Interview of Howard (Howie) Frank

Interviewed by:
James Pelkey

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Howard Frank: Maybe what I should do is give you the background first, and I'll just take it up to current so that you have a perspective of where I've been and what I've been trying to do. I got into this business in a strange way. I went to the University of California as an assistant professor in 1965, in electrical engineering and computer sciences, never expecting to end up, three or four years later, out of the University of California. I was there as a career. My PhD thesis was built on probabilistic graphs of some applications and it was statistical communication type theory, sort of an extension of the Von Neumann work. It was a virgin area. Nobody was really working on it at all.

James Pelkey: Where was your degree from?

Frank: Northwestern. Interesting thing happened. I stumbled on a body of work in the Journal of Mathematical Biophysics that had to do with the radiation of cells, and what happens to cells in the human organism when it gets radiated, and I looked at it and saw it was applicable to communication networks under nuclear bombardment. So, I took the basic mathematical theory -- literally, I didn't create any at all -- I stumbled across it, the work that had been done in the early 1960s and was ongoing research at that time. I have no idea whatever happened with it, whether it was ever any use in that area at all, and I applied it to work that Paul Baran had been doing. I was able to develop a closed form expression that reproduced everything that he had done with thousands of hours of computer time in simulation.

Pelkey: Now, what year was this?

Frank: 1966.

Pelkey: And how did you come across Paul Baran's work?

Frank: He had published a series of papers; one paper in the Journal of Communication Theory or something like that, called "On Distributed Communication" in 1964, and the Rand Institute had put out a whole series of reports on that. There were a dozen volumes in the series in 1964.

Pelkey: You could get access to those?

Frank: Oh, yeah, they weren't classified or anything. So I got all those things.

Pelkey: So somewhere between '64 and '66 you saw those papers?

Frank: Yeah, probably while I was doing research on my PhD, but I didn't actually find that work of the Journal of Mathematical Biophysics until I was at Berkeley. That I definitely know. Why I went there, I have no idea.

Pelkey: That was in '67?

Frank: That was '66. I wrote a paper called "Vulnerability of Communication Networks" in 1967, so I must have written it in 1966, if it was published in '67. That turned out to be very exciting. It literally did, in a page, what Baran had spent, if not millions of dollars, certainly hundreds of thousands of dollars and many, many hours in doing, and it was one page. It was a 40-page paper. Because of that, I got invited to give a talk at the Institute for Defense Analysis in Washington, and because of that, it was somebody in the audience who a year later gave me a call -- actually told somebody else. All of a sudden, in the middle of 1967, I had a telephone call from the White House saying: "How I would like to become a consultant?" My instant reaction was: "Yes." There was no time between the question and the answer. It was zero, you know, faster than the speed of light. I remember, it as: "This is Bob Kupperman of the White House calling." "Yes." About three months later I went out there. It was rather embarrassing and really funny, because, then I heard nothing from them for two months. Nothing at all, and I had already told everybody: "I got a call from the White House. They want me to be a consultant." But then I heard not another word. My colleagues are especially determined. "What's happening?" "I don't know."

Apparently, what had happened was, after I expressed the interest in doing that, they were then doing background checks, and they weren't going to put anything in writing until I passed the background check. Two months later I passed. Because -- I guess somebody tried to get me involved with consulting for the Institute of Defense Analysis, so I had a top secret-security clearance. They transferred that over and I ended up going to Washington for a trip in, it must have been March of 1967, and within two hours of me going there, they said: "How would you like to come and spend a year on leave?" This one took me a little bit of a delay, about ten seconds, and I said: "Yes." I called up my wife and said: "Guess what. We're moving to Washington."

Pelkey: Now, where was this paper published?

Frank: It was published in the Transactions on Communication Technology and it ended up being awarded a prize for the best paper of the year. Now, I must have met Paul Baran sometime around that time, and I'm sure Paul was probably one of the reviewers on the paper.

Pelkey: Is that the ACM or IEEE?

Frank: IEEE.

Pelkey: I can contact them for that paper.

Frank: Yeah, or I can dig out a copy if you want. Make a list of items and I'll do that. I recently looked at it, recently meaning within the last year. It was a good paper.

Pelkey: It must have been. It certainly had an impact.

Frank: I don't know if it had an impact or not. It precipitated a phone call, so it did have an impact on my life. Certainly the work did. It was really quite interesting. What had happened, literally, I went to Berkeley thinking I'd be there forever, or if not forever, certainly for a long time. I was a theoretician. I was working in a truly esoteric area of communication networks in which you found maybe one or two papers published a year, and they weren't very good. My talent is that I'm a synthesist. I'm not an original creator of advanced mathematics. Never have been, but as a synthesist, I can take ideas from different fields and put them together, and I could create new things out of that, and because of that, nobody else was working in the field, I was cream skimming. I could say: "What about this?" And nobody would have thought about it yet. Nobody would have worked on it, so I worked on it. It was wonderful. I couldn't do it now. I would still be a cream skimmer, but they're down into the bottom of the barrel now on this stuff. At the time, it was easy. I published in virtually every branch of the thing. I wrote papers on computing technology. For instance, I wrote a paper for the journal of the ACM on "Optimization of Disk Storage and Utilization and Access." I was a consultant for the Lawrence Radiation Laboratory. That was interesting. I wrote a paper in automata theory. I wrote one on system theory. I did a lot in coding theory, all bringing together things that people hadn't done before. I probably was writing a paper a month, literally. I wrote something like 30 or 35 papers in three years. I probably, for a decade after that, continued at the same pace. The interesting thing is, I got to Washington. I knew nothing about what they wanted me for or anything. It turned out that within the Office of the President was an office called the Office of Emergency Planning, which subsequently while I was there was changed to the Office of Emergency Preparedness, because somebody got the idea you shouldn't be planning emergencies. You should be preparing for them. They changed it while I was there, and it was an interesting office, because as far as I could tell, nothing ever came out of it. It was one of these things where there would be circular paper flow and everything else. It was divided into two pieces. One piece managed the critical stockpile of the United States, of all materials, things like that. It also was the agency responsible for administering disaster planning, so they worried about thing like: "What would happen if a hurricane came over and stopped over New Orleans for two hours, instead of going through?" Then, of course the answer was: "Let's classify that, because there wouldn't be New Orleans. It would be gone. Three hours, there wouldn't be anything around." The other piece did other things, but within that there was something called the Assistant Analysis Center, or Division, that was doing some fairly interesting analytic work on warfare and things like that. Apparently, from what I could tell, and I wasn't

really sure whether it is true or not, but Vice President Humphrey had gotten the idea of sponsoring a small group to prove that an Office of Analytic Planning within the White House would make sense. What happened was, the fellow who had heard me in the audience at the Institute for Defense Analysis, had gone on leave from the Institute for Defense Analysis, and been asked to start a small group of experimental proportions -- a half dozen people, whatever -- to see if they could solve a problem. They said: "Find a problem and solve it." He was the guy, not the guy who called me but the guy who initiate the 'finding me,' and the idea was that I would take over the group after him, and we overlapped for about six months. He was a physicist, not a network theorist. We ended up finding a topic on the design of offshore natural gas pipeline networks for the Federal Power Commission.

This is interesting, because that work was essentially the beginnings of all the topological design of computing networks and so on, so it has an interesting place in history. I ended up in technical charge of the project. I was on a day-by-day consulting basis that meant I was limited by law to be there no more than one day less than a year. It turns out I was there for 11 months and three weeks. The problem was as follows. There were lots and lots of pipeline construction in the Gulf of Mexico at that time. The Federal Power Commission had the responsibility of approving pipeline applications. Pipeline applications were in the order of 100, 150, $200 million a year. Lots of money, and they had no process by which to approve them, other than looking at these things individually. What we set out to do is to find a system and an analytic approach, to figure out how to design these things. The technology of design was relatively primitive. It took me ten years after that to figure out what a pipeline looked like, by the way. These underwater pipelines are immense things. Ask me about gas flow in a pipeline, I had no understanding of all of that when I went into the process. What happened was that we pulled together a team: two, three guys from Princeton, a mathematics professor from MIT, two guys from Berkeley, and some consultants. Len Kleinrock was a consultant, as a matter of fact. I had met Len three years before. There's a wonderful story of how I met Len. He was on vacation. I was teaching a short course during one of the summer sessions at Berkeley. He came off of a mountain to come teach an hour or two hours in my course. Did he tell you this story? It's absolutely true, and the proof is, after careening down the mountain, the proof is we used four by four lantern glass slides in those days, and every one of his slides had a crack through it.

Pelkey: How did you know -- I understand that he called you at the last moment, and Paul had come to listen to his talk, I gather, and he was going to talk the following day, and you substituted Paul for him?

Frank: No, he showed up.

Pelkey: But he showed up late and he gave his talk the second day.

