyway, even in the early days, so they were selling a service and also interested in selling you the network so they could build a private network for you. So if the customer was convinced that he needed a network, we'll go to them, or to BBN. We were the first step to start it.

MR. FIDLER

The last time you said that when you would redesign cable TV networks for local providers, this was a different kind of topological design, —

DR. GERLA

Yeah, the cable TV unit was a separate business at NAC.

MR. FIDLER

Okay, so —

DR. GERLA

That was the original business, so actually NAC was founded by professors at Berkley who had — some of them had participated in a study sponsored by the govern¬ment to lay out cables — no, to lay out pipelines, of all things, pipelines they got from Mexico, so they played around this topo — this network design problems, you know, and they said,

'well, this is very similar to the laying out of cable TV networks.' So they studied these and said, okay, there is a business to do that. So the additional business we do, we lay out cable TV. And there was a major business and the networking was an add-on. In fact, it was the first one when I went to NAC, the first one we started working on the network design, and then others joined. But anyway, this activity initially was supported by DARPA, because DARPA said, okay, we need you to maintain the network, so they give us managing support of those five or six scientists to do that.

MR. FIDLER

So the factors that led NAC from other kind of networks like pipelines, you say, cable TV, and then took them to packet networks, and you're arriving, there's DARPA funding, what were the other things that precipitated that move —

DR. GERLA

Well, the cable TV network had to be self-supporting. Of course, DARPA didn't support them, so that's hard work!So DARPA was easy money because DARPA said, okay, we pay you to — and so, and while you do the design for us, you can of course look around and — in fact, they were encouraging us to kind of transfer technology to the public. They saw us as an intermediate tool, you know, a way of cross fertilizing it. So it was a win-win situation. If NAC didn't do it, someone else would have done it.

MR. FIDLER

But.

DR. GERLA

And so it was a different business than cable TV. Cable TV, they had to be self-supporting, as you understand.

MR. FIDLER

This is what I'm getting at: DARPA would not go to a company in the cable TV industry to say "please do topological work for our packet-switch networks." What made NAC switch —

DR. GERLA

Well, it is a very different type of organization. If you design cable TV networks you have to be — [inaudible] much cost to lay the cable, you know, underground or on the wires, and so, and you must be intimately aware of the urban constraints and requirements. You must [chuckles] know the musical players. You know, it's a totally — you must lobby and so on. It's very different. The networking was much more sophisticated, much more future, projection of the future, yeah.

MR. FIDLER

So NAC would have been involved with lobbying for its cable TV work, is that—?

DR. GERLA

That's right, yeah.

MR. FIDLER

But then not obviously —

DR. GERLA

I was not involved in that part of the business but in order to do the good work on that and — it was a hard business — actually, it's not easy, you know? It was tough! I don't say it's like selling used cars, but it was tough! You had to convince people.

MR. FIDLER

And finally, were there other categories of services? There was simultaneously, for example, 1973, there seems like there was still cable TV work, there was the work by DARPA. Were there any other categories within the firm of significantly different —

DR. GERLA

So it's interesting you ask that, because in I think 73, DARPA started the packet radio project, and also before it started packet satellite project. The packet satellite project, remained a sort of academic kind of thing, ah, but the packet satellite project took more importance, because it was of direct interest to the military, you know? They understood the implications of radios in the battle field. The satellite, already understood it, you know? So that became also a big source income for DARPA — for NAC the last year I was there. And that interest was carried on also by many other company at that time. You know, Qualcomm was called M/A-COM, you know, with Viterbi, and Jacobson was also interested in that. Actually incidentally they were also interested in satellite business, and so in packet radio, no doubt but NAC was not clearly the only one, because there is not much topology design there, it's more of a software, it's a channel modeling and so on. So that's another area where NAC got involved with.

MR. FIDLER

You said that you brought with you from UCLA tools and techniques.

DR. GERLA

Yeah.

MR. FIDLER

And you also said that you improved these significantly while you were at NAC.

DR. GERLA

Right.

MR. FIDLER

And can you go through what you brought from UCLA? Like what practices —

DR. GERLA

Well, actually I had developed several programs [inaudible], and I think we moved to PL/I or whatever language, I don't remember any more, but there was the classic routing optimization, which is underlying almost everything, you know, based on multi-[inaudible] flows. Then there was topology design, where you — and there were different versions of topology design. There was the link assignment optimization, the way you have now assigned the flows and the topology, you want to figure out what capacity you should install on the various links, right? And those are the basic tools — plus simulation, you know, of the whole thing. So those are the basic tools.