Frank: I don't recall, but we did --

Pelkey: How did you know to invite Len?

Frank: Len scared the hell out of me three years before, not because he wanted to -- maybe two years before. He was about two years ahead of me in graduate school. One day a guy comes to me and says: "Your thesis is in the book store." I was about four months or five months away from finishing it up. And I say: "Oh shit!" I charged over to the bookstore, and there I find a monograph by Len called "On Communication Networks, Stochastic Message Flow and Delay." My thing was called "On Probabilistic Graphs of Some Applications." So I opened it up, and I look through it for three minutes, and discover it has nothing to do with what I'm doing. It's the same general area, but he was looking at queues and networks and I was looking at the existence of the fundamental structures themselves. Essentially he was pumping traffic through, and seeing what happens to the traffic. I was saying: "There is an underlying uncertainty in the network itself." You talk about words like capacity, but really that's not a deterministic quantity. The links may not be there because of reliability or vulnerability. Somebody may be attacking them or the nodes may not be there, and I was looking at the fundamental phenomenon of how do you talk about connectivity when the elements are uncertain. He was talking about the delays in the thing when you pass it through when the traffic is uncertain. So I saved my ass, as the expression goes. I could go back that day. I came back with a copy of his book, and I called him up. He was at

UCLA and I was at Berkeley. I don't remember whether I sent him a copy of my thesis or not, but I called him up when I got to Berkeley. When, exactly, I really don't know, and that was the first time we met. Then I came out to UCLA and I think I was guest lecturer in some of his seminars. We sort of kept track of one another thereafter for many years. A lot of them were accidental. For instance, I didn't know he was working on Arpanet when we first got our contract. Didn't know it at all, and I'm not sure whether he knew that we were working on it when we first did, so we were really looking at the thing from a totally different perspective. Back at the Federal Power Commission, the reason the FPC had gone along with us was twofold. There was a very innovative guy who was the chairman of the Federal Power Commission, a fellow named Lee White, who was the last Kennedy appointee in government at the time. There was a very innovative guy in charge of the Bureau of Natural Gas, I think that's what it was, a guy named Jack O'Leary, who subsequently became the head of the Bureau of Mines and became a fairly substantial, courageous figure in government. I think he was finally driven out of government, by the way, as well. They decided to take a chance. The name White House always had a certain ring to it, even though we were sort of in this unit corner of nothing land. Nothing ever happened and nothing ever was going to happen. At the same time that we were there, there was something called the Office of Telecommunications Policy. I guess it was called OTM at the time, Office of Telecommunications Management, and that also was part of OEP, but it was a rather ineffective, quiet little thing at the time. So I went out to Washington in the summer of 1967, and we set up this program. I don't remember whether we got the problem first or we started doing other things first, but somewhere in the fall of '67, we started working in seriousness on this problem. We took if from two approaches. It was really very interesting. One thing we did was figure out how to analyze gas pipelines themselves -- the physical flow, the dynamics, how to figure all about that. The other thing we did is say: "Suppose you can analyze it now. Suppose you had a configuration that you analyzed. Suppose you wanted to change that configuration. The guys that we had brought in as consultants from Princeton were working on something called the traveling salesman problem. I don't know if you know that. The traveling salesman problem is stated very simply: "Find the minimum tour around a set of points and come back where you start with, never crossing anything more than once." They had developed a technique called "branch exchanges," I guess they were called at the time. What they did was they would grab two links, and they'd use certain measures to figure out which links to grad, and they'd exchange them with another two links. It was an iterative process where you were not guaranteed to get any kind of global optimum, but it would converge to some sort of low cost type solution. The argument for the procedure is that it worked. That was it, because it was an impossible analytic problem at the time. What we did was we developed a procedure that essentially we called "branch exchange." I don't know if we coined the term or it came from the traveling salesman problem, but that started out and said: "If you have a pipeline and a pipeline network, and you can analyze it, you then could try to optimize it, so you built within the inner loop of the program an analysis program." We actually did one more thing that was truly brilliant. I had nothing to do with it. We had a consultant from MIT who was one of the geniuses of infernal mathematics, who figured out how to optimize the diameters of pipelines, using real world constraints. It's a very tough non-linear dynamic program problem, and he figured out how to do that. I have a film of it. The BBC did a film, and they flew over a film crew to -- it became a fairly well known type of project in the field. You could take a configuration, a set of gas flows and a set of gas fields, and you could figure out what the optimum assignment of diameters of the pipelines should be. Very meaningful because you could look at a pipeline, a 12-inch pipeline compared to a 36-inch pipeline. The cost of laying is horrendously dependent on the diameter of the pipeline. Tremendous! When you think of a 36-inch pipeline, the way they lay it is off of a barge. They have to lower this thing down into the water, and it's got to be encased by huge amounts of strong material so that it doesn't break when they're lowering it. If they're putting it in 200 feet of water, that's an incredible weight on the pipe itself. What we did was we figured out a way to analyze the system, optimize the diameters, and imbed it in the inner loop of a program, which would then vary the branches and use that doing branch exchange. We subsequently published the computer program, wrote a document about it. Business Week. There were two or three hundred newspaper articles. I've got a press clip book that fat.

Pelkey: When did all this happen?

Frank: '68. It must be '68, because I was there for one year, and I went in the summer of '67 and I left in May of '68. I also met Larry Roberts some way; I don't remember why. I had dinner with him and his wife

and my wife and myself somewhere during '68, and he was talking about some strange thing sounded silly. I really wasn't very impressed, and I promptly forgot about it. Ok? Shows how smart I am. Absolutely tossed it out: "Who was that strange guy?"

Pelkey: Was it just the four of you?

Frank: Just the four of us, though maybe there were two more, I'm not sure. He was trying to hit me up for money. The wonderful thing of being in the White House is you have White House stationery. Nobody knows what power you have. If you have no power or infinite power, it's all the same, as long as you don't tell anybody you have zero power. It's terrific. The best position to be in -- it was a wonderful year. The best position to be in was having no vested interest. I absolutely intended to go back to Berkeley. No vested interest whatsoever. I didn't care if I got fired tomorrow morning, so I could actually do what I wanted to do. I once had nearly a fistfight with a guy, the head of the computer center, in the hallway because I couldn't get computer time for my project. We were actually shoving each other. He subsequently became a friend of mine. He was a fairly well known guy in the business, although I didn't know that at the time. I once captured a computer center -- commando, in the name of I don't know whom. The thing is, I got the project done. One guy they didn't know. He said: "Whose authority is this?" So I gave somebody's name, figuring I'd be out by the time --

Pelkey: By the time they caught up with you --

Frank: Then you fill out your expense form, and I did it wrong. You can do either one of two things. You can say: "Take care of it for me," or "I'll worry about that." If you're a bureaucrat you worry about it. If you're there for a year less a day, you just say: "Take care of it and make it come out right." It was a great project. The idea had been to truly see if you could prove something. We did prove something. Senator Ted Kennedy, at the time, put out a press release saying we saved $300 million for the government. We did something that was absolutely outrageous, but it was exactly the right thing to do. We wanted to be dramatic, so we took all of the gas fields in the Gulf of Mexico and we redesigned the entire gas pipeline system in the Gulf of Mexico, and showed there would be something like a $700 million difference if it had been done using our technique. Of course, it was wrong, because they had been built in stages. We said in our report: "You can't do this, because it was built in stages. Methodologically it is not the correct thing to do, but if you did do it -- " knowing full well that nobody -- you say: "Well, I was misquoted." The point is, what happened was that it made a wonderful example, and it caught everybody's attention because it was a lot of money. It would still be a lot of money. $700 million is a lot of dollars. It was a very big thing. There were a lot of heroes made. The technique was released to industry and literally it may or may not have been adopted by industry. I don't know, because I was never really part of the industry itself. The guy who had set up the group and myself put our heads together and we said: "If only we had two percent or one percent of the dollar savings this program this going to generate, we'd all be rich people. So we decided to form a company. He went out and he finished his year six months earlier than I finished my year. He was also on leave. He never went back and became a professor at Brooklyn Poly and set up in his bedroom a company called Network Analysis Corporation. He was going to be mister outside, I was going to be mister inside running the project, and in May or June of 1968, I showed up after having finished my one year and became the first employee of Network Analysis Corporation. The first contract we got was for designing an agricultural irrigation system, not communication networks. We were pipeline people at the time. It was one of these things where you couldn't have done with it and you certainly couldn't have done without it at the same time. It was a $35,000 contract, and we spent $135, 000 doing it. That $35,000 up front, that was cash flow. The other $100,000 was investment.

Somehow or other, it doesn't have to do with the meetings I had with Larry Roberts, when I met him back when I was in the Office of Emergency Planning. But somehow or other, I got back together with Larry Roberts, and wrote him a proposal to -- I remember the conversation really very well. Arpanet was a four-node network; that's what existed. He had a piece of graph paper on his desk and he was showing me extensions to the network. It was on the west coast at the time. I think it connected to Utah also, but there was nothing on the east coast. He was starting to order (telephone) lines for that, and he said: "I don't know what I'm doing. Just don't know what I'm doing. I'm just drawing these lines. Could you figure

out a way to do this better?" So, we wrote him a proposal, and we got -- I remember exactly when we started our contract. It was October 1969, and we had started the company in May of '68. So it was a fair amount of time that had gone by.

Pelkey: Did much time elapse from your meeting to when you started the contract.

Frank: It was a month or two months. It was very quick.

Pelkey: Do you remember how you and Larry got back together?

Frank: No.

Pelkey: Were you aware of the Arpanet? Or you were aware, although you had forgotten, from the dinner earlier in '68.

Frank: Somehow between the time I had left Washington and we formed the company in New York, because that's where the guy was living, I just don't remember how we got back together again, but I remember going to see Larry. I remember talking to him.

Pelkey: Do your recall if, at that time, you were aware of Arpanet?

Frank: I wasn't aware of it.

Pelkey: So somehow --

Frank: Somehow or other he started telling me about this thing, and it sounded like business to me, you know. Literally, the word 'packet switching' was not used, the word 'packets' maybe.

Pelkey: The way, I think Larry got ahold of you was through Len.

Frank: That's very possible.

Pelkey: Len told Larry about you because they were struggling with this issue, and Len knew that you knew something about this.

Frank: Yeah, that's very possible, because Len had been a consultant for me at the White House, not on the pipeline project. We had a whole series of things that we were doing. We were doing a lot of work on vulnerability of communication networks. I was supporting a lot of stuff. I also started a project that I subsequently did not finish -- somebody who I hired took it over -- for optimizing the GSA Telefax Network. GSA came to us, because of the pipeline stuff that they heard about, and said: "Can you help us?" They sent over some money for us to help them, and I put a crew of people on that, and Len, I think maybe consulted two or three or four days; not weeks at a time. The guys from Princeton actually came for a summer.

Pelkey: Do you remember, during the period at the White House, a General Johnny Johnson?

Frank: I never met him at that time. I know him, but I never met him at that time.

Pelkey: So now it's October '69.

Frank: It's October '69, and we began a crash program to optimize the ARPA network. What that meant was we first built the computer program to analyze it, using classical queuing theory. We then built a program; it was batch processing, by the way. It was a beast, and we were working with a CDC 6600.

Pelkey: You were in New York doing this?

Frank: During New York, right. We were in a Georgian colonial estate on Long Island, when we formed the company.

Pelkey: Whose computer were you using?

Frank: Cybernet Systems, Control Data's timesharing 6600 system. I had been a consultant at the Lawrence Radiation Laboratory when I was at Berkeley. They were numbered models one, two, three and four of the 6600s, and actually the optimization stuff on disks, that I had done, was on the timesharing systems for 6600 that Livermore wrote themselves. I knew a little bit about it, and I guess that's why we decided to go with that. It was a wonderful machine, but also a beast simultaneously. You look at today's technology and you wonder: "How did I ever do anything?" It's like driving across country in a Model-T Ford, and you say: "How did it happen? It couldn't be done today." I hated machines for years and years. I hated it because they never did anything good to me. Everything was to me, but it was never good. Larry had a deadline. It was a real deadline. He said: "I can cancel the orders by this date." We analyzed the configuration that he had given us, and we developed the very first techniques for design of distributed computing systems, which were primitive compared to the ones we subsequently developed, but I would say that within a period of two to three months -- no more than that -- we came back with a design which was something like 25% cheaper and had 40% more throughput than the one that he had come up with. Our original contract was $45,000, I think, and I think it was maybe for a year or something like that. We came back with that design, and of course Larry was immensely pleased, and I think we got an add-on.

Pelkey: Do you recall when you came back to him with that?

Frank: It was probably February. It was a tremendously crash project.

Pelkey: Because by January or February, they were putting nodes on in the east.

Frank: Yes.

Pelkey: Because BBN or Harvard or MIT was the fifth node.

Frank: And we had to tell them which lines to order, and there was a rather long lead time between ordering these lines at the time, so we had to have come back by January or February. I know we started the contract in October, and I know we couldn't have done it in less than two or three months, because it was truly a hard project. We really worked like a bear. Subsequently, we ended up doing all kinds of interesting things. Our contract grew so that by the first year, it was about $125,000 contract. Larry asked us to look at -- well, actually, he would say: "What would you like to do?" I think it was more like that. It was very open. I said: "I'd like to look at the reliability of these things." Of course, that was my pet research thing. And we developed a whole new technology of looking at reliability of networks that is still quoted to this day. I, and one of my colleagues, wrote a paper called On Reliability Analysis of Networks - I. We meant it to be a two-parts. It took ten years or eight years to write the second part, and that's a basic reference in the field today. He then asked us: "What would happen if you extrapolated this to much larger networks?" So we did a project to, first of all, figure out how to design larger networks, distributed networks.

Pelkey: This is during 1970?

Frank: This is '71, '72, in there. The contract grew from 40 or $50,000 to, by '74, it was $400,000. During this time, the questions were: "What would happen if you made it a big thing?" What we did was we took the hundred largest population centers in the United States, built traffic matrices, and learned how to design these things in large networks. We worked on routing technologies. We did the whole family of how you route through these networks, how you design them, what their performance is going to be, how you design it to be reliable, etc. We were publishing a lot of papers and doing a lot of good work. At one point, during the transition when Bob Kahn and Larry were both there, they asked us to look at

how this would extrapolate to defense communications, and we did a study with the DCA providing the data, which we published, called Alternative Strategies for Defense ADP Communications, and that looked at all of the individual networks that the Defense Department was running -- not all of them, 30 or so is number sticks in my mind, it might have been 23. It looked at it overlay, and said: "Ok, here's each of these networks optimized individually, and here's what would happen if you put them all together with a packet switched network," and that became one of the fundamental inputs to the development of AUTODIN II, which is now DIN II. Interestingly enough, we looked at different strategies of procuring the nodes; one strategy being large centralized nodes and the eight sites that ultimately became part of the failed AUTODIN II project, and we also looked at the distributed strategy using ARPA network- like nodes, and showed that they cost the same. It was very interesting. They cost the same, and what you had to do is you had to build up many configurations of nodes, so each node itself looked like a family of nodes with a little network in itself, but it could be in a building, and it showed that the cost of, for instance, 30-node networks, 30-site networks with possibly hundreds of nodes, was the same order as the eight-node network.

Pelkey: Let me go back to '70, '71. You Bob and Len did a paper together.

Frank: Right.

Pelkey: That came out in --

Frank: '72, in the Journal of the ACM -- not the Journal, the proceedings of the Spring Joint Computer Conference, or the NCC, I forget which it was at the time.

Pelkey: When did you start working on this paper?

Frank: '71. It came out in '72, and we started working in '71. Now how we decided to do it I don't remember. It may have been Bob's idea. It wasn't my idea, I don't think.

Pelkey: Did you interact frequently doing this paper?

Frank: It was a miserable experience.

Pelkey: You all share that common view.

Frank: Somebody's idea was to write it over the network, and I had this Teletype guy in my office, and I tried to write this article, and I couldn't write more than two paragraphs in a row without losing the connection or losing something. I proved definitively you couldn't write an article over a Teletype network. So, after fail -- it was terrible. I don't know if you have ever been through this process, but what you want to do is you want to take the lousy thing and you want to put it through the nearest window, except I was on the first floor. I really wanted to see it falling 18 stories and smashed to nothing. That was the ideal. It was ghastly. It would be dark out, first of all, because I couldn't write during the daytime. I had a job to do. So you'd look at it and the periods would start coming up, and you still hadn't gotten more than two paragraphs, so finally I flew up to Boston to discover that Bob Kahn lives without sleep. He doesn't need sleep at all. I've always been an eight- hour person, and today I slept six and a half because I wanted to go walking in the morning. That's ok; tomorrow I'll catch up. Otherwise, by Wednesday I'll be a dead person. Bob doesn't sleep. Never has and probably never will. The longest sleep he's ever going to get is four hours in a row. So there I was, working in Boston. He's also very tenacious. He's a good friend of mine and I really love him, but if he doesn't understand something, he doesn't let up. He's not an 80% person, he's 99.99%, and so we'd go through it again and again, and I'm sitting there, and it's four or five in the morning, and you're thinking: "Bob, I want to go to sleep, I'm numb." We got -- I think Bob and I did the first draft of our sections, and then we sent it to Len. I think that's the way it worked. It was great to be over with, and we've agreed that we're going to write another one in 1992, a 20-year retrospective of what we learned, and it will be a very short one. We learned not to write papers. It was worth it, because what we discovered -- we didn't, I don't think, really think about it beforehand very much, but what we

discovered is that we'd come out using a completely different family of techniques with the same conclusion. The first conclusion was, which, of course, after you say it, if you understand and have 30 years of experience in the field you say of course -- came up with the fact that there is a limiting property about these networks that we called 'Cut Saturation.' It comes from my end of the business. A 'Cut Set' is a set of links that, if you remove it, separate the nodes into two disconnected sets. It turns out that, if you look at these networks in the right way, there will be bottlenecks, and it becomes obvious if you think about it, because if you've got two sets of nodes -- (drawing a diagram) you've got a set of nodes in here and you've got another set of nodes here, and then you have links attaching these. I've specifically drawn it this way. There are some capacities on these links, ok. It can all be the same; it doesn't matter. Clearly, I can't put more traffic across than the sum of these capacities, ok? So now, whether or not it's equal to 100% of the capacity or some lesser number because of queuing networks peak out when you push it that way, this forms a basic bottleneck, and literally, the bottleneck that you look for is the minimum of the family of sets of capacities which separates it, and that will be the first bottleneck to saturate. Now, what we did -- and we discovered that independently using separate techniques.