MR. FIDLER

Did your work in further developing those change significantly when you got to NAC? For example, the amount of freedom you might have had to work on various problems, the — whether or not they were more applied, because I know you continued to developing them —

DR. GERLA

Well, we extended tools, you know, not only from the point of view of efficiency, but also using interfaces. We developed graphic interfaces. Still the graphic interface didn't exist when I was a student, but then I already after two or three with the Alto machine, people started playing with graphics, very, very primitive, you know. And there was also interest in DARPA to fund the interface, the graphic interface, so that was an area we

worked on. Being able to say to, okay, I want the link between here and there, you know, that type of thing.

MR. FIDLER

Let's return to your move from Network Analysis Corporation to both UCLA and the Computer Transmission Corporation,

DR. GERLA

Yeah.

MR. FIDLER

or TRAN in 1976.

DR. GERLA

Right.

MR. FIDLER

So on the one hand you mentioned at Tran you were working on PACUIT,

DR. GERLA

Um-hmm [affirmative].

MR. FIDLER

and can you say more about what that technology is, what the hopes for it may have been, and the broader work you did with them?

DR. GERLA

Yeah, actually, when I went to an interview at Computer Transmission Corporation, you know, Ray Sanders, and he wanted to hire me full time, I had received a good recommendation from Vint Cerf, he said [chuckles, inaudible comment]. And, but, at the same time I liked keeping a foot in the academic world, because that was the reason really why I had come back and that there was no full-time position here, but Len needed some help with a packet satellite project, so I — and I felt that in this dual position was actually the best for me and for Tran, also, because they couldn't afford — there was nothing of theoretical work to justify my presence full time.And also that company was very much involved developing a product, and I helped them, ah, develop the product and, sort of figure out how you could be inserting some applications and I would compare with packet switching. So that's what I did for this year that I worked with them full time and part time, and then I continued to work for them on a consulting mode until 1980 when they moved out of Los Angeles area. At UCLA I was working on the satellite project, which I liked very much, and so there was interesting work to be done there. And this project had interesting partici¬pation. Viterbi and Jacobs were representing M/A-COM, you know. There were other — SRI was there, there were lots of interesting people around. It was a very nice project. And Bob Kahn was sort of managing the whole thing. Vint Cerf was working with him. And we had — so I stayed on the project for — even after joining UCLA full time, well, after one year, and then getting a permanent position, I stayed on the project for several years and we traveled quite a bit. So this idea of the satellite was in fact one step towards including other countries into the ARPANET domain, you know?

MR. FIDLER

I'm going to spend a bit more time with Computer Transmission Corpo-ration, but we can stick with SATNET for now if you like or we can go —

DR. GERLA

No, let's go back to CTC, yeah.

MR. FIDLER

Okay, so —

DR. GERLA

So we finish it off there.

MR. FIDLER

Great. You mentioned products, and I'm hoping you can elaborate more on what the products —

DR. GERLA

Ah, the product, the main product was basically a router, or maybe you call it a switch, because it was actually taking inputs, bits, and sending them out, sending them out. Now, this concept of PACUIT had been already proposed in the literature before that. There was a company called TYMNET. TYMNET, I don't know if you — it was one of the main, ah, concepts that proliferated around the same time when the ARPANET was born, so it was a glorification of time, I think, a time division multiplexing where you would multiplex and [inaudible] on, on just a single link, but throughout the path, so bits would come in and go out on frames, you know? You would move frames around. And the Pacuit was a similar to that, you know? But, um, it was actually designed to meet the requirement of modern networks. In fact, they sold the system to DATAPAC, you know? However, you have to understand one thing — or maybe not, I don't want to teach you anything new, but [chuckles] this world of communication is a world of standards. It doesn't matter how good your scheme is, it doesn't become a standard, it's going to die.