Pelkey: What were the three perspectives that the three of you brought to the table.

Frank: I was doing optimization. Literally, we were looking at how to add branches. What we would do for an optimization is we would say: "Well, if this is saturated, then the only thing I can do to increase the capacity of the network is either increase the capacities of this, or add another link." Then we developed, subsequently to that, a whole new family of techniques that are the basis for all distributed network techniques, called 'Cut Saturation.' Len and his folks were looking at something called 'Flow Deviation' at the time. I don't remember how we came across the principal, but they were looking at it like a linear program, and they came up with the same thing, and Bob did it by a set of experimentation. When it got articulated, it looked like we were all coming up with the same principal, and it was really very interesting. It was completely different points of view.

Pelkey: All three of you say the same thing. Interesting that you had different perspectives, yet you came up with the same thing.

Frank: Well, you know the thing is; if you find something that is akin to truth, you're going to come up with the same result.

Pelkey: Do you remember if there was some moment of comfort or joy or exhilaration?

Frank: No, just too tired. There's no joy in that. The joy was in seeing it done. The process was not fun at all. It isn't even - - it's fun thinking about it, because I don't have to go through it again, but it was not fun. Certainly, we would do it differently now.

Pelkey: But the three of you became friends.

Frank: Well, I had been friendly with Len before, and I had met Bob. I can't say we were friends. I can't say we were friends after that experience either. Our friendship actually matured later. We were working on a lot of things together. Our involvement -- there's a number of interesting historical perspectives, some of them you may actually end up labeling as sour grapes. Our involvement continued on the Arpanet stuff. By the way, Larry was still there.

Pelkey: Excuse me, one last question, your recollection is you sent the paper to Len and then he wrote his section --

Frank: Right, and then I don't think we got together again. I think we talked . . .

Tape Side Ends

Frank: . . . I think it was just one overnight, and I don't think we slept at all. Let's see, if that were 1971, I was 30 years old, and I could do it at that time. I don't think I could do it now. I like sleeping, and I've realized that if you take two days, 1972 will still be there. So that was that. In terms of our work, it went in three different directions. One direction - - we started this Network Analysis Corporation, we started looking at the properties of very large networks, packet switched type networks, and Larry Roberts and I once went to make a presentation in 195 Broadway, essentially to interest the AT&T to take over the Arpanet.

Pelkey: What year was this?

Frank: It's got to be '72 or '73. Got to be in that time frame, '72. I guess their reaction was a giant yawn. I presented graphs of the economies of these things. Larry started talking about 30 cents a kilo-packet at that time. Those numbers came from our analyses, and we did a whole family of curves that --

Pelkey: Was this after the scenarios.

Frank: The what?

Pelkey: The scenarios, you know, October of '72.

Frank: I can't tell. I'm not sure. We did a family of curves that were size here (drawing on graph) versus costs for given throughputs, and they all showed things like this -- showing that there were clear economies of scale in the technology, and we continued doing the optimization of the Arpanet, so that was an inter-active on-line thing. Larry would call up and say: "I want to add the following four nodes," and we would get some traffic -- I think Len probably did that, but I'm not sure any more how we got it -- and then we would come back with a design. My guys, at that time, were developing the next generation design program, which is still the best network design tool in the business now. It's called GRINDER, Graphic Interactive Network Designer, and subsequently we built that as a truly an interactive graphics program for distributed network design, at a time when nobody ever showed a map of a network on a tube. A little bit later we delivered that to the Defense Communications Agency when the DCA took over the design of the process. It became a commercial product, and it's being used by DEC and AT&T and a variety of other people now. It was the fundamental tool in the business, and we published the whole theory behind it, so that somebody could reproduce it if they wanted to, but the practical techniques of how you make it work in real-world networks, sort of the art of network design as opposed to the theory, and that stuff you could never publish in a journal, because they wouldn't want to hear of it, and at the same time that's the difference between a proprietary design tool and one that's an academic paper. Another thing that we did is that Larry was, at that time, I guess in '71, maybe '72, ruminating about what would happen if you covered the earth with radios and you tried to transmit a message through these radios. He had written a paper on hand-held terminals earlier, and nobody took it seriously at all. He asked the question, and he described a technique for what he wanted, and I went back, and it was a rather informal type of working relationship that you couldn't do in these days. For instance, I didn't have any contract funds or anything for the thing, but I asked my guys: "What would happen if you did that?" I was involved also, so when I say I asked my guys, I was the principal investigator for the project. We showed that all you needed to do was transmit one message and it would saturate the earth, according to the way Larry had described it. It was a good thought; it just needed a few more practical things. He had every repeater repeating. Well, what would happen is that the thing would just repeat and repeat and repeat, and it would end up saturating the earth, so we needed to start putting constraints on it, whatever. We started work on the packet radio project, it must have been -- Larry was still there, so I don't remember when Larry left.

Pelkey: '73.

Frank: Ok, so it had to be in '72 that we started. We were probably as early as anybody else -- I don't think there were any earlier contractors than us, because nothing had been built, and we were investigating the propagation characteristics, not from a point of view of how does UHF happen between two point, but from the theoretical point of how you actually build networks of these things. Now,

something which is not known, and is very interesting -- and this is the thing that is going to sound like sour grapes --is in 1972 or 1973, we built the first local area network as part of this project. What happened was -- we published it in '74, I think. We came up with the conclusion that you can cover the earth with these things, but Larry asked the question, and it was also Bob at that time: "What would happen if you did it in an open environment?" My company at that time was very active in the design of cable television systems. We knew a tremendous amount about cable television systems. We had built -- when we went and formed Network Analysis Corporation, we formed it with 'if only' concept, and we said: "Ok, where is the next large application?" If you remember those days -- you've got enough gray hair so you do remember those days -- cable TV was the thing of the early part of the decade. So we built a computer system to lay out entire cities for cable TV. We automated the entire process. It was --

Pelkey: A lucrative effort.

Frank: No. It cost us our ass. It was a terribly difficult problem. If I recall -- don't forget, we were working on 6600s. To get a run, you had to get 93 batch programs to run together. That was one run through, and there was a combination of human and in- human design processes, and it had heuristics in it. We would go so far as to tell, in our construction maps, it would tell the technicians what gains to set the amplifiers on the poles. The entire city went in. It was a monumental feat. Monumental! We designed --

Pelkey: Did you figure out what programming should be put out on the network?

Frank: There was no programming at that time. It was all distant channels plus all the local channels. We designed -- Canada was more advanced in cable television. We designed a lot of them. We became the turnkey design contractor for Gerald Electronics, which was the largest cable TV electronics firm in the country. Gerald had two kinds of business: bill of materials business and actually turnkey where they did everything, and we became their turnkey designer. They were then building to a fixed price. In bill of materials -- our thing was an optimization program that minimized the cost of the system that generally involved minimizing the amount of electronics in it. Therefore, bill of materials -- optimizing bill of materials would only reduce Gerald's price. It was only turnkey that made sense for them, but what we were competing with was that the manufacturers conventionally gave away design for free, and the market was a very unsophisticated market, where the cable TV businessmen at that time had basically come off of telephone poles. They had very long arms and lots of hair. Because of that experience, we knew a hell of a lot about cable, and when we were asked to say what would happen if you put this packet radio technology into an urban or suburban environment, the first thing we looked at and said is that: "After a certain time, you're better off putting it on cable." So we did a family of analyses of packet radio on cable television systems, coaxial cable television systems. Then we got to a certain point, and we said: "There's only one step left, and without it, there's no point in talking about it more. We've got to build one of these things." So what we did was we ended up building -- we wired our building with cable television, and we built what may be the first packet radio . . .