MR. FIDLER

Is it a coincidence that you are that issue up in the context of control –

DR. GERLA

CTS, yes, because actually, after working on this, Len and I got involved in another project with an inventor that had invented some kind of a token ring. Same thing. It the previous scheme, we did our own analysis with Len. I don't remember the name of it, maybe Len remembers. And worked with Len and some of the Ph.D. students here. Good work! But then eventually the Ethernet came out — I mean, this thing was designed to connect buildings. AT&T was very interested in that there was also FEDI and other [inaudible], but, you know, ah, Ethernet came out, and became so easy installed, cheap and so forth, and eventually — They, AT&T, had already signed the contract with this company, they canceled the contract, and went with it. So. The standards always win. And so Pacuit was a good concept. They sold to DATAPAC, but then eventually they had to close, close production because, you know, packet switching was winning. I mean, you'll remember that at that time also, IETF had come up, Internet Engineering Task Force with the RFCs and so forth, and the, and the [chuckles] so the industry was falling. So that's it, that's what I can say about Pacuit. You know, it was an interesting place to work, interesting concept.

MR. FIDLER

Did you make proposals for firms much in the way that you did with NAC?

DR. GERLA

Something like that, you know, we, I think we went after Citicorp or something of the kind, yeah. But that was just about it.

MR. FIDLER

Well, while we're on this topic of the reasons that standards win and lose, are there other particularly memorable examples from your career where you felt a particular way about a standard but then watched a different one take over?

DR. GERLA

Well, sometimes the technology evolves, you know, so suppose — okay, let's say you have a 802.11b, then you know, then the new technology comes out, you get 802.11a, then you go to gigabit, you go to 802.11[inaudible], so, then eventually maybe five years from now, 802.11b will be forgotten, but because the technology has involved, you know. A standard fits a certain technology. When the technology evolves, the standard is in between, it — no, I mean, I have to say the companies often try to be backward compatible. For instance, look at IPv4 and IPv6, you know? I think you heard of that controversy. It's no question, there's no question, IPv6 is more efficient, it has all sorts of — it allows you to expand the scales very well, simple to process — but so much investment in IPv4, nobody wants to switch over. I mean, people trade off the — I mean, what, what — the change is there is not the technology change, it's a change in population size. People figured out a way of fixing IPv4 so that it would scale for the next ten, fifteen years. So I was very happy [inaudible], so IPv6 everybody talks about that, let's bring it in when it's necessary.

MR. FIDLER

So if it's — you mentioned population as one of the driving forces behind the eventual adoption of IPv6, and you talk about kind of incremental technological advances when it comes to Ethernet

DR. GERLA

Yeah

MR. FIDLER

standards for example, but then when it comes to something like Pacuit versus packet switching with circuit switching —

DR. GERLA

Okay, that's not an issue of technology. Pacuit, Pacuit is around the same, on the same lines, you know. Of course, the switches must be different, but they're built with the same technology, no? The preference, one versus the other, it is the way, ah, you sort of accustom, you know? So they send them and say, okay, with Pacuit, and now they came up with another fast circuit switching, say, look, with my technology, I'll give you a pipe, and you can transmit, I don't know, a hundred megabits per second. Actually let's not go with that speed, maybe 1megabit per second, A to B, with no buffering in between, and people say, okay, wow, but I give you the packet-switch connection and you've got some latency, maybe ten, 15 milliseconds, and it's totally "below the noise" who cares? I say ok, ok! I'll give you a break! Because you used your technology, it's not standard, I have to change my entire network, you know? I'm not gonna do that unless the customer says, you know, I want to have a microsecond latency. You know, [inaudible] application microsecond latency [inaudible] come and talk to you, but until then!

MR. FIDLER

[laughs].

DR. GERLA

Right?

MR. FIDLER

Right.

DR. GERLA

Anyway, so that's the way I see it.

MR. FIDLER

Okay.

DR. GERLA

[laughs] You first have to go visit customer, then you microsecond latency, and then they buy it.

MR. FIDLER

Let's move back to SATNET now.

DR. GERLA

Okay.

MR. FIDLER

So you mentioned a moment ago that when you came back to UCLA it sounded like Len was working on packet satellite and asked you to help, or was it —

DR. GERLA

That's right.

MR. FIDLER

Okay. And what was the — what did the project look like when you arrived? Like, what were people doing? Who was working on it?

DR. GERLA

Actually I think that was the time when, um, it was after that I believe that Len give up. Actually — jog my memory. At some point, Len gave up his involving networking, gave up his ARPANET project, [inaudible] if I remember, you know? [Inaudible] worked on this satellite project and packet area project for one or two years, and then the project — and then we move on to other things. Then Len for a while — jog my memory, Len for a while didn't work on networking, he was working on connection machines, a model of computation, the benevolent bandwidth, you know, and I was a bit disappointed because — but, anyway, so eventually he came back to networking, you know.But so this period is still when he was working — going high on networking, so 76, the project looked very interesting to me because there were interesting participants. Ah, Viterbi, Jacobs, who I'd known before, and they actually offered me a job also [chuckles]. They were — yeah, they had offered me a job before. SRI, you know, there were — Vint Cerf, Bob Kahn, it was a pleasure, see, to go — BBN was involved, and it was — actually it was also a good project because it went beyond the just a single network, it was an opportunity to implement TCP/IP and its full capability, you know, I decided, well, here you have the ARPANET, the LAN network, you have packet radio, you've got the satellite, and clearly they require different for inside, different properties, so you want to — you don't want to force the same technology on each, you want to interconnect them transparently. So the Gateway Project was then going on at BBN, and it was, ah, some — I think the, the TCP/IP protocol was put to a test there, you know?

MR. FIDLER

When you looked at SATNET then, were you thinking about internetworking as the, as one of the more interesting —

DR. GERLA

Um-hmm [affirmative]

MR. FIDLER

— parts about the work that you were doing then?

DR. GERLA

Oh, it was important, it was an important aspect. I never understood the importance of internetting before, you know? Ah, and so it became apparent that that was the future. But actually my work within the satellite project was not so much on the Internet part, it was on the access protocol for the satellite network.We started looking at the ALOHA scheme that Simon Lam had developed, but he did it for short propagation delays. We looked at large propagation delays. And in fact I worked closely with some researchers at, at M/A-COM then, you know, with Viterbi and Jacobs, so we were all working on that. So we came up with interesting protocols. Lots of work. We did several experiments. Ah, very successful, too, but then of course, you know, it is a situation where, ah, that work became actually, it was actually transitioned to some military satellite systems, but the commercial satellites certainly didn't implement that. And besides, the commercial satellites became not very interesting for communications anymore, because the network — see, okay, the original idea was to interconnect the internets through satellites, but then it became apparent that fiber optic did a little bit better job, so satellites took a — became specialized in something else. But, nevertheless, I worked on it for two years, so we generated quite a few interesting papers.

MR. FIDLER

Before we get to some of those experiments, you mentioned off hand that this is when you started to understand the importance of internetworking with —

DR. GERLA

I think so, you know, that, it was when I came back, I mean, even at, it, ah, NAC was still looking at a single monolithic, monolithic network, you know, but when I, you know, by necessity, you work on a satellite network, you realize it has to be connected to the Internet at both ends. Also packet radio was then becoming important, so that was another requirement. And at the meetings, BBN was then designing the gateway, so we looked at the gateway functions. So we started — there was a concept of, aboard the gateway protocol already, you know, BGP, and those things, those ideas were kicked around at that time, you know? And, so.

MR. FIDLER

What was your interaction with people working on the gateways? Did you do any of that work yourself?

DR. GERLA

No, I didn't, but I listened to the presentations, you know, because, ah, it was a project funded by DARPA with BBN, so BBN at that time was building the gateway, yeah. I don't think we were deploying any more IMPs then, you know? In fact, not to long, long after, the IMP was decommissioned, you know, the network even over, yeah, taken over by — yeah, and this happened, so.

MR. FIDLER

You mentioned that the technologies you developed didn't go to the private sector so much as the military, the SATNET.

DR. GERLA

That's right, you know, that's right. Ah, at least the technology we developed. Because at the same time, Linkabit was working on satellite, special-purpose satellites, satellites to

track car, you know, track trucks and so, but those were special protocols, you know. They were using CDMA and so forth, you know. They were not communication satellites per se.

MR. FIDLER

Can you tell me about the experiments that you did and the work you did on SATNET?

DR. GERLA

Yeah. We did measurements. We had three sate — I think we had access to a satellite that was connecting three nodes, so we did some measurements with it. But, you know, with three nodes, there is only limited amount of experiments you can do, so we quickly developed a simulation environment to, to evaluate our protocols, and the, the major issue was stability, because, you know, the ALOHA protocol tends to be unstable, unless you control the rate of the transmitters.We also came up with a, with an emulator, where we implemented I think a ten [inaudible] stations per node, initially three nodes and we were running experiments with 30 stations, you know? Or 33, you know? There were a real station and the rest were emulated, so we did something like that. So we did quite a few experiments, and UCLA was involved. The stations, I mean, there was no station here. I think one was in [inaudible], another was in Washington, D.C., a third was in Norway, so they were spread around that way. And, you know, of course, as part of this project to be were, we had meetings in London, meetings in Norway, meetings in Washington, D.C., so we traveled quite a bit. I got to see the Nordic country, [chuckles] I went twice to Norway, you know.