<div align="center">**Interruption in the interview**</div>

Frank: . . . We built a repeater. We built an actual bus interface unit. We subcontracted with somebody from the University of Hawaii, but it had the full Aloha protocol in it and everything. It was built on a Nova computer, and it was in a box this big. We built the first LAN, using Aloha protocols. It ran in our building, and we published some articles on what happens when you stick packets into the guard band of a TV signal, and that's a good place to put them, by the way. You put them in their own channel, and cross-modulation kills you. If you stick them in the guard band, the TV receiver has wonderful suppression capabilities right there, so that's where you want to put them. You don't want to give them clear space. We built this thing -

Pelkey: This was in '72, '73?

Frank: '72, '73. Published the papers in '74.

Pelkey: Where did you publish the papers?

Frank: Transactions on Communication Technology. Ivan Frisch, who was one of my colleagues at both Berkeley and Network Analysis Corporation.

Pelkey: Now, Abramson built AlohaNet in '70, '71.

Frank: Yeah. He was part of the original packet radio working committee.

Pelkey: I haven't interviewed Norm yet, so I don't know enough about those dates.

Frank: Aloha already existed, and Frank Kuo and Norm Abramson were part of this original working committee, which I think BBN was on it, they were on it, Bob was the one who actually led it, and Bob Metcalfe participated for about nine months or a year. The sour grapes part is that Bob got a lot of his ideas from the working committee, including -- I don't know this for a fact -- but when he went to Xerox PARC, he already knew about the fact that you could put these things on cable because we had already discussed it with him. That work is never referenced anywhere. It doesn't matter, that's history, but it's very interesting. That was when -- and it wasn't our idea, packet radio -- it came out of the packet radio group. Our idea was to put it on cable. We actually built it. Then we looked at it and said: "What the hell do you do with this thing?" It was one megabit, by the way, at the time. We built a one-megabit packet radio bus interface unit that went on cable.

Pelkey: What happened to that?

Frank: It became a paperweight, I believe. It was a monster. It cost a lot of money. What do you do with a thing like that? It wasn't until the invention of the microprocessor -- putting them on minicomputers was absurd. It required another generation of microprocessors before that became a truly viable type of technology. We looked at each other and said: "There's something here, but certainly we can't do anything with it," and it sat around. It literally was a one-megabit paperweight, the first one in history.

Pelkey: Was that funded by ARPA?

Frank: That was funded by ARPA.

Pelkey: Did you meet Norm and Frank during this period of time?

Frank: Yeah, I met them as part of the ARPA packet radio group. Whether I knew them before then -- I did know them before that, because I know we had been out in Hawaii when I was back in Berkeley.

Pelkey: So you met them when you were at Berkeley, but --

Frank: I didn't know them, really; I had met them.

Pelkey: When did you get involved in the packet radio group?

Frank: The very first instant that -- Larry had asked some basic questions right at the beginning.

Pelkey: You started an ARPA contract in October of '69, so it was shortly after that that you got involved in that?

Frank: No, it had to be '71. Larry was still there. It was late in Larry's tenure, rather late in Larry's tenure, and it was before there was a working group, as a matter of fact, that we got involved. We got involved first in some analysis of routing strategies and whatever. I had a mathematician working for us that did a giant piece of work on combinatorial routing and these kinds of things. Then we helped, through the working group, we did a tremendous amount of work in helping develop the original packet

radio routing simulations, the concept of central station, the initialization procedures; that whole thing was basically our theoretical work. We built a packet radio simulation system on top of that that was a fairly elaborate simulation system. That had to be '74 by that time. On top of that -

Pelkey: When did you become aware of Metcalfe's Ethernet at Xerox PARC?

Frank: Much later. There was this whole blackout period when nobody was talking about it. It was not really viable in the early '70s from a technology point of view. Then I guess I became peripherally aware of it, and I guess I became really aware of it in '77, '78. That's when it became of real interest.

Pelkey: So, after Larry left DARPA, IPTO, you were getting heavily involved in NAC, in terms of all kinds of other projects and growing NAC.

Frank: Right, sure, but I was still principal investigator on the ARPA contract.

Pelkey: Ok. Until '75 when it got handed over to DCA?

Frank: No, you see what happened was that the Arpanet design got handed over to DCA. Our ARPA contract went until about '77 or so. What happened was we did one more really interesting thing. Around '74, people were starting to talk about packet voice, and I guess this started around '75. We started a project that was two years in scope. I had about 20 people working on it.

Pelkey: Twenty people at NAC?

Frank: At NAC working on the thing. It was to look at the economics of switching technologies for voice and data. We worked with the Defense Communication Agency for databases and things like that, and they were also the outside reviewer of our work. Over the two years, we did what is still today the definitive study on switching technologies for voice and data, and we analyzed packet voice. I think we published it in '77, at least in report form. It was more like '78 or '79 that it came out into the literature form, the IEEE Proceedings had a special issue on packet switching, I think in '79, and we had a paper there. What we did was we demonstrated that integrated packet voice systems were more economical than classical circuit switching for voice. We looked at three technologies. We looked at packet switching for data; we looked at packet switching for voice; and integrated packet switching. We looked at hybrid switching, that were switches that were both packet and circuit switches, and we looked at circuit switching for voice and packet switching for data, and of course circuit switching for all of them, and built, based on DOD type traffic, built a complete model of the whole thing, including models of the computers and switching and the transmission tariffs, and sort of built this huge design model that -- I don't think anybody else has ever done anything like that. DCA was our reviewer, and I think the project took two years, something like that. Interacted with AT&T. They had interest. This was after the project was done. Kept it kind of quiet up front.

Pelkey: And you completed this around '76?

Frank: I would say closer to '77. Started in '75, completed it in '77 I think. I may be off by one year. May have been '74 to '76. I think it's more like '77. It became the definitive treatment. That was the last major thing that we did for ARPA. What had happened was, well two things: Bob became director of the office -- must have been '76. Was that when it was? Ok, definitely then we completed it in '77. Bob became director of the office. I sort of became too busy, so I assigned it to somebody else. Bob also assigned the contract to somebody else. They didn't get along, and I didn't know that they didn't get along. It just sort of tapered off; plus the fact that the thing was becoming much more structured, and a lot of the creative energies and creative work that we were doing was really no longer the opportunity that was there; plus the fact that Bob and I, during that period of time, from the time of '73 to '76, had developed a personal relationship, so we would sort of go off somewhere and we would talk about problems in networking. We would do this once every three or four months. Out of that would come the next proposal, and it was addressed towards meeting their needs, and the fact we had invented a lot of good,

sound research on our part. Bob didn't have time to do that, I didn't have time to do that, and the people that were our designees never could have done it, whether they wanted to or not. I don't think that they wanted to, but they couldn't have even. So I think we probably did our last work for ARPA in '77. By that time Network Analysis Corporation was -- if you look, the ARPA contract, the last year had been something like $2 million per year, so it was a sizeable contract. It also -- even the Network Analysis Corporation -- no it couldn't have been $2 million a year. It could be a million dollars a year.

Pelkey: How large was NAC at this point?

Frank: NAC was about $2 million a year.

Pelkey: So it was about half the business?

Frank: It was about half the business,

Pelkey: Yet you were so busy that you could just let half your revenue just flitter away?

Frank: Yeah, because we were replacing it now. For instance, in '79, Network Analysis Corporation was $4.4 million, and it had no ARPA business.

Pelkey: You were president of NAC?

Frank: I was president.

Pelkey: The other founder who --

Frank: He was gone after a year. He was the guy who was the supposed-business person. I became president in 1970 of Network Analysis Corporation. At that time I had no money, no contracts, and no prospects of either money or contracts. So he resigned.

Pelkey: Did you want to be president then?

Frank: Oh, it was terrific. My first act was to tell half the people they were fired. There were ten people at the time. My second act was to tell the lucky survivors that they were going to have to go without pay for an indefinite period of time, and the company was not going to build debt. They would not be owed the money. They were just going without pay, period. We went like that for six, seven months. We ate off the credit card because you didn't have to pay that right away. At least that's what my wife and I did. One thing we did pay was Checking Plus because you got the money back, minus the interest, so that was the only bill we paid. We went deep into the hole, but it was all worth while. We went after the cable TV business in '75. It was the best early decision while I was learning about the business that I made, because we had gotten the program to the point where it was really a brilliant program, but we were competing against free goods in an unsophisticated marketplace, and I decided that it was the wrong thing to do, and I had the feeling there was a prospect of a downturn coming. Not only that, the downturn did come, so I made a decision. It was a renewal time for a contract, and it was a half-million dollars a year, with Gerald, and I turned it down, and went out of the business. We were probably, at that time, doing a million dollars a year, of the million and a half that the company was doing, and within 12 months I replaced all that business with commercial telecommunications work. That's when Network Analysis Corporation really became a classical telecommunications group. Before that, our --

Pelkey: This was what year?