MR. FIDLER

You worked with SRI and BBN and —

DR. GERLA

And that [inaudible], yeah, and then there were representatives from London, Peter Kirstein, from Norway, Pål Spilling, another. And then eventually Jack Ziegler went to work for the Defense Research Center in Norway as part of this project, yeah. Yeah, so he got recommended, you know, I think in the [inaudible].

MR. FIDLER

Because of the Norwegian institution that you were dealing with SATNET, was it defense institution —

DR. GERLA

It was a defense institution, yeah, yeah.

MR. FIDLER

The name escapes me for a second, but —

DR. GERLA

ND or something like that, yeah, yeah, yeah, exactly.

MR. FIDLER

What can you say about the relationship between these different organizations that were involved? There's UCLA, BBN, SRI, Norway —

DR. GERLA

Actually it was surprisingly smooth and cordial and productive, you know? Well, you also have to understand that the commercialization of the Internet had not started yet. When the money, when there is money, people become, ah, sort of antsy, you know, I mean, and they try to withhold things, but since there was no money involved it was all just open, you know? [Chuckles] Nobody really, there were no prima donnas there. But

then, you know, we — so that actually was a way, maybe I can use that to introduce the concept of the spread of the ARPANET, you know, because, actually one of the reasons for deploying this SATNET was also to export the Internet technology to other countries, you know? Because in fact, Peter Kirstein and Pål Spilling and the other guys, so those became the key guys that then introduced the Internet and ARPANET to the UK and to Norway.

MR. FIDLER

So SATNET did facilitate the connections with the UK and Norway. Were the other — you mentioned those people in particular, were there other —

DR. GERLA

Much later, you know, then France. I think the other countries had to be connected, they were not connected by satellite. I don't know how they were connected, they were connected through commercial lines eventually, either through the UK and then satellite, or just commercial lines. Not very high speed lines. Costly lines, but, you know, nevertheless [chuckles]. Also, the biggest countries started developing their own structures. Although we had to wait until the 80s to see such deployments. Now, the exception is France, because France started very early, you know? With CYCLADES and CIGALE.France, I think France, Pac is also — TRANSPAC was a commercial network. CYCLADES and CIGALE are research networks in France, and they were sponsored by France Telecom, so they were up and running. In Italy there was a network called [inaudible], but it came a bit later. And Germany also came along eventually. So, so these networks were looking at ARPANET and Internet, and then became connected. So each one of these countries has its own father of the Internet, you know? Although it is always a debated and challenged position everywhere.

MR. FIDLER

Beyond the actual connections that SATNET allowed, were there other ways that it exported ARPA standards, ARPA protocols to other countries? I don't know if you were hinting at that before?

DR. GERLA

I actually was involved in the connection of the Italian network to be, you know, to the, to the ARPANET. I remember that it was the late 70s — I was in Italy and I was talking to Lenzini, and he said, Bob Kahn, you know? Specifically asked me whom he should talk to in Italy to bring into the, to connect the Internet to. And he gave me a few choices, you know? And then I looked at them and I advised him that maybe they guy to connect to was Lenzini in Pisa, more than Torino and Milano. You know, Politecnico di Milano had researchers but no facilities, so Pisa had been very, very active with the large computer, and that they would have been the pioneers, you know, in informatics, say, in Italy. So eventually the connection between the Internet was made to Pisa. So that was the time when centers in different countries were connected to.

MR. FIDLER

And this is in the 1980s — you're talking about —

DR. GERLA

I believe it was the late 70s, early 80s, yeah. And I don't remember the date exactly, but it must be that time.

MR. FIDLER

And so you're speaking about an ARPANET connection?

DR. GERLA

Well, it was actually Internet then, you know? I know that Bob Kahn was involved, so Bob Kahn...

MR. FIDLER

so maybe an experimental TCP connection or was it a long-running link?

DR. GERLA

Ah, it must have gone along, oh, some commercial link, you know, that was, ah, perhaps paid for by DARPA. I mean, DARPA would pay for the connectivity in some way, then maybe — they maybe even have arranged the connectivity to London, then via satellite back to the US, and I don't know exactly how the connection was set up.

MR. FIDLER

But probably through —

DR. GERLA

Through some lines they had, you know, I mean, the, the Department of Defense and then there is — remember, at the time the Wall was still up, so there was an enormous presence of Americans [laughs] in Europe. They must have had a lot of lines, the Department of Defense, so they must have used some of those lines to connect, you know.

MR. FIDLER

And were you aware about the use of this connection, or were you there mostly when it was established?

DR. GERLA

Well, I didn't monitor the, ah, progress, but clearly, ah, the result of interest by that time, everywhere, in the Internet, so people already — remember, the, the Ethernet was already in existence, so these local networks proliferated, you know, I would say that — but people started doing Internetting with the buildings, so the, they were familiar with the protocols, so connecting, connecting to the Internet, via the gateway, was an opportunity to exercise the Internet protocols, or doing the same work remotely that you're already doing locally. Right? It's not that before the connection Internet, nobody did any networking. There were — I mean, the nationwide networks took a while to establish, you know, because you need a lot of money, motivation and support to do that. But the local networks within buildings, those were happening already.

MR. FIDLER

And so at the University of Pisa, that would have been active, it would have been active research and perhaps a —

DR. GERLA

That's right.

MR. FIDLER

well used local network.

DR. GERLA

Yeah.

MR. FIDLER

Based around the time-sharing system, for example? Or?

DR. GERLA

I think the local network at the time would have been the Ethernet,

MR. FIDLER

Okay.

DR. GERLA

See, the Ethernet was invented 76. By 1980 it was quite popular. There were also other — there was DQDB, there were other, other technologies available there, at that time. Yeah. And also at that time was when I was in Italy, I was also consulting with Italtel, so when I was actually following, ah, Italtel was a telephone company, you know? So they were actually looking at it from the telephone company point of view. They were interested in ATM. So ATM was the technology, Internet techno — network technology pushed by the communication television companies, you know. And it was supposed to replace everything. I mean, it was supposed to combine voice, video data, and so with this new standard. Which then happened, but this was integrated under TCP/IP anyway, [chuckles], instead of ATM. But, so in the 80s, so a bit later than, you know, the, the telecoms got involved eventually everywhere, pushing ATM. Before, before that they were really skeptical to join the networking bandwagon, but then they decided it was the time to do it, and they came with no proposal, right? Actually I'm simplifying the — greatly simplifying it with the advantage of 30 years' back. You know, at that time I would have said things differently, because actually I was doing work on ATM myself. I thought it was an exciting technology, and it's an opportunity — it was an opportunity to publish papers. You know, you're a young professor, you want to publish papers, so you [chuckles]. Anyway.

MR. FIDLER

Can we — we can come back to that. I'm wondering —

DR. GERLA

No, I think that's probably enough said, because there are so many technologies I could talk about,

MR. FIDLER

Of course.

DR. GERLA

but, ah, but, yeah, the Internet, right?

MR. FIDLER

Well, in particular, one of the things we spoke about last time that would be nice to move to is the spread of networking technologies and practices throughout the world, and I think we came back to this when we spoke about the University of Pisa getting some kind of ARPANET access. It seems like they would have had access to a host at London or some kind of extremely distant host interface to an IMP —

DR. GERLA

No, once they got into the net from Pisa, you could see the entire Internet, everywhere, sure. You would be connected to everyone on the Internet. Ah, so, right.

MR. FIDLER

And this was something that — where Bob Kahn, you said, approached you and asked

DR. GERLA

Yeah-yeah

MR. FIDLER

about the best place —

DR. GERLA

He was looking at that time for the best place to bring the Internet to Italy, and then of course the rest of Italy would just get into Pisa and connect to the Internet.

MR. FIDLER

And I'm a bit confused about the years. You're speaking about Internet, but this is —

DR. GERLA

Ah, now the year's okay, but I think it was in the late 70s, you know? It must have been between 76 and 80, something like that. Probably not before that.

MR. FIDLER

And would —

DR. GERLA

Would have to ask Lenzini. In fact, I can probably find out very easily.

MR. FIDLER

And Bob Kahn's choice to extend connectivity to Italy, what would have gone into a decision like that?

DR. GERLA

Ah, I think there must have been a DARPA interest behind, you know? To take technology to other countries, and of course it was — there was a cost involved, because the — I think DARPA was paying for the communications line to Italy, and although as I said, probably DOD had a lot of lines to Europe still, you know, somebody has to pay for that. Why did they do that? I think it was the interest in extending the U.S. technology to other countries. If they didn't do it, some other country would have done it, and would have come over to the US! [laughs]. Right. You know, I think that that was probably the idea.