Frank: 1974, '75. Before that, our work was in the cable television business, plus ARPA, plus occasional commercial clients. That was basically it, and ARPA was definitely the largest customer we had.

Pelkey: So, its '77 now, and as of '77, your revenue was all commercial?

Frank: No, we had other government contracts. There was about 60% commercial and 40% government.

Pelkey: When did you sell to Contel?

Frank: 1980. Control Data had approached me, by the way, in 1976. We had a deal, and we came within 12 days of closing. What had happened was I negotiated with Bob {Robert M.} Price. When he came in to room, he said: "How much do you think your company is worth?" I said $6 million. We were doing two at the time. He said: "Well, I think my company is worth $54 a share, and it was selling for $35 at the time." So we made a deal. They were going to buy our company for $6 million, with $54 per share prices, but two years hence, if it weren't at $54 per share, they were going to make up the difference. It was doomsday for that deal, because the second we signed the letter of intent, their shares started dropping, and when they were $11 a share, Price chickened out. Subsequently -- of course, you can't forget about something like that, so I would look at the price per share, and I calculated we would have been the largest single shareholders if the deal had gone through. We would have had about 5% of Control Data if it had gone through. That's where their prices were. Then Xerox made a tentative try in 1978. We became -- do you remember X-10? It was a radio communications system that was going to connect up the United States for office automation and -- it was the beginning of cellular radio. This was a cellular data radio system. Network Analysis Corporation was seminal in the development of that. We were sort of classified contractors to Xerox for a year in 1977, and apparently the idea for that came out of a talk that I had given at a Frost & Sullivan conference on opportunities in communications. I talked about using radio transmission, a la packet radio, to link data communications terminals, etc. A couple of guys were at that meeting and they heard it. They went back and they sold management at Xerox Development Corporation the idea of actually funding this, and Xerox made a major attempt to build this thing, and they mismanaged the project horrendously, like many of the things they do. They killed the project in '78. We also did a lot of work for AT&T on the Advanced Communication System (ACS). If you recall, they announced a delay around 1979, saying that ACS would be delayed by a year or more. We did a very interesting project. There was nobody better in terms of network technologies, of topologies, and analyzing whatever it is, and we had gotten it to the point where we could -- it was not quite automated in the true sense of the word, but it was truly a reproducible technology that had lots of tools along with it, and we did a study for AT&T that looked at a variety of customers, and looked at their network needs and showed how to service those needs using a half a dozen different technologies, and we had to design a network for each one of those things. It was a horrendously complex project; a lot of hundreds of thousands of dollars of work which, for a consulting company, was a big piece of change. We showed that the ACS was going to be twice as expensive as the next lowest competitor, and about four times as much as the best way of doing the technology. I remember during this snow storm, 7 in the morning, and I gave a presentation to a bunch of high-level people at AT&T, and showed this, and a month later it was announced that the project was going to be delayed for an indefinite period of time, and subsequently that thing died because it was an engineering abortion, and it was not a market oriented approach to the thing. Bob said one thing to me at once time, and it must have been '75, '76. Now I remember. Our largest contract was about $500,000 a year, not a million dollars a year. He said: "You are the best contractor we have in the agency, and you're a pain in the ass, because every year we come up with problems and every year you solve them, and to keep you going, I got to give you more problems. Whereas," he said, "you look at BBN. They're ok. They keep going and going. They're running and building these things. They don't have to; there's always another year's worth of work. I don't have to think very hard about giving them the work." Whether it was that minute in time or that was an input, I decided we were in the wrong business. We really were. We were in the high intellect end of the business, where you had to really be smarter than your customers, and with people becoming much more sophisticated that was entirely too difficult. I didn't know anything. When I got into the business I knew nothing about anything in terms of business. I was an expert, therefore. An expert is somebody who knows everything about everything, but nothing else. I knew nothing about nothing. That's the same point on the continuum; you just reach it going the other way. At some point in time, I realized we were in the wrong business, but because I really didn't know enough about business to know how to get into the right business, there was just this comfort level. I was trying to always grow the company, and it was --

Pelkey: Getting harder and harder.

Frank: It turns out, by the way, that nobody has built a telecommunications consulting company half the size of the one that I did, if I throw inflation on it. There's nothing like it even today in the marketplace. There are $4 million companies, but we would have been a $10 million if you looked at our last year's revenue before we sold to Contel, it was the equivalent of an $8 million company now. We did a couple of things. We packaged our design tools, and in 1978, we began selling software as a design aid. In 1979 we established what we called the NAC Systems Committee to figure out what kind of new businesses we should go into, and we picked local area technology. I believed it then, it is obvious now, that was the seminal advancement of the 1980s. We started investing a substantial amount of money - - to us, as a $4 million company I think we invested $100,000 in 1979. By the way, NAC did $4.4 million, and it made $440,000 pre-tax, after investments and development and technology and introducing the tools and all the rest. I was hunting business, and in fact, I didn't even write the original letter. My VP of Marketing wrote a letter to Bob LeBlanc, who was the vice- chairman of Contel at the time, and it just so happened that we knew a lot of the same people, and we wrote the typical love- letter thing: "It looks like you're doing good stuff and we're doing good stuff. Maybe we can help you. We know a lot of the same people. Maybe we should have lunch some time." Wrote that in September of '79, and then I promptly forgot about it. I just forgot completely. I just forgot it. I remember, I went off to a telecommunications congress in October, and I came back in November and there was a telephone call from Bob LeBlanc. He said: "I'm waiting for your call. I haven't eaten yet." I'm not kidding. That's what he said. In December of '79, we had breakfast, and we started talking about what they were trying to do and what we were trying to do, and I wanted to become a systems company. It was one of these things where the all the vibes were the right kinds of vibes and the comfort level was there, and within -- let's say the breakfast lasted three hours, which it probably did; it went from 7 o'clock until 10 in the morning -- at the end he says: "Would you be receptive to an investment by Contel in your company?" I said yeah. If you say no, there's nothing to talk about after that. WE then got together again, and I guess we got together in January. We got together with Bob and with the Vice President of Corporate Development at in our offices in Great Neck, and the conversation was the kinds of things we could do together. I started really thinking about it, and it was obvious that the only really logical thing was an acquisition, and in February I sat down, and it was really funny because, when you open your mind, you generate ideas that didn't necessarily exist one minute beforehand. Before, my goal, in the early '70s, was to get to the end of the day. That was my time frame, and it literally, at the end of the day, I looked at the bank account, and it was still -- when I inherited the business, it was negative $40,000 net worth, so all I had to do was whatever came in went out as long after it came in as I could possibly make it, and I managed cash flow. The very first year we did $220,000 and we made $2000 profit, and the next year we did $330,000 and we made $3000. Then we did $450,000 or so, and made $23,000. My time frame, somewhere in the '74, '75 period changed from the end of the week then to the end of the month, and then the year. By '77, I was thinking about next year, but not the year after that, because it was silly. I wasn't going to spend a dime on the year after that. I was still operating on the philosophy that if I take 12 months, and I have all positive numbers, I'd have to have made money at the end of the year, or if I had one parentheses, I didn't necessarily make any money, so I could never have a negative month. I had no money. I had nothing to fall back on. It really is amazing, because there's one seminal thing. He says: "Ok, what if you had money?" All of a sudden, I became a strategic planner. Within 24 hours, I was a strategic planner.

Pelkey: Remove a constraint.

Frank: I presented -- I've got the document. It's one of the few things I kept: the Acquisition Business Plan. This is a $4 million company. If we became part of Continental, we would built a systems integration company, focusing on local area networks, real-time communications systems, data communications, the interface between the DP and the communications business, and build a $100 million in the sixth year -- and they bought it. They didn't believe it, it subsequently turns out, but they bought it. In February -- in April we had a letter of intent, and closed the deal in June of 1980. It was just interesting, because we never had the luxury of thinking about 1985 or '86.

Pelkey: When did you leave Contel?

Frank: I left Contel in April of '85.

Pelkey: And when did you start NMI?

Frank: Formally started in August of '86.

Pelkey: I presume that NMI at some level is pursuing what you conceived of in the late '70s, which is this—

Frank: Not really. If you're looking at how ideas come about, I think there's an interesting moral with the thing. With Contel, I had a "straw man" strategy that said the first thing you do is you get bigger in your area. Within three months of being acquired by Contel, I realized that was exactly the wrong strategy. Really what I wanted to do was, instead of building to my strengths, I wanted to correct my weaknesses. If I'm going to be a systems integrator, my biggest weakness is implementation. I didn't have an infrastructure to implement. I had a bunch of people who knew how to design things, so I went off and I started shopping for a company that was a software company, I real implementing company. I found a company that also had done $5 million in business the year before, and acquired it in '81. The organizational dynamics of making an acquisition like that were interesting.

Pelkey: What organization was that?

Frank: It was a company called International Computing Company, located in Bethesda, MD. We were located in Great Neck, NY. I acquired the company in August -- it's funny. It was April that we signed the letter of intent, the exact same time I was in Paris, at the time, with the chairman of the company, and we closed it in August. We decided that the thing to do was that we couldn't afford the year of planning how to merge two companies, so I smashed the two companies together like two halves of uranium in a nuclear -- to get a critical reaction. I merged them on January 1st, 1982. Going into -- well, in '81 NAC had $5 million in revenues and ICC had seven. So going into '82, we had two little companies that added up to 12, but it wasn't a $12 million company. It didn't have the infrastructure. We came out, we did $18 million in '82, $25 million in '83, $37 million in '84, $55 million in '85, and the company did about 85 - $90 million in '86, and did what we said we were going to do.

Pelkey: Very impressive.

Frank: We had negotiated a buy-out deal with Contel that changed a few times, but it always had one characteristic that remained the same, that we would get a multiple of future earnings, less the cost of capital, for any of the acquisitions or investments that Contel made for us, and I guess when we first negotiated that buy-out, that sounded ok until I realized what the cost of capital was. I was paying 12% after taxes. I paid $8 million for ICC, so I literally have a million dollars after tax earnings to break even on the ICC investment. Then, any money that Contel advances in terms of equity was also that way. So I did the entire thing; I took $5 million of equity from Contel and $8 million for the acquisition, so I brought it to that size with $13 million in capital investment, plus $3 million in cumulative profits that I sent back into the business, which then converted to losses. My deal was that we were going to get all of our returns were going to be based on '85 and '86 earnings, so my strategy was to earn nothing, or as close to nothing as I could possibly get until then. Actually, I had written off '85, because really, I said: "Do one blockbuster '86," and there was an averaging effect that would have protected us against a disastrous '86 if we had a couple other good years -- but our strategy was -- you can't turn a company in a year. It's too hard. Therefore, my goal was to make money in '85, and our budget was $3 million in '85 and I think we made about five. I wasn't there for the whole year, so I don't know; then to really have a 'bonanza' of a year in '86. What happened was that Contel wanted to reorganize, and they needed to be able to merge my company into another group, so therefore the entire buy-out arrangement was activated in January of '85, January 1st. We negotiated it in the late fall of '84, so I sold all my stock, and I got a nice check on January 2nd of '85. As part of the reorganization, there was going to be a new Executive Vice President in charge of a sector called Networks and Systems. I was the internal candidate for that, and they brought in somebody from the outside, somebody whom was truly terrible. One month later I discovered what it's like to work for a truly terrible person, and I left.

Pelkey: There are a couple of perspectives that I'd appreciate. During this period of time, you brought to this industry this process of network planning, in terms of big networks. It is and will continue to have a very dominant influence on the industry. During this period of time, you saw the perspective of organizations change, in terms of attitudes about networks. Why did that change take place and what were the driving forces, focusing on data communications, how the switches in the technology and the user perspectives. Networks are perceived as being strategic, but that wasn't always the way it was.

Frank: No, it wasn't. I've done a lot of writing about this and a lot of thinking about it, so I think I at least have a position. Whether it's the correct position or not, nobody will know. I think there were a variety of factors. First of all, if you look at the '70s; do you remember the story I told you about getting this article written on the machine? It was too hard. The things didn't work in the '70s. You spent your entire lifetime making them work, not using them. Among the things that we did was to look at how you plan these things, and planning -- when I started, in the early '70s, planning was: "What kind of modems do you pick?" By the later '70s, we were looking at organizational plans, but the first part of that was: "You should get a utility of some sort." It was only until the early '80s, or even just like now, that it became possible to actually assume that the damned things were going to work when you put them in. There was no way . . .

Tape Side Ends

Frank: . . . to become strategic -- I think that's the first element of something to be strategic, it's got to be able to be routine. If it's too hard, it's never going to be strategic. I think, also, during the '70s, there were a few examples of the strategic application of this stuff, but nobody knew they were. It just wasn't apparent, and it took -- I remember in 1979, we did a course for McGraw-Hill, one of these three-day seminars, called "Strategic Application of Communication Resources" or "Telecommunications as a Resource for Management." That's what it was called, in 1979. It was in San Francisco, and I was amazed, because there were hundreds of people. It was amazing. I had never seen that many people come to a course on networking before. At that point, there was a realization, but everybody was asking the same questions, and everybody always had the exact same comment at the end. "Gee, I wish my boss had heard that talk."

Pelkey: At this point in time -- in '76, SNA was introduced.

Frank: Right, but it was a laugh and it was a joke until about '81.

Pelkey: What was it that these people were concerned about? What were the issues to them?

Frank: They were beginning -- one of the issues was the multiplicity of choices, and they weren't officers of the corporation. They were MIS, or most likely, the highest-level communications executives, who were still rather low level. They were groping, and the more adventurous ones were the ones where they were starting to worry about: "I've got so many choices, I've got to be able to do something -- "

Pelkey: But what choices did they have at this point in time?

Frank: They could still have lots of carriers. They weren't thinking details of bits and bytes. They had lots of carriers, lots of architectures. Each of the vendors was providing architectures now, with DEC-Net, SNA-Net, etc. They were Net, Net, Net and Net. You had SBS. X-10 was making noise. ECS was making noises, and a variety of other carriers like that. They were all sort of groping. Then there were the consultants, and the magazines were all writing about integrated voice and data systems and things like that; over-layered on distributed processing, and there were just enough things that they started worrying about planning now, where planning was still technological planning, but it was the first attempt at a planning type function in what had been a very reactive function before. This was the late '70s to early '80s.

Pelkey: It was because there were so many choices, which were a result of all the different carriers out there and each of the manufacturers starting to announce their grand networking schemes. The questions were: "How do I make all this stuff play with each other?"

Frank: Nothing ever worked with one another either. Everybody had multiple networks of every sort. They still do. The problem hasn't changed in that regard, so I think that was the second input, multiplicity of choice. The third thing was that there is a cycle. The cycle goes as follows: A few consultants discover a term -- this is a very narrow type field in that regard -- a few consultants discover a term. They start lecturing about it. The trade press picks it up and starts writing about it because it's new and novel -- it doesn't exist, by the way, but it's new and novel -- and then people start talking more and more about it. The second tier of consultants start doing it, and all of a sudden now you see, because the conference circuit desperately needs to be fed because it's very tough to get new topics and they start picking it up. This happened in the Strategic Applications of Communication Resources around '83 or so. Hardly anybody is doing it, and the ones that are doing it didn't know they were doing it, but now, because you need to talk about it, you start looking for examples. Then you find examples. Everybody finds the same three examples, it doesn't' matter who it is, because that's all there are. Now, all of a sudden, everybody keeps saying: "I wish my boss had heard that." That's the refrain of the 1980s and '70s: "I only wish my boss had heard that." But now, because they are all trying to become business people, since that is part of the next step in this maturation process, and the technology is getting simple and the overlapping alternatives are getting to be more understood --

Pelkey: Excuse me, when you say simple, simple in the sense that --

Frank: It works. That makes it simple. Sticking in a 2400 bit per second modem in 1972 was hard. Putting in a packet network today is about the same level of difficulty, even though there's a much more complex base of technology under the packet network. You get the positive collusion of consultant, trade press, and conference circuit in areas where there really is something. There are lots of things that just die, but in areas that really have some promise, it generates this wave, and that collusion occurred on a technical basis in '82 to '84 or '85. Now, another interesting phenomenon has happened, and it really points to the maturation of the process. You get a few business people, like Michael Porter and that whole crowd, who discovered this thing, and they've now made it respectable from a business point of view. That's the difference between the how the '70s worked. They have to keep feeding their own voracious appetites for clients, so now they've done it. Then you find Peter Keen getting an institute set up over here, and you find the schools all talking about it. The essentially technical consulting and the technical trade press and technical conference seminars really did do it. I was one of those at the beginning, and what I discovered is that I had an hour's worth of material. I ran 55 minutes, I was in great shape, I could take questions, and if it was an hour and five minutes, I had them hung for five minutes. So I went back and tried to learn more about that and that has become my specialty now.

Pelkey: So what you went through, on a simplistic level, is that in the early '70s it didn't matter because there were so few networks and the technology was archaic. It wasn't until the mid '70s that there were enough building blocks; minicomputers starting to be used and intra-company timesharing applications. You started to get statistical multiplexers that people could buy and use. Modems started to become reliable. There started to become lots of alternatives. People had to start to think about networks because you had DDS that was announced and you had all these modem/statmux solutions. Things were going very rapidly. Then, in the late '70s, all the major manufacturers are starting to announce networks. You went through a period in the '70s in which the technology was starting to gain acceptance at a very elementary level. Toward the end of the '70s and beginning of the '80s, people started saying: "Wait, I have to make all this stuff work, because things are starting to become real, more alternatives are starting to take place." Now, it has become fashionable on the business side to be thinking --

Frank: Becoming fashionable. It's not fashionable yet.

Pelkey: Becoming fashionable. They're thinking about strategic networks within their companies.

Frank: I don't think it'll be really fashionable until the early '90s at the business end. It's evolving, but we're nowhere near where recognition of computing technology is now for networks. Interesting observation. The Conference Board tried to put on a seminar on this stuff about two years ago and they cancelled it for lack of interest. I bet you that if they put it on now, there would be plenty of interest. I'm going off tonight to give a talk to the Unisys Board Room series on this topic, to senior executives.

Pelkey: At Unisys.

Frank: It's in Florida, and sponsored by Unisys.

Pelkey: During this period of time, this concept of communications moved from being the techie down in some department somewhere to moving to the central information officer, the CIO --

Frank: No, he's still an illusion in a lot of cases.

Pelkey: But they're starting to move up in terms of higher visibility --

Frank: Moving up -- the merger of the DP and the Communications Departments are an important function of that.

Pelkey: And that's in the process of happening. That began in this '83 to '85 time frame.

Frank: Yeah, some of the more advanced companies did it a little bit earlier, but according to the statistics that seem to always crop up and always give you the same answers, therefore they're probably at least indicative, is about two-thirds of the departments in the country have now merged. They either are one department, or they both report to the same individual. I think there's like one-third that are one department, and on-third report to the same individual.

Pelkey: Now, another critical thing that happened -- some people were aware of it because of alternate carriers, but clearly deregulation, post '83, really did make a difference, because now there was no end-to-end service. Before that, Ma-Bell could take care of you end-to-end, and all of a sudden there was no end-to- end service available in the United States.

Frank: And that's where -- when you asked me the question of why the idea of Network Management comes out of the 1970s, it doesn't. The idea of Network Management Inc., as a company, is a reaction to two things. One thing, I believe it has become easy to build networks, but networks have gotten so big that the really difficult part now is running networks. That has become the problem of difficulty, the process is not a well understood process, and the tools for doing that are, in a computer sense they're certainly not here, but in the human sense, the procedural sense and an organization sense, they're also not here. There the break-up of the Bell System was a giant enabling impulse that accelerated the process. It started in government very quickly, which is why we acquired a Government Service Department person, because we actually had network management contracts, and I believe it will lead to the same sort of marketplace in the commercial end.

Pelkey: Systems integration, to me -- if a company is in the networking business now, if they don't have systems integration skills, they are not going to be a major player. And there aren't very many systems integration companies around.

Frank: No there are not, and in fact, the idea of Network Management Inc. -- I went to work in the venture capital business after I left Contel for about 25% of my time, and I was sitting in a typical Monday morning meeting and a fellow walks in with a report under his arm by H&Q called Systems Integration, the Next Frontier. It was a 1986 report, and I leaped at it, because my interest is systems integration. Within that same week, a couple days earlier, I had been in a Broadview Conference where every third word out of Harvey Poppel's mouth was 'systems integration.' Something else had happened at the same time, to the point where I looked at it and said: "This document from H&Q, the first two- thirds of it looks like my

1981 business plan, and the last third are a bunch of incorrect recommendations on how to buy into the marketplace." Therefore, I finally discovered the market. It's on Wall Street. You could buy and sell these companies, and you can sell only to large companies that need to be in the marketplace, or to Wall Street, and that was where the idea for Network Management Inc. came.

Pelkey: What venture group were you with?

Frank: Personal. I was spending 25% of my time. When I left Contel I stayed on a retainer with Contel for a year. I sold two companies for them. I did a little strategic consulting with a couple of large corporations, and I started that. I really didn't commit myself, but I wanted to learn the venture business, so we put together NMI, in the summer of 1986, the idea being to build a systems integration company through acquisition, but focused on the network management business, the care and feeding of networks.

Pelkey: It's a great idea. Now, it's my belief that, for the next five or ten years, we're in this phase where it's not technology driven. It's user driven, and the user is saying: "Help. This is too complex. I can't hire people to run these networks because there aren't enough people around who can do it. I got 50 different vendors providing me 50 different -- I want one vendor to deal with all of this network management nonsense. Over this period of time, we'll start to develop more and more talent, and the vendors will start to provide these solutions. Then, the user will go back to wanting to buy the best solution, not the total solution. They'll start to look at optimizing any one purchasing decision, as opposed to saying: "I don't care. Just make it easy." My sense is that the next wave of technology that will come in is one that you worked on very early, which is fast-packet technology.

Frank: But it's coming, in the sense that --

Pelkey: But there is none today.

Frank: Well, you look at the guys that do the packet multiplexer, Stratacom.

Pelkey: But that's a compression technology, as opposed to a distribution technology.

Frank: Right, but that's one of the real advantages of the packet switching, it's a superior form of TASI. There's lot's of gains to be gotten out of that.

Pelkey: But you don't create a network in which packet voice goes from one node to the other.

Frank: No, but AT&T is reportedly building that technology right now.

Pelkey: Right, but that next wave, of which I presume AT&T won't be a leader since they're never a leader in anything. But packetizing voice and data over the same networks will be the next technology wave that will be profoundly important, and at the local level, if will be FDDI, just higher speeds.

Frank: I agree with you. It could come relatively soon from a technical point of view, because it's relatively easy to do right now, and you've got this whole new wave of little start-up companies like Netrix who can build switches that will make it work.

Pelkey: Yeah, but Netrix isn't that.

Frank: No, it's not that, but the technology level in the switches --

Pelkey: The technology level is having complex chips; it's getting enough semiconductor chips to do fast packetizing, you can't do it in software. You've got to do it in hardware, and we're starting to get hardware at the clock rates and with the cost to implement that. You can start to do these kinds of things.

Frank: Now, where it will go -- and our prediction in '77 or so when we published -- I guess the first article that we published was in Data Communications Magazine on it, before it was published in the IEEE -- I think it will go into the private corporate network first. We said that then and I still believe.

Pelkey: If you're not playing in private corporate network these days and haven't been for the last three years, you're not anywhere where the business is growing.

Frank: Also, you can't put it to the public switched network because you've got the issues of compatibility and investment and the effect of the long range planning cycle for the telephone companies and for the switch manufacturers is too long.

Pelkey: I also believe that the ISDN is going to end up being cost pushed.

Frank: ISDN is useless.

Pelkey: Absolutely, and until there gets to be a broadband ISDN. Channelized ISDN is a joke.

Frank: One of our groups just finished a study for somebody, who's got to remain nameless, and looked at everything that's coming out with ISDN and the economics of it. It is completely worthless for any corporate type use.

Pelkey: It's incredible, because clearly the RBOCs ought to be worried about fiber-optic in the local loop and the distribution out to the end-points, and when you start to thing about that, and the amount of capital required to do that and the amount of capital they're going to put into this ISDN switches, plant and equipment, they're going to take them out of the marketplace for so long, in terms of implementing the next solution, and ISDN is the wrong interim solution to be investing in. It's going to take them 20 or 30 years to get it in place, and they'll persist because they don't understand.

Frank: I understand some development plans and test plans are being changed right now to accelerate the development of broadband ISDN, and to skip --

Pelkey: It has to be.

Frank: I think that's being discovered now, as we speak. One of our guys made a major presentation last week to the appropriate people --

Pelkey: It's a major, major faux pas on the part of the telecommunications infrastructure in this country.

Frank: And the thing is, it's been relatively well known for a while.

Pelkey: I know. You have been very helpful. I have thoroughly enjoyed this, and you've given me great insight into some of these concepts.

Frank: It's also been remarkable because it's been accidental. If I hadn't gotten that call from the White House, I'd still be teaching at Berkeley.

Pelkey: I have to tell you the number -- of every industry in data communications -- of someone knowing someone and something being accidental, it's everywhere.

Frank: Well, sure. If you look at my seminal event, that was the first -- well, there was one earlier, but then the writing the letter to Bob LeBlanc and maybe one or two more, and everything else was a lot of hard work in between, and then huge step functions and hard work. Linear progression between huge step functions, which is I think the way of life.

Pelkey: And it's the way of this industry, and understanding that concept and how the first step functions take place is critical.

Frank: By the way, my footnote to history, just to make things complete, is about a year ago, I was called by the chairman of Contel and asked to join the board of Contel, and I've been on the board now for a little bit over a year. The fascinating thing is that I had left Contel on April 17th or 19th, I can't remember, and I was asked to join the board on April 17th or 19th, two years later, within one hour of the time I had left the company. It is truly ironic.

Pelkey: Thank you very much.

END OF INTERVIEW