MR. FIDLER

And of course speaking about the Internet connection, and this is an example of DARPA funding a project that leads to the, in this case, overseas expansion of its own —

DR. GERLA

Yeah.

MR. FIDLER

[inaudible]

DR. GERLA

Yeah, I would say so. Because that's what — that was the time when the IETF came up, you know, and they were issuing the RFCs, Requests for Comments, and which then were practically the standard, so, and that mechanism was developed in the U.S. Now of course the IETF moves all over the world for the meetings, but the clear, ah, um, guidelines were coming from the U.S. community at that time, you know? And I think the U.S. wanted to retain the control of that. So it expanded to other countries that were able to make sure you would, ah, at least put a good basis for it, right?

MR. FIDLER

And that was a concerted DARPA effort that Italy would have been a part of.

DR. GERLA

That's right. Okay, well, these were a part of NATO, so NATO, all the NATO countries got brought in. So, so Europe was the first, so the first, ah, area, region to be connected. So I said London and Norway first, because satellite, and then the others shortly after. So. But you have, you have the numbers, right? You know exactly when all the countries came into the Internet [chuckles].

MR. FIDLER

I try to. Were you —

DR. GERLA

[chuckles] You know better than me

MR. FIDLER

Were you involved in the expansion — there was a brief — if I'm getting this right — pre 1983 there was a brief expansion of the ARPANET to Western Europe. Those connections were later moved onto MILNET. Did you have any involvement with MILNET, ah, from

DR. GERLA

No.

MR. FIDLER

1983 on?

DR. GERLA

I heard about MILNET as the military part, and then I never heard of it again. I don't even know what happened to it. Probably they dumped all the switches to something else [chuckles]. But then the ARPANET became NSFNET you know as you know, and the switches changed, you know, they put more machines, and so.

MR. FIDLER

Last time we spoke about the spread of — we talked about the instance of Italy and the spread of knowledge about networking, earlier on, for example, in the early 1970s, between the United States and other countries, and you said one way that you participated in that was to get students excited about computer networking. I think either students you had in the United States who went back to Italy,

DR. GERLA

Um-hmm [affirmative]

MR. FIDLER

or students in Italy that you were meeting with and discussing these ideas. Can you expand on your involvement in, in taking these ideas that you were —

DR. GERLA

Yeah, actually, they were European students in the group here, ah, Luigi Fratto, for instance, my colleague at the Politecnico di Milano. He went back and he was a bit proselytizing, you know? But the — I remember distinctly then when I went back to Italy in 1970, you know, or 71, something, ah, 1971, I started working on the Internet. I talked to some of my professors, you know, about the Internet, and they looked at me strange. "Networking? Well, you know, it must be an interesting technology, you know? So when you come back to Italy, I doubt that you'll be working on internetting, we don't do that here, but whatever work you do will be useful!" [chuckles] So I was stunned, I said, what are we talking about? And this was actually a professor who had been one the real pioneers of computer, the design of computers in Italy, you know? So there was a lot of skepticism in the early 70s, one or two years after Internet. So the students, of course, you know, were not educated about the Internet. So that happens to the students who came in and then went back, and they became professors and, of course, if I had gone back to Italy after finishing my Ph.D.; of course, I would have also advertised the network. So I think what happened is that people who came to the States went back as professors and

they introduce technology. The commission of that, and the connections to the Internet made things happen.

MR. FIDLER

So initially, when we're talking about the early 1970s when, for example, e-mail was not widely used, like the very early 1970s, you'd have people that you would know face to face though teaching and

DR. GERLA

Um-hmm [affirmative].

MR. FIDLER

advising, but then later on, those same connections would be maintained by e-mail? Is that?

DR. GERLA

The e-mail, it took a while to take off, actually, even I didn't use it at the beginning, you know, when I was a student, I rarely used the e-mail. It was not a very flexible mechanism. But, of course, shortly after, when I went to NAC, you did everything through e-mail. In fact, e-mail was the most important application, probably the first four or five years.

MR. FIDLER

One distinction that's made when talking about the transmission of ideas, especially in engineering, or scientific ideas, is between formal and informal knowledge, so formal knowledge is something that's codified and, for example, published and shows up in reports

DR. GERLA

Um-hmm

MR. FIDLER

that everyone can access. And then informal knowledge is tacit knowledge sometimes called "water cooler talk", where you learn things that may be necessary to do your job or to run an infrastructure, but it's only through —

DR. GERLA

Word of mouth.

MR. FIDLER

and discussions and kind of professional socialization.

DR. GERLA

Hmm.

MR. FIDLER

Is that something, is that a distinction that makes sense —

DR. GERLA

That was happening there?

MR. FIDLER

in your history with networking?

DR. GERLA

Hmm.

MR. FIDLER

Because we spoke about what seems to be an informal process with the spread of at least enthusiasm and foreign, perhaps, techniques as well, networking to Italy.

DR. GERLA

I'm thinking about it. Well, there was no grass-root wave of interest and enthusiasm for the Internet, which was — so it's not as if people were totally excited about it without really knowing what was the Internet all about, because the, there were no accompanying applications, that's the point, you know? So the layman wouldn't understand what the Internet was anyway, you know? Ah, so I'm saying introduce the cars and people drive the car, although they do not understand how the engine works [chuckles]. At that time, people didn't understand how the Internet worked, but they didn't know to use it, because, ah, see, I think there was — there is not — had not been at the time major emphasis on educating the people in the streets, the layman, if I may interpret what you said correctly, you know? So there was no incredible enthusiasm about this technology, even before you knew how it worked, yeah, so people who worked in the area, like, remember us, you know, in the late 60s, early 70s, you know? Understood about it. It worked and we thought it was a great thing, but I don't think we put a lot of effort in convincing others that it was the way to go, I mean, because, we ourselves we didn't understand what the limits were. You know, at that time, everybody was using the phone as an [inaudible], they're using, using time sharing, and honestly, the fact that I could connect my laptop to someone more — at the time there was no laptop anyway, my computer work station, say, you know, to another work station in New York, you know, it was a good exercise, but, you know, so what? [Chuckles] There was no data to cache there or anything. So I — there was no way I could get anyone excited about it. If you know what I mean.

MR. FIDLER

Certainly. My take away from that is that insofar as there's proselytizing it's within the professional community, you're doing that, for example, with students, maybe with other professors, but the public is —

DR. GERLA

Yeah.

MR. FIDLER

— completely absent from the conversation.

DR. GERLA

So why would the students be interested in that? Well, because these were new problems, you know? For instance, I would say that when I did my Ph.D. I was overwhelmed by the number of problems that were popping up. I — nowadays, a student has to go through an incredible search effort to find a problem that has not been worked on before, you know? And in fact it a successful thesis, is really sometimes luck because you come into a problem that nobody has done before. At that time, you know, anything was new, so I could have decided to work on Internet protocol instead of routing, but, you know, that came out naturally because I had to take — I had taken a course with Len and we were looking at natural flows. So and you can imagine if you go back to Italy and you have this new scenario of problems and people will love you because they say, "Okay, these are great ideas! They're great — I can make a contribution, you know? And nobody's done it before." There is queueing and so forth, all these new things. But of course you go out to the man in the street won't understand anything, 'Okay, forget it. [chuckles] I can't understand! I understand cues but…' [Chuckles] They didn't know how to spell them anyway, you know. [A pause]

MR. FIDLER

And is there anything else you wanted to say or anything else that I might ask you?

DR. GERLA

No, is, so I think this interview has been complete, and it has covered all the areas that we wanted to cover before. We didn't talk about the current situation, of course, because, you know, I've been involved in panels where we interviewed, you know, Bob Kahn, Pouzin, and asked them so what has changed between the days you were pioneers then and what you do now, you know? And they all gave different perspectives. So I think if you look at the Internet now and the researcher work on the future Internet and so forth, you could have predicted, you could have seen the same trends 40 years ago, you know. But the major change, as I said before, between now and then is then there was no commercial pressure. Now, everything comes with a promise of a lot of money, so every little bit of thing you design, you always have to think, well, how can I sell this, you know? And that changes a bit of the spirit of collaboration of people, but, ah, but, hey, you know, that, that is also good, because there are so many more applications out there, and people then are trying to do something useful for the community, so. Okay, anyway, I appreciate your taking the time to talk to me also, and, okay!

MR. FIDLER

Well, thank you!

DR. GERLA

Thank you! [Chuckles] [End of this interview, at 1:59:18]

Date: