Interviews of Lawrence G. “Larry” Roberts

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START OF FIRST INTERVIEW

[Editor’s Note: This is the first of two interviews by James L. Pelkey of Larry Roberts. This interview took place on June 17, 1988.]

James Pelkey: You graduated from MIT in 1962?

Larry Roberts: Ph.D. in '63, actually.

Pelkey: As I understand it, on your dissertation day, you took your dissertation along with Leonard Kleinrock and Ivan Southerland.

Roberts: Yes.

Pelkey: That you had to demonstrate your thesis together.

Roberts: Well, it was all in the same time. I don't know about the demonstration. Ivan and I worked alternate nights on the computer. We were using the same system.

Pelkey: You were doing a hidden lines thesis?

Roberts: I was doing a 3D recognition and display. The display did hidden lines. I thought that was a minor part of my thesis. It turns out to be one of the major reference points in history, as far as if you look back in history and find all the documents that reference previous documents, this is one of the flux points where everything emanates from, and that was almost irrelevant to my thesis. I had to find a way to display this 3D stuff, so I did.

Pelkey: The three of you all shared, for example, Shannon as a doctoral advisor?

Roberts: I can't speak totally for them. I did, and I think Len did.

Pelkey: You knew Len, then. Did you discuss with him –

Roberts: We had the same office.

Pelkey: -- this idea of queuing theory and all that at that point in time?

Roberts: Yeah, we all talked with each other. He didn't have much on network queuing theory at that point, because it wasn't what he was into, so I don't know what his -- I can't remember enough about what he was working on then. Ivan I remember more because we worked a lot together.

Pelkey: Then you went to MIT Lincoln Labs after getting your doctorate?

Roberts: Right. I was working at Lincoln Labs as a staff associate all through my doctorate, so I was there and then the head of the group, Wes Clark, and Bill Papian, who were running the group, left after a disagreement with the management. In the midst of that time –

Pelkey: Around when did they leave, '65?

Roberts: No, '63, early '63, just when I was finishing my doctorate. So what I did was I took over the group, not in terms of -- formally, but informally, I just started -- nobody was responsible. Nobody knew what anybody should be doing with the computer. We had the biggest transistorized computer around at

that point -- this TX-2, which was a fabulous research tool that Wes had designed and built. It was really a tremendous machine. So, I had done all the system software for that, and I just started enrolling everybody else to do everything that needed to be done, and went and got money from ARPA. Ivan went to ARPA, so we worked together to supply money to the group, and as a result, I wound up being in charge of the group as the contract monitor for ARPA, but on no formal terms at Lincoln.

Pelkey: Then, in 1964, you attended this Hot Springs conference, which, up until that point in time, your interest had really been in operating systems and --

Roberts: Graphics.

Pelkey: And in 1964, you had this meeting at the Hot Springs in which you met Licklider and started to get interested in communications?

Roberts: Well, I was interested in communications, but I didn't have any strong direction at that point, or before that point. Lick was arguing for the 'Galactic Network' concept. Corby and I and Lick and a number of other people talked at the conference, and talked about what the next thing would be, the next thing in the world, and I concluded from that whole conversation that the thing to work on would be the communications between computers and to computers, because the computer stuff itself was a big team activity at that point, and one that I thought I knew how to handle anyway. Both Corby had done a good job with MIT system and we had done the same thing at Lincoln, and we knew how to build timesharing systems with multiple users, and the real challenging task was to try to interlink these systems now.

Pelkey: Did anything happen on the communications front between then and when you became the interface to Lincoln Labs for the CCA contract that ARPA let to Tom Merrill to --

Roberts: Well, I can't remember how it worked precisely, but my belief is that that contract was actually let by me to Tom under the ARPA contract, because I needed help in evaluating the whole thing, but I don't know. It could have been --

Pelkey: Did that come as a consequence of the interest that was --

Roberts: Yeah, right. We had worked together and then doing the first experiment --

Pelkey: You and Tom?

Roberts: Yeah.

Pelkey: And Tom was at CCA?

Roberts: Right.

Pelkey: Had he ever been at Lincoln Labs?

Roberts: No, but he had been --

Pelkey: How did you know Tom or CCA to do it with them?

Roberts: Well, Tom had done, at BBN -- he had been around MIT and Lincoln. I don't know exactly. Somehow I got involved with Tom and he was a good resource, and we investigated the remote access issue. I just don't know how it started. I'd been friendly with Tom for a long time, so I don't know when it started.

Pelkey: That activity was in 1965 and took some number of months, I presume, to connect these computers to see about using them.

Roberts: I'm going to leave that to your reference checking. I don't know the year.

Pelkey: It was '65.

Roberts: We did the experiments with SDC and that sort of thing.

Pelkey: Right, and it was just a circuit with modems on it.

Roberts: It was a dial circuit, a Western Union dial circuit. We had managed to get 2.4 kilobit dial modems and a dial capability from Western Union, which was slow and unreliable, but it worked, sort of.

Pelkey: So you got some feeling about how to connect these things together and the issues involved?

Roberts: And what we found, as the report suggests, is that you can connect the computers fine internally, as far as their software goes, and the timesharing systems both could call on each other, but the communications was slow and unreliable and difficult -- made the whole process so slow it wasn't very attractive.

Pelkey: Now, Paul Baran's article was published in March of 1964 in IEEE, On Distributed Communications: Networks and Protocol. Do you recall that at that point in time? When do you recall coming in contact with any of Paul's ideas?

Roberts: When I came into contact with Paul's stuff, as I remember it, was at ARPA after I had started the Arpanet, and at that point, when we were studying all of the technology as we had planned the network, his stuff came up. We looked at it and found reading techniques and that sort of stuff, but I don't remember -- in fact, as best I remember it, to this point in time, I've checked -- in fact, I've searched for references in publications of Paul's, and the set of documents which I had at ARPA that were, some classified and so-on that -- after the Air Force were early, but I've never found the published article. So, if there is one, that's great, but I didn't see it.

Pelkey: Yeah, I have a copy of the one that was in the IEEE in six parts in '64, which was actually submitted because he made a presentation on that article at the first Congress.

Roberts: It's clear that Paul did the work much earlier than anybody else. The problem that I keep noting is that he didn't, somehow, get the rest of us informed about it.

Pelkey: Now, in 1965, you met Donald Davies as well?

Roberts: It's apparently true that I met him sometime in there, but the first time we really sat down and talked about the network in detail was at the Gatlinburg conference.

Pelkey: His recollection was that you came to the NPL in England, after this conference in New York, and he then put on a two-day conference in London to discuss Multix and what was happening in timesharing and so on, and you went to London and that's where he met you. You represented the MIT group.

Roberts: It could well be. That was when?

Pelkey: In 1965.

Roberts: It could be. I've been to London with him many times in that period, so it could well have been --

Pelkey: The only reason I mention it is because you had met him at MIT in 1964.

Roberts: Yeah, I've seen him make references to that, and I assume it must have happened, but I can't remember meeting him at MIT. I certainly know that I've seen him in London.

Pelkey: Now, in early 1966, I gather, you then were recruited by Bob Taylor to join IPTO office?

Roberts: Yes.

Pelkey: And you ended up making that decision later in 1966 and moving to Washington with your family at the end of 1966, Christmas of 1966?

Roberts: Right.

Pelkey: During that period of time, from completing this assignment with Tom Merrill connecting the SDC and the Lincoln Labs computers, were there any other activities you were doing that were communications oriented or were you going back to Europe for timesharing?

Roberts: I didn't do any other experiments that were published. I worked on the concepts some as to what we might want to do about it, and that's one of the reason that Ivan and Bob brought me to Washington, because they knew that I wanted to pursue networking.

Pelkey: Was that a difficult decision at that point in time, to go to IPTO?

Roberts: Clearly, at that point, when they first approached me, my response was: "No, go away. I'm having great fun doing research," and they finally went to Herzfeld and said: "Do something about this guy." So he talked to the head of Lincoln - - I forget which one that was then -- but he called me in his office and said: "I think it's in our best interest that you go. They've told me that they have 51% of my funding, and I'll support you going down."

Pelkey: When Taylor told me this story, I accused him blackmailing you to come.

Roberts: And, in fact, he did. He helped convince me that it was in my best interest to get into management more and do this, but they did that to me, and it worked.

Pelkey: Now, were the seeds of this network project in place then?

Roberts: Just in my mind. I just knew that it was an important thing to pursue, and I knew I had enough experimental results to undertake the direction. All of us in computing were clearly not going to go after it on a circuit switched basis. We were all thinking in blocks in some text. That's the way computers worked. So we approached it very differently -- anybody in the computer field, Tom and I and everybody else, worked within the whole ARPA community – not with the communications people. So we thought in terms of: "How can we do this such that it will be a functionally useful service for the computers?" I got together groups and committees of the ARPA people and started working on it.

Pelkey: Conceptually -- maybe you can help me -- there's this issue of 'message blocks' or datagrams, and there's the issue of store and forward, which aren't necessarily the same. They tend to be in terms of when you put systems together, though. Were they different issues, or were they just needed to build a system, that they were together?

Roberts: Clearly, if you're going to build a system, you're not going to link every node to every other node with leased lines, because the communications are going to be too slow, even if you bought the bandwidth. If you have divided it up into little teeny channels, then you have slow communications. So, you want to have wideband channels, that are fast, and you clearly have to have some kind of switching.

Now, what kind of switching? All of us thought, clearly, in those days, about computer switching rather than circuit switching; some sort of computerized switching. You got the traffic in and you put it out. It could have been that we put it out block for block as fast as it came in; it could have been that we stored the whole message and forwarded it. What we concluded was that you wanted to not store the whole message and forward it, and you couldn't have a perfect virtual cut-through where you sent every block immediately synchronously because it might interfere with the next message, so you had to do it in some smaller breakdown, which is like a packet, or whatever, which, of course, is the size lump you're in anyway, because you've got to put sum checks on it every interval. So, there wasn't any question about packets -- and clearly Donald gave it the name -- that we had to be in that sort of size. Now and then, each one of us in the world would derive what length that ought to be ultimately for sum check, because of errors, and that was around the thousand-bit area, with error rates that were in existence then. Today, it's probably much longer. It is much longer, if I'm right.

Pelkey: From here, your having gone to ARPA at the end of '66, I understand there was a meeting that is referred to as the Michigan meeting, which I guess is when the ARPA contractors would get together and meet with each other?

Roberts: We did that each year. One was in Michigan, I guess.

Pelkey: It's alleged that the Michigan meeting happened in early '67, and there was a cab ride that you and Wes Clark and Bob Taylor and, it's not clear whether JCR Licklider was in the cab --

Roberts: I don't think so. It was primarily Wes and I interacting. There may have been other people.

Pelkey: That was Wes and you?

Roberts: Yeah, and the result of that meeting was that he said: "No, don't do it in the central computer, do it in the little computer." Not many of us knew about minicomputers much at that point, but Wes was building little boxes, and he was clearly the person to listen to in terms of the computer architecture issue, and he was right; separating it was valuable. So, it didn't take much to convince us, once he thought of it.

Pelkey: Then there was a subsequent meeting, I gather, in the spring, that you convened, that had Uncapher, Shapiro, Kleinrock and Baran at in which there was a planning session on how to do the network, how to create the network, what the architecture of the network was going to be?

Roberts: It could have been. The meetings during the course of that year, I don't have very good records of how to reconstruct myself. What I know is that in the course of the year, I wrote the paper that I gave at Gatlinburg, and that's the best paper I can find as to what transpired that year. That describes the structure that came out of all that thinking, but I know I met with everybody in ARPA to try and structure it; to figure out the host protocol issues, the host interface issues and the whole thing; how you do it; what it looks like and so on.

Pelkey: When did you actually start doing the RFQ, in terms of having developed the ideas enough that you decided to document it in terms of the RFQ?

Roberts: When did it come out?

Pelkey: Well, you made the decision in Christmas, as I understand it, of '68.

Roberts: The award. So it came out in the summer or something, so we wrote it in the first part of that year, probably in '68. I think we wrote it after the Gatlinburg conference.

Pelkey: Ok. You would have been out, during this whole period of time, drumming up support and presenting the ideas, trying to get people interested and trying to make sure that the ideas were solid --

Roberts: And working out the ideas, like with Wes and everybody else, trying to figure out the right way -- and with Paul and whoever.

Pelkey: You didn't have much of a staff then. It was primarily you just going out and talking to people?

Roberts: Yeah. I didn't have staff to speak of. I think (Barry) Wessler came on board somewhere in there, but I don't know when, exactly.

Pelkey: Barry Wessler?

Roberts: Yes.

Pelkey: Now, you didn't spend much time at this point on the host protocols? You were more concerned with what was to become the subnet?

Roberts: I was more concerned with that. I knew that we needed to solve that, so I got Steve Crocker involved in it eventually. He formed a committee that worked forever and was a year late, but eventually did it.

Pelkey: That was a source of frustration, Steve said, and it was a difficult period too, in terms of getting the host-to-host issues worked out. He said at some level, it was hard to get other people to take it seriously, because some people really didn't want to interface to the network, because they wanted to protect their own private interests to get more computing funding at their own site, so it took a lot of politics and arm twisting to get people's cooperation.

Roberts: That's right, because the problem that most of them had was that if they agreed they would not do as well in their computer funding. They would rather have it themselves. So we just convinced them all they weren't going to get any computer funding anymore unless they cooperated.

Pelkey: That must have been an interesting process. People must have loved you at that point in time. I can only surmise. Why the four sites that were selected?

Roberts: Well, I've been asked that, and I don't know anymore. SRI was involved in the documentation, as we know. And I think that was the reason for SRI, although they were also an active computer site that was interested.

Pelkey: The work that Englebart was doing, did that have any impact in terms of thinking that was a good network application?

Roberts: It was a good application to have on it, because what I was looking for at that point was not people who could build networks, but people who could offer services over a network, and one of the things they saw was the documentation and library.

Pelkey: It was a good function.

Roberts: It was. It was a very powerful function for a number of years. In fact, we still have lawyers coming to me talking about patents, at this point, about how this article was published only electronically during that period. How do we award this patent? I say: "Look, it doesn't matter how it was published. It was published more broadly then than any other time point in history."

Pelkey: So SRI had the documentation system. You also had, what, graphics at Utah? You had the network measurement stuff that was going on, first for computer network measurement but was to become network measurement down at UCLA? Kleinrock was there, and they had been doing

measurement issues, and I guess measurement was an important issue if you were going to put a network up, in terms of knowing how to measure it?

Roberts: Secondly, general issues of who was going to be on the net had been more or less decided throughout the country. We knew the first set of 20 sites or whatever, and now we had a topology issue or how to start the network. So, you're going to start not cross country, you're going to start it in a relatively reasonably nearby topology, and so although a few of those sites, like SRI, were probably key because we wanted them on early for application, and UCLA for the measurement, because we wanted to measure this thing when we got it up, I can't see that Utah was on for the same class of reason. Although it was an important research site and would contribute and was supporting the thing - -

Pelkey: It may have just been geographically --

Roberts: Well, Ivan was there and Ivan was clearly supportive of what we were doing.

Pelkey: It seems to be that UCSB just became a default site because it was a convenient geographical location, although Glen Color was there and what he was doing was --

Roberts: Yeah. Clearly Glen didn't need to move anything over the net and didn't much. Glen was doing his own speech research and didn't care much about everything else.

Pelkey: The process, then, of selection became relatively straight- forward. It was clear that the BBN proposal was the outstanding one.

Roberts: In fact, there was a very strong competition between them and Honeywell -- I think it was Honeywell. Anyway, there was one commercial proposal that -- Raytheon? Well, they both were using the Honeywell machine. I think it was Raytheon that had a good proposal that competed equally with BBN, and the only distinguishing thing in the long run for my final decision was that BBN had a tighter team organized in a way that I thought would be more effective than a very steep commercial structure with lots of managers and vertically -- so I didn't believe they'd keep the schedules as well, but they had a good proposal.

Pelkey: I understand that IBM and CDC just 'no bid' it.

Roberts: IBM and CDC 'no bit' it because, they told me: "If we used Model 50s at these sites, you're going to go broke, and we think you're crazy." And what else is there, of course, besides Model 50s.

Pelkey: Once the selection had been made, the first one went in September '69 at UCLA, and was delivered on-time Labor Day weekend, which caused consternation at UCLA to hear their side of the story, but from '69 until the end of '71, when their was a forced linkage up of all the sites, in order to get people to really link these things together.

Roberts: Well, we forced the host protocol.

Pelkey: Right, which was at the end of '71. That was a decision to try to force that, because in order to be able to get this thing to be pulled together --

Roberts: Well, we also had introduced the TIP in '71, which gave us a lot of use without the host protocol, at least to the 10s, or whatever, that had an interface, but the host protocol was clearly critical, and getting it implemented at all the sites. So we forced a date when they all had to have it finished. If we hadn't done that, they would never have finished.

Pelkey: Because of the --

Roberts: Well, they didn't need to; they didn't want to.

Pelkey: You had Steve Crocker, in terms of these graduate students doing it --

Roberts: Well, it wasn't Steve's fault. It was the fact that the sites didn't want to move. Steve worked very hard to try to get them together. They would just as soon not cooperate. In fact, if you look at ISO and some of the other standards groups, they have that problem because there's no reason for the big manufacturers to cooperate. They lose by cooperation, whereas in CCITT, you always have cooperation, because they are independent geographic areas trying to cooperate.

Pelkey: We had talked about this before, but this issue about layering and the host-to-host software, this concept of layered protocols -- the host-to-host, which then flowed through over to TCP and has now ended up in the seven-layer model -- that may have been natural to all the computer engineers who came to this process because operating systems are layered, but this had a profound impact. It may be naturally obvious, but it is a contribution of what happened through that process, is it not?

Roberts: Yeah, I think so, and I don't think it even went through TCP to get there. The thing split and took two paths in the midst of the '71 to '73 time frame, or whatever, when I left, I then took it off into X-25 and that virtual circuit direction, and we still had the seven-layer model. We introduced the first three in X- 25, and the next levels were in the host interface. Bob Kahn and Vint Cerf went ahead with TCP and pushed the current original datagram concepts even further. Everybody agreed -- we had more headaches with anything that didn't obey layers in the whole system, from time to begin with -- every time anybody violated a layer we got in trouble. So, everybody knew that you needed as cleanly defined layers as possible, and that went on even very early, even in the first implementations, in terms of the file protocols and on top of all of the communications protocols. So it was very clear from early on, and I think -- well, you may have researched who was best at stating it; everybody experienced it.

Pelkey: The Arpanet was really a virtual circuit.

Roberts: No, Arpanet was originally a datagram network. It had -- it allowed virtual circuits [sic] to be created at the host, but inside the network it didn't know about them. It was a datagram network. The first telenet was based on that, so telenet had a datagram subnet, and it put virtual circuits on top of it, and the same is still true of Northern Telecom's switch. In fact, I was just screaming at them as a vendor because they are back in the dark ages, but --

Pelkey: So the TIP came about because there was a need for sites where there was no computer for people to be able to access these computing facilities at other sites?

Roberts: It became clear that we were using the computers more and more for terminal-to-network access, and that a big PDP-10 might be totally used by 30 people trying to go through it to get to the network. This was stupid. So, as I started seeing more and more people sitting on the computer going through to the network, and having a high failure rate of their computer to get in for that purpose, and a high cost, we quickly built the TIP so that they could get in without having to go through their computer, and then they could go to any computer they wanted. They could go to their own or they could go to some others.

Pelkey: And if I understand correctly, although I don't have the statistics, a good percentage of the traffic at that point in time on the IMPs was intra-IMP. The IMP was serving as sort of a local area network in some of these sites.

Roberts: Yeah, clearly -- and the statistics are available. Some of them are published in papers Kleinrock put out that said what the fraction was. It was very high in the early years, because, like any

distribution of traffic that you look at, corporate traffic or whatever, there is more traffic close to neighbors than there is to far neighbors, because of the proximity and the knowledge and the interest in the community, so that, although over time I think that it has flattened out in industry and communications today, it is much broader distance-wise than it ever was, if you had two computers at MIT, they talked to each other a lot, because that was the immediate thing that they needed to move data in between; the AI machine and the Multix machine, or something like that, and the network was the first bridge between the two. Those people knew each other and they knew they wanted to move the documents, or the file, or the program . . .

Tape Side Ends

Pelkey: The process of bringing other resources aboard, such as a Howard Frank, was an important one, in terms of a group of you deciding what was best in terms of making sure that the network was being designed correctly topologically?

Roberts: Well, I still have lots of old files of all the original topological designs I did, and I did a lot of work topologically, designed all our initial nets, but it became clear it was much more complicated than somebody ought to be doing on --

Pelkey: The back of an envelope.

Roberts: It wasn't even the back of an envelope. I started using computers, but as a secondary task. It needed more attention to do it effectively, so we did contract with Howie to do that professionally, and he did a tremendous job.

Pelkey: Now, the growth in sites was predetermined once you got them up and running, so that, as you said, the 20 sites -- it was known who they were going to be and it was just a function of having the equipment come available and as the sites were ready, to roll the sites out?

Roberts: Well, at some number of sites, and then as we went beyond that, we kept on adding new sites as the situation became clear that they should be added. I don't know what the number was in the first evaluation.

Pelkey: The use of the network once it was up and running, was it what you expected it to be in term of how it got used?

Roberts: No. Clearly, what I had first expected was that it would be computer-to-computer; it would be transfer of software, the remote use of software, the interaction between machines -- that people would be on their own machine doing something and they would need another machine for cycles or something, and what it turned out is that most people just went through and were an individual terminal on the other machine, and therefore got on the TIP eventually, and just used the remote machine. So they were only using one machine at a time, in reality.

Pelkey: So the concept of distributed computing that you thought --

Roberts: Was much slower to develop than the concept of distributed people and computing.

Pelkey: Do you have any views as to why that was the case?

Roberts: Well, it was a much more future concept in a lot of respects, and the short term need was for a much better communication system to get people to their remote computers. The network turned out to be a far better way of doing that than anybody had imagined. We clearly imagined that it was good for that, but it turned out to be the near term desirable facet, as well as electronic mail. File-transfer and file movement and so on was always a background activity, lesser. It also took a lot longer to develop the

software to do the other effectively. Everybody had terminal software that you could get into the remote computer.

Pelkey: I was at ENE a week an a half ago, and it's amazing the usefulness of networks, just FTAM seemed, at that level, on the commercial side, how much power they see in it, and here its 1988. So, you had this session at the end of 1971 for connecting groups together to try to force this issue of the host-to-host software development because that had lagged for the reasons that we had noted. During '69 to '71, was the Arpanet the place where you were devoting most of your time?

Roberts: No, it was maybe a third of my time. I did a lot of work on the Arpanet, both personally with the topology and the design and the decisions, and the jawboning of all the sites and the other issues that were required, but I did also develop and build the overall computer science program at ARPA to where it was from $15 million to $50 million during the same period. I went to Congress and got more money and built the ILIAC IV and built the -- which Ivan had gotten started, but he left me with this dinosaur -- and various other activities, including the speech understanding program and so on; to create major AI program and major computer science activities in various domains, so I was spending a lot of time in other areas as well as the Arpanet. That was my job.

Pelkey: Did you launch the Aloha Network?

Roberts: Well, the idea for the Aloha packet radio concept was there. They developed that on their own, in a way, but they didn't have enough funding to do anything with it, and so they contacted me, as everyone in the country seemed to, at that point, for money. I thought it was a great idea, it fit in with the direction. So I funded them to proceed and build it and get it going. Then we started into publishing articles about it, and of course I published the first articles on Slotted Aloha, which is still the basis of a lot of the LANs, and the reservation Aloha, reservation techniques on the satellite. So we took what they were doing --

Pelkey: Do you recall what year it was that you started funding their activities?

Roberts: No.

Pelkey: Norm is one of the people I haven't talked to yet. Was it mid '60s?

Roberts: It wouldn't have been the mid '60s because we didn't go there. It would have been around 1970, but I'm not sure of the year. You can probably – there are a lot of papers published -- Slotted Aloha was one, that's what this patent --

Pelkey: In the IEEE?

Roberts: No, never published in hardly anything for a long time. What happened was that it was published in SRI's thing, and that's what this patent search was all about. I invented that back then, and everybody has contended the fact that it wasn't published formally for many years thereafter, and yet probably more people had seen it during that period than any other paper in existence.

Pelkey: You and Bob, and it's not clear which of you, but this idea of the ICCC came up --

Roberts: Bob Kahn?

Pelkey: Yes.

Roberts: Bob Kahn clearly wanted to move it into the conference. I quote him as responsible for the motivation to do that. I wanted it to happen and I helped him make it happen, but I was never as strong on making something like that as Bob was, probably.

Pelkey: The choice of Bob Metcalfe as a facilitator, to go around and put the Scenarios book together, was that something that Bob Kahn dealt with or was that something that you --

Roberts: I don't know that I can't tell you. Bob Metcalfe was a good friend of everybody's, and he was there. I don't know exactly how it happened.

Pelkey: In terms of intellectual property, the impact of communications thinking, it strikes me that Licklider had a vision that he set forth for people, saying: "This is all to happen," and Wes Clark had an architectural -- in addition to his influence in terms of his computer and significance influence in the computer field. A specific example was the idea of the communication network being separate from the computing --

Roberts: Wes was there specifically about something that was pretty well formed. We were going to string lines between all the computers, and he said: "No, break that piece out." Wes Clark had a contribution to the structural, rather than designing any of it, and he said: "I see a different vision of how you should build it if you’re going to build it."

Pelkey: Donald Davies, clearly, and Paul Baran, both in terms of background work and original thinking work, relative to the message block or packet switched networks --

Roberts: No, there were store and forward message switched even before that. I'm not sure you can credit the message block with anybody in this crowd.

Pelkey: It had preceded everybody because of the nature of the old torn paper systems?

Roberts: And the store and forward message systems that came after them. When we started the Arpanet, we were looking at store and forward systems as an example of a very slow and laborious process, based on torn paper tape to begin, and had been automated: very poor systems. They had very slow disks, and they put everything on a disk, and then they brought it back out and sent it on. The military used those for store and forward.

Pelkey: You had a tremendous amount of influence --

Roberts: You're trying to state a whole picture.

Pelkey: At some level, one can make the argument that there was really no intellectual development; it was reducing to practice things that many people commonly understood and --

Roberts: Oh, yeah.

Pelkey: -- it was a really good management principles.

Roberts: I think that the best piece of evidence of what the development really was is the '69 article that I wrote on the crossover of computers and communications. That's the trend that made it happen, and without realizing that trend, there were a lot of technical things that lots of people had been doing. Unless you saw that trend in your mind somehow and acted on it, you didn't see the future of this new technology. It was purely economic in my mind. Since communications was now getting more expensive than computing, and computing was changing in its relative position, you needed to do something to change the structure of communications, so you looked around at all the things that people had ever tried, and store and forward had been around a long time. Mail started out that way. So clearly, there weren't any original concepts involved, but there were lots of little pieces like Wes breaking out the box. Donald certainly did some early work and Paul wrote a beautiful set of stuff, when you go back and look at it, but it wasn't until you really put it into a context of 'here is the economic picture' that, I think, you get the real impact on society. You could have invented it in 1900 and it wouldn't have been a viable invention.

Pelkey: Would you make the same comments relative to the local area network, what became Ethernet and Token Ring? That they were a natural economic coming into being of trends, and this crossover point -- the need and --

Roberts: It turned out, at that point in time, after we started the Arpanet and it was successful, and about when AlohaNet was starting and so on, a lot of people, Kleinrock and myself and everybody in the community, started really thinking about all packet techniques, because we were really excited, at this point, about the change in conceptual approach. So, we started applying it to everything under the sun. There was a lot of work; to apply it to satellites, to apply it to radio, to apply it to LANs, to apply it to cable, anything, so there was a lot of work, but it was very interesting new ground for which nobody had really done the analytical work, to see the impact and how it could be used and what you could do with it in all these areas. Once we figured out how to do those, then Metcalfe and others carried it on to LAN, and various groups carried on various pieces, but the whole growth became a natural thing that came out of the excitement with what had been achieved: statistical allocation in communications and packetization. Then one tried to apply that all over the place and see what affect it would have. The economics held all the way through. The economics were changed for the whole community. Computing was cheap enough to do whatever you needed to do with everything. Now, of course, it was very different then than it was five years later, and that's why virtual circuits became even more -- weren't so clear then, and then became clearer. With the datagram system that we had at that point, we were still a generation away from what was going to happen, because it was uneconomical, in the long run, to have the address header as long as it was, and all of the packets. The communications became more and more expensive over time, and computing got cheaper and cheaper.

Pelkey: Right, so you want to go more and more into the computer and less --

Roberts: Right, so that it kept changing, and people had to keep on seeing that trend. That's one of the arguments that I have about invention, in general, is that it has to follow the economic trends and you have to keep changing with them, whatever they are.

Pelkey: What would you, in general, say the contribution of this period of time was?

Roberts: Well, simply, the contribution was to demonstrate that packets and packetization and statistical multiplexing was effective; to develop all of the theory surrounding it for every media that nobody had developed the theory before. Clearly, what Kleinrock did as well as what the Slotted Aloha paper and the reservation stuff and everything else that was done in that period including the work on the Ethernet, which is CSMA, those techniques were all researched in that period. All of those techniques needed to be understood, documented, and the theory developed, as well as successful implementation, although you don't develop all the theory unless you see some success, perhaps. So now we had enough success that everyone went out and started doing the theory as well, so now we understood buffering and everything else associated with it a lot better. The first argument that I heard, back in the '67 time frame when I was starting the Arpanet was, from the communication community: "You're going to run out of buffer space. You can't possibly do it. You're crazy," and they were mad because they believed that somebody was crazy, and one of the reasons that they believed that with was buffers. Well, we didn't know about the buffers precisely, we didn't have the theory worked out, but we thought it would work, and it did. I had reasonable probabilistic theory that I could apply to it. That's one of my minors in school, so I knew about where I stood. Now, Kleinrock got it down to a science.

Pelkey: Is it true that AT&T was approached in the early stages to see if they would build this network for you?

Roberts: No, AT&T was approached in the mid stages to see if they would take it over.

Pelkey: After the ICCC?

Roberts: Yeah, it was in the '72 time frame, I would suspect.

Pelkey: And they said no.

Roberts: They were formally approached. The Washington division was excited. They said to me there was a lot of revenue they were getting from the leased lines; they thought it was great. They got excited about it, and Bell Labs got involved, and they had a huge committee, and I presume they went over and over it, and they kept on looking at it, and eventually -- they never gave a response, because that was their way of doing business, but I found out that Bell Labs had said: "No, it was not compatible with the plan."

Pelkey: Bell Labs at that point in time had that view about lots of things in communications technology, that some of it wasn't very experimental for such a place where you would expect innovation.

Roberts: And one of the reasons why it wasn't into this at all was that way back in history, one of the original court decisions was that they shouldn't be in store and forward messaging, so they didn't allow anybody to work in the area, not until the Arpanet was successful. At that point, they put the team of people together, and even though they turned it down, they put a team to go do research and figure out what they could do. After studying it three times, they finally bought switches and put something in.

Pelkey: In terms of other people, I mentioned Licklider, and Clark, and Davies, and Baran, and clearly yourself. My assumption is that Kleinrock -- that queuing theory was his areas, once it got going -- made a contribution as did Howard Frank, but that, in terms of the concept of all of this, you took it over and put your imprint on it and coalesced the ideas and made your contribution to making it happen -- is there anyone I'm missing, in terms of having an influence on you personally in your thinking about networking?

Roberts: Not that I can think of.

Pelkey: Who influenced you to the important issue, because you're the one who --

Roberts: Well, clearly, the whole community influenced me, in that I talked to everybody and tried to collect ideas. I think that in general, one has to look at the follow through; what is it that makes is happen, the whole process? I've seen lots of people with ideas, and they mention them and no one picks them up and they don't carry them forward. You've got to then believe and see that it's economically attractive and viable and have enough confidence in that to carry it through, and that's really what happened with the Arpanet. I don't think it was an invention; it wasn't a theory breakthrough like Einstein. It was a collection of ideas that were around at the time. The computer people had always had blocks, and lines were always around; that was nothing new. In fact, I really don't believe that Paul Baran or Donald Davies influenced the design all that much, because they were hardly involved. Donald did in the sense that he got me to use higher speed lines than I would have used - - to really look at paying more for them and doing that -- but, outside of some of those influences, and Paul had done the 'hot potato routing' and we looked at that first as a good example and proceeded from there. So, those were pieces that we applied because of the thing, but the real issue was to carry through and see that it was important and it was economical and it was going to have an influence and make sure it happened.

Pelkey: And that fell in your camp, of having successfully managed it and having gained support for it behind the community and forced it to happen.

Roberts: And that's what's going to have to still happen with fast- packet.

Pelkey: I agree, as in most of these areas. It's the systems engineering perspective, even the Xerox example. Xerox PARC was a good example, where they may have created all of this, but they didn't have the will to manage it in the marketplace, and it got taken away from them. So, it's the follow through issue.

Roberts: Now, in fact, in some cases they carried it through to a clean demonstration, which was better than just having an idea.

Pelkey: Yes, and clearly Xerox PARC was profoundly important. I don't mean to minimize that at all. I don't have any more questions given our time, and again I thank you.

END OF FIRST INTERVIEW

START OF SECOND INTERVIEW

[Editor’s Note: Exact date unknown. This interview is noted as occurring a “few days after” the first interview that took place on June 17, 1988.]

Pelkey: . . . but in terms of number of transactions, electronic mail became something that made it hard to get rid of Arpanet, because the community that had been created through the E-mail process --

Roberts: It was very powerful in that respect, and it was a lot the traffic. On the other hand, I doubt if it was a lot of the bits.

Pelkey: A lot of the traffic, but not relative to the number of bits. Was that a benefit from Arpanet that you had anticipated when you started this in '68, '68?

Roberts: In '67, we had anticipated resource sharing, resource sharing in terms of all sorts of intellectual property exchange, which the messaging wasn't the particular piece, but was clearly related, to keeping people in touch. What happened was that it developed much more seriously than we had imagined, even though store and forward messaging was not unknown, and of course there were store and forward switches way back in history. So, it developed as a new form, the mailbox concept, and was quite attractive to those people on the system, because they were heavily computer oriented. As it developed over time, it may even die some day, because it doesn't attract enough people as a mailbox thing. That is, the current business today, as best I can estimate it worldwide, is $100 million. That's not a big business. The reason for that is largely that you have to have at least ten messages a day before it's worthwhile being on a system, and they're not interconnected very well, so it's not a universal forum and there's no universal standards like there are for facsimile or other things. Facsimile has quickly overtaken it in terms of being able to produce clean images and a standard interface and it's on all the time, so you can force delivery. Those factors are ones that could have been done -- something done with, but it was hard for that community to spread into that environment, but it was extremely valuable and probably will continue to be within computer environments, computer people.

Pelkey: When did you decide, and what prompted you to decide, that scenarios were required? That was your decision, right, and your idea to have what became the scenarios, the public demonstration of --

Roberts: Bob and I put that together. I don't know whether I would credit it to Bob or me. We thought that it was a valuable thing to do to get it out, and I wouldn't credit the scenarios as being as big a thing as maybe you are, in some respects, because the demonstration was one of being able to show that the Arpanet worked, and it allowed people to try it. The scenarios were a way of doing that, of letting people go through a process and find out what it was all about. It was exciting, and people had a fantastic time at that show doing it, and that really spread the word more quickly than it might have otherwise, but that was the primary benefit of it.

Pelkey: I don't mean to be a public relations benefit, but it was really the popularizing of it and saying it's a fait accompli and "here it is" and broadening the message about it, as opposed to just being papers at conferences which you and other people had been going to, saying here's the Arpanet. It wasn't believable until some people could get on it and work with it.

Roberts: I don't know exactly when the impact happened, or where, with respect to the rest of the world. Clearly, by 1975, we had reasonable world concurrence on our standards and the plan for packet networks in major countries, at least a few major countries, but back in the early '70s, that had to be propagated someway. Whether that was done through the conference papers or that, I can't be sure. It was certainly a valuable experience for all the people at ICCC.

Pelkey: A lot of people who were very important in the industry were part of that event, too.

Roberts: Almost everybody came to those meetings at that point in time. For some reason, and I don't think it's happened since, the whole community attended ICCC.

Pelkey: It must have been a very exciting period in time for people who were there. The scene was described that people just didn't want to leave the building that night, because anybody that knew anything about computer networks and computers, they were in that room, and that was the place to be. There was nothing formal about it --

Roberts: A lot of people put a lot of time into getting it ready so that you could use their machine effectively remotely.

Pelkey: Did you interact much with Robert Metcalfe during this period of time?

Roberts: We certainly worked with their node at PARC and with the people there. Those people all were stolen from ARPA over time, so --

Pelkey: As DEC has done, in turn, to them. In early 1972, you really wanted to commercialize the Arpanet. You realized it was real, and you wanted to get the commercialization happening, and encouraged BBN to commercialize it.

Roberts: I was encouraging them and anybody else who would listen, although that was the one that came through.

Pelkey: Now, there was a group that spun out of BBN in '72, a company called Packet Communications, PCI --

Roberts: The guy who did that, I forget his name, was working on the evaluation that I asked BBN to do, about commercialization. He didn't think they were moving fast enough, so he left and started his own activity, taking a lot of the key people. It was probably not very moral because he was doing what they were asking him to research, but they continued to decide it was a good thing, and decided to do it, and he decided to do it, but he spent all the venture money he found on planes and boats and other things, pizza parlors.

Pelkey: BBN, maybe rightly because it wasn't a very ethical thing that he did, wasn't very cooperative in terms of providing the code to him that one could argue was a public domain issue.

Roberts: Well, it's not that simple. You would have to have supported it with a lot of work as well. Even if he had had code, which we did provide to people over time. I don't think he would have done any better.

Pelkey: That may very well be. A compromise was reached, if I understand history, in the sense that BBN, not wanting to share this code, finally was encouraged to share the code if they could keep the 10-X to themselves as a quid pro quo for providing this code to PCI. Is that your recollection?

Roberts: It wasn't PCI in particular, but it may have been triggered by PCI , that of them providing it to the world, making it more available, and so they did. I don't know that there was a quid pro quo, a

compromise reached, but I can't remember the negotiations. But clearly they did have some rights to 10-X too.

Pelkey: Going back to interconnection. We were talking about E-mail before. If BBN had been encouraged, or whatever the elements, without laying responsibility specifically at the door of BBN, but in terms of sharing the concept and the code and supporting that so that everybody who wanted to build one of these could have built it conforming to a standard so that as these nets started to proliferate, they would have been able to talk to each other, it would have been a very different world than what did develop, where you had nets developing but they couldn't talk to each other very well, such as what Tymshare did versus what you got around to doing in Telenet, where they really didn't talk to each other very easily. So you had these different nets. Was that ever discussed at that point in time or a concern of yours?

Roberts: As far as the commercial nets occurred, we all worked with X-25 and they could talk to each other, so what period are you talking about?

Pelkey: X-25 didn't come around till after '75 -- before that, the momentum to move in this direction --

Roberts: Tymshare didn't exist before that. Tymshare was doing their own thing for their time sharing users. In '73, we started Telenet, built this new protocol which was like X-25 but was different than the Arpanet because we needed to get the interface out of the mainframe so we didn't have to do as much work inside it, so we made it more of a transmission protocol than a multi- wire thing, and Barry and I redesigned it then to be a communications protocol rather than a host interface, if you will.

Pelkey: So you could just sell boxes and hook them up to the host without having to worry about doing drivers and host software and all that.

Roberts: And the biggest problem was getting the Hosts so that they didn't have to do much, so that they could connect easily. So we did that, redesigned it so that you could just run a wire from the network into your host, and redesigned it to be more of a virtual circuit design, although we actually used the Arpanet code and built virtual circuits around it. So the internal guts were actually datagrams, and the external interface was X-25, was virtual circuit. Later on that changed, but it was many years before we actually changed the internal part.

Pelkey: When did you decided to go to BBN and join them?

Roberts: I didn't go to BBN. They asked me in the beginning of '73 if they started Telenet, would I become president, because they didn't really want to proceed without it. I agreed in the beginning of '73. They had actually formed the corporation, but were playing around with whether to fund it or do anything with it, because Phil Walker and Stu Anderson were there, their lawyer and the other guy, playing with the concept that we had started, and then I didn't get to go until October, because in the meantime, they were writing the FCC filing, and I was working with them on that on the side, and I had announced that I was leaving, but I couldn't find anybody to take my place at ARPA. So, finally by October, I found somebody to take over and left, because we were going to file the next day when I got there, and we didn't want to file until I got there.

Pelkey: So you actually formally joined Telenet in late '73?

Roberts: October 1st.

Pelkey: And when you filed, you basically knew you were going to get a carrier --

Roberts: No. We didn't know for sure. We were --

Pelkey: Confident.

Roberts: Confident that it was likely, because we had been talking to Bernie Strassberg[1] during all that period, and that was one of the reasons I had been encouraging people to do it.

Pelkey: Bernie has agreed to sit with me in a couple of weeks. Help me understand the relationship of X-25 to the series of events that you were involved with.

Roberts: Well, nobody really thought much about the standard until about when Telenet was starting. We did this unique interface that was now different than anything else that had been done, and got it working in '74. The problem was that we needed now to get hosts to interface to this and build it, and to do that we figured a standard was tremendously valuable. If there were a standard, then hosts, IBM and other people, would build the interface for their machines. That's saying a lot for IBM, but since they never did, really probably for a long time, but other people certainly did. Other people in the world, in England, France, Canada and Japan, were interested in the same thing at that point.

Pelkey: The same thing being?

Roberts: A universal standard for these evolving networks. There was a project that was starting in Canada to build a packet network, and they wanted a standard, and there was a project in England. Eventually, England bought equipment from us, rather than building it, because they could never reach agreement as to what they wanted. It had been evolving ever since they started, long before in England, as a project, but they never got it built themselves, and in fact they were building a packet network that came later in time, but they wanted a standard as well very much. And so in England and France they knew they had to have it, because that was CCITT country, and in Japan they followed with it and wanted it, so the five of us got together as sort of a unique group and forced a standard much faster than any other standard I have ever gotten through at CCITT, because those were the only five countries involved. AT&T wasn't involved, so I led the US delegation in this, and I actually did all of the negotiations directly.

Pelkey: You were representing the US in these discussions, under the Commerce Department or something?

Roberts: I represented the US, and Telenet was a member, so I was not only a member of CCITT, but was running the US portion of this activity. But in reality, the five of us just formed an ad hoc group of five countries that were willing to make an agreement and worked out and argued out the spec, and the worst arguments were with France, because they wanted something totally different. I had a working system, so that I showed them that I could interface with an IBM mainframe, and here were the problems that their thing wouldn't solve. So, we finally convinced them that certain things needed to be done. They made us change it somewhat so that it was a little bit different than before, and continued to screw around with it for the next three years after the first standard, but we got everybody in agreement finally, because we had a working system and if we just modified it enough to make it work for everybody, then everybody finally could come to an agreement. And they all wanted a standard very quickly. So we put that forward, and no other country in the world had anything useful to say about it, including AT&T and IBM and everybody else within the United States, because they didn't know what it was. IBM eventually caused some annoyance on datagrams later on, or other people did, because they wanted -- actually, their goal was to stop standards, as far as I could tell. But, they didn't have enough influence with the committees to do anything much to stop it from passing. In CCITT, there wasn't anything much to stop it from happening, so it got done, and X-29, which allowed us to do the TIP type thing, to communicate from asynchronous terminals, got through, which was the second layer of protocol. It was actually the next layer up.

Pelkey: Was theX-25 standard approved before the end of '75?[2]

[1] Director of the FCC, Common Carrier Bureau. (See the Strassberg Interview)

Roberts: Yeah, there's a date.

Pelkey: So during 1975 you were pretty busy, I gather, in terms of trying to coalesce and cause this standard to come into being.

Roberts: I was doing that heavily, as well as running the company --

Pelkey: That was a busy year.

Roberts: -- but they were very interrelated.

Pelkey: Did you end up going to Europe a lot during this period of time?

Roberts: It was adopted in March '76, but I think we did it during '75.

Pelkey: The French had their perspective, but did you travel to Europe a lot during this period of time?

Roberts: Yes. I spent a lot of time in Geneva. All the meetings were in Geneva, and then the five of us got together at various places around the world all the time, so we spent a lot of time meeting one place or another on this to get it resolved.

Pelkey: Who were some of the key people from the other countries involved in this ad hoc committee?

Roberts: Dave Horton from Canada, who is the --

Pelkey: Horton of Canada --

Roberts: And he eventually went to GTE later in time. I don't know whether he's still there or not, and Remy Despres from France, who was the chief arguer. The French can't give up, so they had to win something.

Pelkey: Remy, if I understand correctly, was also participating in the Vinton Cerf meetings in '72 and '73 relative to networking and protocols and so on that led to TCP. Do you remember that?

Roberts: I don't know the time frame of that off hand. Clearly during this period, Remy was also responsible for the development of the Transpac system in France, and wanted to have a virtual circuit standard, and was not particularly sympathetic to anything else, so I don't know, he may have participated with Vint, or something, but --

Pelkey: A lot of people have very strong views about Remy Despres.

Roberts: He's a very strong individual. I don't know what he's up to now. He's with some company doing something. And of course the English were a group of people. I don't know that I can place all of them. The Japanese guy is not clear in my mind. It was their CCITT delegation and it wasn't that totally clear to me.

Pelkey: Was Davies involved in this?

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[2] In 1975 the ad hoc group worked on a First Draft of Recommendation X-25 that they produced in March 1976. In September 1976, a majority of the members of the CCITT plenary approved the Recommendation and thus it became a standard.

Roberts: No, Davies wasn't. He corresponded with the group some, but they saw that as totally--

Pelkey: The PTT was a CCITT --

Roberts: Right, so it was all CCITT, and the universities and everybody played games in the thing called -- there was, after the Arpanet there was a European network that was created, and Davies and that group got involved in that.

Pelkey: Were they importing the IMPs and all that, or was that --

Roberts: No, it was just all on the Hosts, and then they were connecting with lines. There weren't any IMPs.

Pelkey: That's strange. Think they would have learned.

Roberts: It never got to be that major an activity, but it was -- I'm trying to see if I reported on it here.[3] EIN, the multi-national packet switch network (European Informatics Network). I don't know what happened with it.

Pelkey: Who else was representing the United States? Were there other companies that were part?

Roberts: I know it's in my book somewhere, if I go through every page.

Pelkey: They weren't that memorable at this point in time.

Roberts: Actually there's one simple way to do it.

Pelkey: Were there other US companies that were part of the US effort in this area, other than Telenet?

Roberts: No.

Pelkey: So it was really Telenet and Larry Roberts that were the --

Roberts: Then, after I got X-25 done, then I put Peggy Sharpe in as responsible for my dealings, and Steve Ike after that. Steve's here now with my company, and Peggy's has been with us. She's now gone off to do here own consulting, so we sort of had people aggressively be involved later on, but I did it all to begin with, because we needed the strength of having done it and having run the company, to force the original agreement. It's always -- well actually Maurizio Decina, who is now the head of the committee at CCITT, and I have spent a lot of time talking and working on the fast packet business, because that's the next whole generation of this that's going to happen, and that will change the whole telecommunication world in total, in voice and data.

Pelkey: Fast packet being having voice packetized as well.

Roberts: Without some checks and without the same complications and fixed sized short packets, without some checks, are the basic concepts -- so there's it's all done in the hardware. So there's no complication in software. It's all rooted in hardware. I've designed a very high-speed switch and it's now been five years since I presented all of that, and the industry is finally to where it might accept it in another year or so.

[3] Roberts was on-line throughout the interview responding to email and writing code.

Pelkey: Now you have a standard. It's the beginning of '76. You have the X-25 standard endorsed. People have to begin to write software now for hosts around the world, but that's in the process of starting to happen, I presume, in '76 --

Roberts: We did our own software for the IBM, which we had already done by that time in '74. We had it done by a small group, and we had done it for the PDP-10, so it was interface software that we then modified to be X-25. So by the time the standard was done, we had X-25 fixed for the IBM and the DEC, then got people to do it for other machines.

Pelkey: When did Telenet start to ship product?

Roberts: '75.

Pelkey: It was slow going though for the first few years?

Roberts: Yes. It kept on building at a continuous rate from then on out, and by the time I sold it in '79 -- by the time I quit in 1980, it was about $100 million, so it grew exponentially, well not totally exponentially, continuously through that whole period. I don't know exactly --

Pelkey: When did you sell Telenet?

Roberts: '79 we sold it to GTE.

Pelkey: Beginning of the year?

Roberts: Probably March or something?

Pelkey: Why did you sell it?

Roberts: It was two problems. Phil Kelley --

Pelkey: Do you know what happened to him?

Roberts: I think he's still at the Post Office.

Pelkey: Isn't it going to be nice when they get rid of the high frequency noise off these computers? They don't stay on because of that.

Roberts: I know, I have been threatening to have that power supply built into the wall.

Pelkey: I have an SE. I'm writing this on an SE. I'm having to buy -- in fact I may convert over to a Mac II just so I get a bloody fan, and the power supply in another room so I can sit there and have a quiet environment. The SE sits there and all you hear is this --

Roberts: There's another approach, and that's to use a laptop.

Pelkey: Right, when Apple comes out with a Mac laptop, I'll be glad to accommodate. In the meantime I'm getting a Toshiba, unfortunately because of their ethics, but it's the best machine, and putting E-mail on it. In fact, Action Technologies product, Coordinator, I am going to start coordinating my projects with it.

Roberts: Which Toshiba?

Pelkey: It may be the 1100, whatever the lightest one is.

Roberts: The T-1000 is the lightest.

Pelkey: It may be the T-1000. It would be nice to have a more --

Roberts: Trekking all across the country this week.

Pelkey: Because I do a lot of different kinds of projects.

Roberts: The silly thing is six pounds. Everything else is 12.

Pelkey: Yeah, and get the T-1000 because of the weight, and put E- mail in -- computer conferencing software. I'm a big believer in what's going to happen with computer conferencing, and start to force the companies I'm on boards of to do this. People don't want to do it. I'm going to say: "If you want me to be on your board, you're going to buy a $495 package and you're going to run it and connect to the network and that's it."

Roberts: Well, you've got to also look at other possibilities with respect to multi-broadcast fax, because it may be more amenable to some of the people.

Pelkey: To what?

Roberts: Broadcast facsimile.

Pelkey: Yes. We'll come back to that in a little bit.

Roberts: I'm just saying there are types of people, and I don't think you can assume all people are the same, and therefore it may be attractive to one person and not to another, like voice mail and E-mail are attractive to different types of people.

Pelkey: Well, fax is clearly the easiest for everybody to deal with. It's a common denominator approach. So you were saying, you sold Telenet because of a couple of reason.

Roberts: Well, the first reason was that there was no way to get the large companies like General Motors who is putting a little bit of stuff on, and was willing to go with all of the Chevrolet Division or whatever, but they wouldn't --

Pelkey: The typical big company won't buy from small company.

Roberts: They were legitimately afraid to put it on all of their dealers, because if they did, on a lease line environment, and we went away, they would be out of business for at least a month while they reorganized what they were doing, and that would be too big an impact for a company going away, so they really wouldn't do it. The dial business we could get reasonably, if they had other options, actually having Tymnet competing helped, because then people could go on both and have options, but they didn't see any way to solve that problem and get big customers. When we looked, our economics, the educational costs for people were so high per customer, that for big customers we didn't get the economics we wanted. So we really needed to get -- the economics of the service were fine. We had a huge service and training program for each customer to get them to where they understood it and could interface all their terminals and get everything working right. It was too difficult --

Pelkey: Front end loaded with costs and you didn't get your money back over --

Roberts: And it was continuously loaded as they came up until they got their problems straight in all their terminals that they had on correctly, and then it al worked fine. Then you could expand indefinitely with that class of terminals or whatever they were doing, but that was a continuous problem. We saw that that

was vastly better to get them on and with no growth essentially -- Telenet stopped growing almost after I left, because they didn't have any other services, they didn't have any new hardware, they didn't have any new anything, but they did get the big customers on and they did -- that did stabilize them to where the economics were favorable.

Pelkey: And you sold it for what, $60 million? Why GTE?

Roberts: Well, GTE got interested in getting into the business, and so they came after us and they told us that they had learned their lesson with several other companies they had bought and they would never do it again. They'd let us do our own thing and everything would be fine. That lasted for one year and then after that the management changed every few months and they kept on trying to figure out how to position it within their organization.

Pelkey: Now, when you sold it there were only two classes of shareholders, there were employees and BBN?

Roberts: No, BBN was a minor shareholder even from the start. BBN only invested a quarter million to begin with, and should get us to where we had done a filing and we'd get venture capital. At that point we went to venture capital and we got Bessemer Securities and Palmer and Lehman Brothers, which turned into a different group, and BBN and then some other people. So we went out for venture capital and did several rounds of venture capital. So BBN was always under 20% probably.

Pelkey: Do you happen to have that early financing document?

Roberts: Probably.

Pelkey: When did you go public?

Roberts: In '77.

Pelkey: Who took you public?

Roberts: Rothschild.

Pelkey: LF Rothschild and it was --

Roberts: Tobin.[4]

Pelkey: Tobin. December 21st, 1977 was the effective date.

Roberts: That went very well, and people did well on that issue as a result of the GTE sale.

Pelkey: The I.P.O. price was $9 a share. I'll get a copy of the final Prospectus.

Roberts: (unintelligible) . . . in '75 when we started and they continued that way for a year or so and decided it was a good business and we had been doing it, so they filed with the FCC to become a carrier and go into the same business so that they could get in '76, '77.

Pelkey: And the two of you were the primary providers or this kind of equipment and service?

[4] L. F. Rothschild, Unterberg, Towbin

Roberts: Still are. It's a $500 million business, of where Telenet's $250M or so and Tymnet is $200M or so. There are a few other people.

Pelkey: How did the ISO OSI stuff come about? Do you have any view on that?

Roberts: I don't have any detailed stories. One of the things that I mentioned earlier was going on was that there were people who couldn't influence CCITT because they didn't have any way to do that that, and so they started working with ISO to try and get something structured. They weren't carriers, in general, and so that started going on X-25 and there was a lot of similar people, so there was a lot more commonality, but I don't know the entire story of the ISO thing and I stayed out of it because I really wasn't interested. ISO, to me, was not a worldwide standard that anybody would adhere to for any particular reason. CCITT is a set of independent countries, all overlapping and needing a service that worked between them, so there was an absolute requirement for them to work together, and a standard meant everything, whereas ISO was a non -- it was an overall organization where anybody doing anything, a lot of parallel organizations like IBM, selling worldwide, could try to create a standard doing whatever they wanted, and it wasn't at all clear to me that anybody would every do anything that was useful. Nor would they believe it if it was done, so I didn't pay much attention to it. Slowly the concept that we had started with X-25 and layers one, two, three and four expanded on up and they did it CCITT, and then six and seven are primarily ISO, but CCITT now has five levels within their protocols, and acknowledges all of the same levels that ISO does. The facsimile standards and their four hundred standards all integrate up to the fifth level, you're talking about documents.

Pelkey: Now, X-400, if I understand correctly, Jim White, who was back at the UCSB node, some people see him as important in this process of X-400.

Roberts: Can't tell you.

Pelkey: Were you ever involved in the X-400 issues at all?

Roberts: I was involved in the CCITT at that time. I've been watching it for the last several years and looking at what's come out of it, but I haven't been interacting in it.

Pelkey: So you stayed with GTE/Telenet until?

Roberts: Late '80.

Pelkey: And then what did you do?

Roberts: then GTE wanted me to move to -- build a combined voice data something or other and take over their PBX activities, so I did that, and built a new voice/data switch that never got done because they couldn't figure out what they were doing and they changed management every three months. So we reorganized their PBX. Actually, they're selling that now. They have a reasonable voice/data PBX, and did a big switch that never got done because there was too much controversy within GTE. That was a fast packet switch. The people have all gone by now. Holger Opderbeck, who was my designer at Telenet went there and continued to do it and then finally left and started Netrix because they wouldn't do it. After I left it all fell apart because the controversy from GTE Labs was too strong and they were telling the chairman all the time that packet switching is the wrong thing to do.

Pelkey: So Netrix now is the repository of that technology?

Roberts: No, Netrix went sort of a combined circuit/packet approach because of the people that Holger had, so they are building a switch which is a nice switch, but its sort of a mixture of circuit and packet.

Pelkey: That's what it strikes me as.

Roberts: It's not a fast packet design.

Pelkey: Is there anyone that was working with you on that project that's gone off to work on a fast packet switch?

Roberts: Just me. Steve Ike is with me and is working on it with me, but really, somebody has to fund it, and that's -- we've been looking at that issue of funding it. It's very hard to do within a conventional corporation, AT&T or GTE, because of the internal controversy. We've even seen that within one of the T1 multiplexer companies we talked to. They couldn't -- they want to go outside to get it because there's too much controversy inside. It's still a totally controversial issue.

Pelkey: That of the viability of fast packet?

Roberts: No, not the viability. The technologists can't live with each other. The customers all want it. I think there's probably 90% convergence of all the PTTs in the world wanting it. That's what they think is going to be the next generation of equipment, and it's going to handle all their voice and do their multi-rate speed: 16, 24 and 32 kilobit voices, 64 and video and data. And for the government, their high-band stuff, 45 megabit, 100 megabit, but there's very little way to get that together, except to build a company, as far as I can see.

Pelkey: Did any T1 companies' core people come out of Telenet?

Roberts: The people who started NET weren't involved in anything. They were all in the circuit environment. The people at --

Pelkey: Cohesive or NSS?

Roberts: I don't know. It's hard to track everybody. There is some fast packet in the midst of the thing that's being done at -- that Codex is buying from somebody.

Pelkey: StrataCom.

Roberts: StrataCom, but it's only the back channel way of multiplexing -- of switching, so it's not particularly strong fast packetizing.

Pelkey: What's the difference between back channel and fast packet?

Roberts: You can bus things together with a local area net with a back channel bus with any sort of thing. If you have a back channel bus and you use a fast packet approach on it that is a good way to bus. It's not that different from a computer bus. So if you want to switch a bunch of things in a box, that's one way to do it, and it's perfectly viable. You're not developing a fast packet transport anywhere in the system; you're just using it as a back channel multiplexer. And it's a very good approach. It's probably the best way to build a high-speed switch, so that's what StrataCom did, in that respect, and it helps them build a higher speed switch.

Pelkey: But there's no one right now that's building a fast packet switch in the sense of on nets --

Roberts: Well, AT&T and BELCORE both have research prototypes, and the French, so those are the three that we know of that are -- and the one I did at GTE, but I'd say that --

Pelkey: But are there any commercial companies or entrepreneur companies?

Roberts: No, not at the moment.

Pelkey: Were there any other communications companies that spun out of Telenet that you're aware of?

Roberts: Well, lots of other people. For example, at TeleStream, which is building a packet box, John Peters, who was one of my chief people at Telenet went there, and is working with them, but I don't know exactly his influence there. Clearly, the LAN business. Another thing that happened is Equatorial, which is doing the VSAT thing, is all slotted Aloha, which is what I developed and wrote the first paper on back when we were doing the satellite experiments and the Aloha experiments at the University of Hawaii.

Pelkey: I wasn't aware of that. Could you come back to Abramson's work? I need to talk to him because he had a big impact on Metcalfe in terms of what became Ethernet.

Roberts: Yeah, well, what happened is that Abramson developed ALOHAnet.

Pelkey: Independent of your activities?

Roberts: Virtually independent of everybody, I think. Maybe not?

Pelkey: It was taxicab oriented?

Roberts: Yeah, it was sort of a local island communication technique to transmit at random times and see, if there was a collision, to just try again. So he wanted funding to make that a reality, so from ARPA, I funded that as a new segment of the packet technology, and got that developed further.

Pelkey: Do you recall when that was?

Roberts: Oh, back in the early '70s. I don't know exactly what year. He and Frank Kuo were there, and we developed that to where we had good radios and so on, but one of the things we started doing then, in the ARPA community, was to start writing papers and communicating through the SRI data bank about all these packet techniques. There were hundreds of papers and activity was huge, activity on local area nets and radio nets and satellite nets, developing the packet technology we had gotten from 1971 and '72 and '73 was very prolific, in terms of everybody looking at all of these issues. (Referring to a paper in his hands) I don't think this paper covers much of that, but what I did at that point -- when I looked at what they were doing in ALOHA, I wrote a paper called Slotted Aloha, which is the first paper in terms of local area nets and satellite communication technology, because what it does is improve the throughput by a factor of two over what Norm was doing, and it developed -- then there's another paper on reservation technology and how to improve the throughput a of lot other ways, but Slotted Aloha was the simplest and next step . . .

Tape Side Ends

(Transcriber: The following material is of marginal reliability at best, due to extremely poor quality of the recording:)

Roberts: So the concept was to -- instead of having random Aloha disasters to happen to be (unintelligible) or not. So there was a problem. That got incorporate in local area nets got incorporated in the satellites, and commercially they are the system that Contel just bought, which is the Equatorial Corp. It's based on that technology slotted technology. And they use that for all the VSAT antennas. The local area nets use collection of the technology, CMSA is of course what sort of evolved out of the next step, and all of that evolved out of the ARPA working group, so you saw papers that Kleinrock was writing where everybody in that whole group, and I don't even have the whole track of who wrote on CMSA first, but there was that whole series of papers that was ongoing very rapidly at that point.

Pelkey: And this is in the '71 to '73 time frame?

Roberts: Yeah. And then out of that grew the all of the various packet technologies going off into other areas.

Pelkey: Were you involved in any way in terms of this launching of Vint Cerf's efforts of looking at, and improving, the host-to-host protocol. I understand that when he came to Stanford he got involved first in looking at other protocols that eventually led to the concept of inter-networking became an important issue became connecting radio networks to land based networks and so on.

Roberts: Well I started that whole project of the radio network at ARPA and so on, and as he came to ARPA, he and Bob started working on this whole internet thing. And the internetting thing has always seemed to me as somewhat crazy, because if you build unrelated networks without standards, you have to do something, but if you build networks the way that they commercial world would clearly build them, there is no problem. Just interconnect them cleanly, so I've never understood where it fits into the world. I mean, it fits into a research environment and you can build great internet gateways that can somehow get you from this totally non-standard technology to that totally non-standard technology, but the only place I've ever seen it fit in commercially is to connect from the commercial networks back into the research environment, as a gateway between the two, because in reality, with the worldwide network that we have today, it's all packet switched and we have no problem in the network we have now for facsimile interconnection of all of that and it interconnects X-21, X-25 and circuit switching and packet switching throughout the world with no trouble at all, over satellite, radio or anything. So I don't understand why you have to have this complex gateway. If you have a clean protocol, you know what to do. You know how to set up this virtual circuit. When you want to set it up, you set it up. Whatever the net technology is or what it does. So you just have X-75 between networks.

Pelkey: I'm not a technologist, my understanding is that one of the issues is the acknowledgment; has a packet been received so that these gateways, in fact you have these radio networks where information comes in essentially one way, how do you ever broadcast back and get any kind of response that makes any sense over the total network?

Roberts: Well, it all depends on what the acknowledgment is. There aren't any networks with only one way broadcasting to speak of, except a version of the Equatorial System that's for outbound. Most of them are two-way, and therefore you can acknowledge eventually. A lot of what we do in facsimile is one way for a period, because you don't have much to do the other way, then you eventually acknowledge the page, and there's no problem with that. If there are errors, you just send all of those blocks that were bad again. So you just send back some information saying: "These blocks were bad in this thing," and then acknowledge the rest. So that's easy to do, and people have developed protocols to do those things very smoothly. The end-to-end process is not difficult because all of the processes include that. If you just use X-75 to interconnect things, everything works. If the process on one end is a radio net, acknowledgements may take a while. You may need long acknowledgement sequences, but that's not a problem.

Pelkey: But your argument, your view, is that if everybody manages to function with one standard, then there is no problem connecting. Standard being a packet size --

Roberts: No, no. The packet size -- you can have all sorts of packet sizes and all sorts of things and they can go on into the circuit nets and so on, and they don't have to have one standard delivery end --

Pelkey: If transmitter (unintelligible) right.

Roberts: Not necessarily. We can translate between all of the various standards that exist commercially --

Pelkey: But isn't the concept of the internet working just doing the translation between them?

Roberts: But that's not a complicated concept at that point. We build a box that translates between protocols. It's no complicated thing at all. It's a little box. So that's just a - -

Pelkey: Matter of degree.

Roberts: You should see the complexity that the goes through in these internet boxes to try and coordinate empty spaces and other things. They play lots of games and it becomes a very complex process, and all I'm saying is it's not a complex process, and I wouldn't even rate it as something which deserved to be mentioned, hardly, but they make it into such a big thing because of the difference of the technologies. If you have virtual circuits across all systems, there's not a problem. If you don't know the addresses of the other network, you've got a problem; if you don't know how to set it up, you don't know how to get acknowledgements, you don't know how to do anything. There you have to set up something, so commercially, nobody's had any issues with it. It's never been an issue that was even mentioned because you just build and X-75 interface between the two systems or an X-21 interface or whatever it takes.

Pelkey: Do you have Abramson's number? Is he still at University of Hawaii?

Roberts: I haven't kept track of him.

Pelkey: In terms of the history of certain issues that I was aware of, is there something that we haven't talked about --

Roberts: Well, the next issue is fast packet. I introduced that, probably it was at the Ericsson ceremony when I gave the Swedish paper. I won the Ericsson Award, Len and I did. And so I then wrote a paper on Reuters, how that was being transitioned to packet switching.

Pelkey: Can I get a copy of this?

Roberts: And so that was the first --

Pelkey: This was 1982, at least the prize was. Work was done when?

Roberts: Paper was done in '81, '82, just before the thing. And then I was busy building the experimental switch at GTE, or the first -- it wasn't experimental. It was a product, although it never got finished. And the whole concept of fast packet has developed since then to where I believe that it's ready to go commercial, but -- and I have been designing, recently, a very complete system around it, but it's still a guess as to where it happens in the world.

Pelkey: Let me ask an editorial question --

Roberts: That will, in fact, in the next generation, facsimile. It will be necessary for facsimile. Facsimile is totally uneconomical on the phone network. About five percent efficient over the phone network, so it's going to have to go on the data networks, and the data switching rates will be far beyond what the phone

-- I mean the current data networks can handle. So we need a new technology. Packet networks with X-25 work fine up to a point, but I think it'll last about two years (unintelligible) of the facsimile before they'll fall apart with the quality switches on the market. So we need fast packet for that. We need it for voice. We need it for a lot of things to integrate it all and, then when it's all together, then I believe that the whole concept of what you sell changes. You just sell access to that worldwide trunk system utility, and essentially, instead of selling somebody a T1 span between Chicago and New York for their business, you'll sell them T1 capacity of fast packet between wherever and whenever they feel like it.

Pelkey: How does this coincide, coalesce -- PTTs are trying to foist on the world what they call ISDN.

Roberts: That was a poor predecessor to the right step.

Pelkey: I share that idea.

Roberts: It'll happen and it'll help in some respects. It's a good local loop technology for getting 100 kilobits or whatever.

Pelkey: It's neither here nor there, isn't it?

Roberts: It basically what you need for facsimile and your voice, so those are the two primary utilizations today. Nobody has developed video beyond that to speak of, so to the extent that you look at what people would really want to do today, the biggest data uses they could possibly generate by an order of magnitude is facsimile. And the other biggest one, I mean the primary biggest one is voice, so those are the two things --

Pelkey: What about bit mapped graphics?

Roberts: Bit mapped graphics is facsimile. What's the unique difference?

Pelkey: Just the amount of data?

Roberts: Bit mapped graphics is -- facsimile is bit mapped graphics compressed, and of course if I have a bit map that I want to send to a laser printer somewhere, I've got to compress it, so you put it in Group IV technology, typically, to send it anyway. Then, with the X-400 overlay, I can have text and graphics mixed together, text and fax mixed together, so I can have a mixed document, the picture being a compressed image. Not a V-29. It would be a Group IV compressed image, and then the rest of it being text. And that's fine, that's what people will be sending in a couple of years everywhere, and that's what we do now with our machine that we're building. We have a local area net that goes all around the building. We send everything in the mixed mode and it generates fax. Essentially, the output of that goes to the printer port, which expands it back to a bit map for a laser printer. So everything gets moved around that way and then moved around the networks that way, and the volume today is about four times as much as any other data volume that's on the phone network. That will probably grow by another factor of ten over the next ten years, so that becomes a very significant volume and the ISDN will help us handle that at the local building economically. It's not the right interface. It separates the two totally, and it has signaling on a third channel, which (is unused), but it was the best people could agree to at that point in time, and it doesn't really matter because I can put a box at the other end that integrates it all back into anything I want. So who cares what it was on that channel? So what's being built --

Pelkey: You just have to add another level of boxes.

Roberts: Standards are almost always beneficial independent of whether they are great or perfect, because then I can go buy standard things, I can put on a standard thing and I can do it economically. So there will be a standard bus off the ISDN and when it gets replaced with a fast packet pipe, that'll be a fiber coming into my house with just fast packet, and an integrated signal handling voice, data and video.

I can go to whatever I want, but in the meantime, before that happens, this is a technology. Most people wanted to wait for that -- some people wanted to wait for that at CCITT and say: "We really ought to wait until it's fully integrated," and nobody could wait because it would slow up technology too much. So people did this, and I think this -- it may not fully happen before it gets replaced.

Pelkey: Why did the modem guys and multiplexers completely miss out on it? Some of them acknowledged that they were aware of Arpanet, somewhat -- the whole process of X-25 and local area networking, they missed it. Why?

Roberts: It was almost the same thing as -- DEC grew out of circuit switching technology, and the modem people were -- bit modem designers, Bell and other places, so they learned how to modulate signals in a single dimension without any statistical multiplexing, and the whole concept of statistical multiplexers slowly infiltrated the multiplexer technology, but slowly, because those people were happy with their fixed channeling.

Pelkey: TDMs?

Roberts: TDM. So that progressed for quite a while and became what some people did, and then some people still haven't changed. T1 environment that's still potentially an outgrowth of the same concept except that it's gotten a lot more complete. But I think, generally, when I look at some of the T1 multiplexers groups and doing that, they're all circuit oriented, they're all TDM structure oriented. They think in terms of fixed allocations instead of statistically variable allocations and they're always subject to the problem I see all engineers subject to, usually, and that's one of the things I always have to fight, and that is they look at the worst case and they say, we have to design for the worst case and leave enough buffer to (unintelligible) everything for the worst case. I say: "No, you've got to design for the statistical case, not the worst case, because if you design for the worst case, you're way out on the end somewhere, so let's look statistically at what it is," and they don't have the probability background to do that, so they don't. So I have to keep on going at my engineers all the time and fixing that, because they keep on designing to the wrong point, and that's historically true. I think anybody who has done any -- developed any packet switching has somebody that has probability data doing that.

Pelkey: Did Leonard Kleinrock have any impact on you in that?

Roberts: No, not in my training. I learned probability theory. That happened to be one of the things I studied at MIT, but we both went there and we both went through the same teachers and we both knew the same background.

Pelkey: Were you there at the same time?

Roberts: Yes.

Pelkey: When did you finish up there?

Roberts: I finished my PhD in '63. We were both their in '61, '2 & '3 doing PhD work, so we both finished around the same time approximately.

Pelkey: MIT was clearly the center --

Roberts: He had a lot of impact on lots of people. I don't want to minimize that at all.

Pelkey: No. I look forward -- hopefully I'll get to meet him next week. I'm trying to set that up. Another kind of question? MIT in the '60s was a powerful place. Xerox PARC became, in the '70s, became the seminal spot of technology and ideas. At some levels, it strikes me that MIT got swept aside in terms of influence, in terms of where things were happening, but in the '60s, much more was happening at MIT

than anyplace else. Was it a function of strategy or luck? Why did that happen? And can Xerox PARC be replicated or was it once and done?

Roberts: No, it's easy to replicate it. In fact, it was do to the fact that Bob Taylor went there, knew all the people, and went after them with enough money to hire them all. Here, you can lead a wonderful life with all these other people, and they all said: "Great, I'll go to California and do that because you're paying me enough," and I was busy screaming at him because he was taking all the key people from all my projects around the country -- not screaming at him, because I liked him, but it was a continuous process at that point of losing these people from MIT and BBN and everywhere. And Bob knew them all because he was in ARPA, so he went there, being a good recruiter, in a sense, and a good person to not lead the projects but pull it all together and make sure that something happened, and that's really what happened at Xerox PARC. They got a lot of bright people in one place at one time and paid enough and so on. MIT had that because of the amount of money ARPA gave them back in the early years, in part. There were probably other sources of money too. Rad Lab was doing pretty well as a result of radar and other things. Rad Lab is research laboratory in electronics at MIT, developed -- well worked through all of World War II on radar and other things, and Multix was funded --

Pelkey: ARPA funded that?

Roberts: Yes.

Pelkey: And that came out of John McCarthy's thinking?

Roberts: Well, Licklider did the funding from ARPA. John McCarthy was one of the people who were generating it. (unintelligible) was the program. John was pushing the that it happen. Actually, he spent all his time on the PDP-10, so he didn't pay much attention to it as it proceeded, but he was one of the people on the committee who was pushing for (unintelligible) was happening at MIT. I was there at the time, and was watching it, but I wasn't involved heavily in the design.

Pelkey: As I understand, this is a digression but, in terms of operating systems, Multix was --

Roberts: It was ideal.

Pelkey: It was simple in terms how the idea got pulled together.

Roberts: But it didn't ever go anywhere itself, because they did it on the wrong machine and they weren't associated with a commercial organization.

Pelkey: That process of -- now that Bob Taylor is at DEC, and presumably he's still well connected, do you think the same thing could happen at DEC that happened at Xerox PARC because --

Roberts: Probably not.

Pelkey: So it's more than just money and Bob Taylor pulling the right people together.

Roberts: It depends on when the right project happens, too, at the right time.

Pelkey: What was the right project?

Roberts: There were a number of projects. Local area net activity and there was the small machine editing, the Star predecessor, but none of it went anywhere, and so now people are pretty leery of all of that, because they saw Xerox never take it to production, and so Apple and other people took it and used it, but Xerox never did anything with it. So, most of the people who were there got tired of it and it would -- and are probably more likely to try to work within an environment where that it would happen. But I don't

know, clearly there's going to be areas of excitement where people create and leave exciting projects, wherever that is.

Pelkey: Two events happened --

Roberts: But they also need the money.

Pelkey: There were two sources in the '60s and '70s that were critical. The '60s, in particular, were critical in terms of research in the United States. One was ARPA funding, which in the early '60s probably funded 60% of the computer research that was done in this country.

Roberts: The early '60s, before I went, it was about 15 million a year, and that was a lot. It funded mostly university activity. I expanded it to 50 while I was there from '67 to '73, and it's now grown, after shrinking some. After that, it has come back up even larger. But it's not going to the universities so much. I think that it was the primary source of our engineers, was the funding of the universities.

Pelkey: I agree. When Mansfield came in in the early '70s --

Roberts: Yeah, probably '71.

Pelkey: You were still at ARPA?

Roberts: I had to get around it.

Pelkey: It strikes me that that was a critical decision on the part of the country, in terms of forcing where you spent your money, to be much more focused on immediate defense applicable projects, as opposed to more fundamental research.

Roberts: It was, and we had to keep on working to get around it, but it got harder and harder with time.

Pelkey: It strikes me, in terms of long term R&D in the United States, given the critical role that ARPA played during the '60s and '70s, if you look around now, in terms of technology growth, and it came through the kind of projects that you funded in the '60s, that we've taken that resource away from us.

Roberts: I think DARPA has still been doing it at some level, but the level has been -- and the freedom has been impacted, so there's not as much basic research funding coming out, and it has been hoped that -- and NSF has been trying to rebuild that, but that hasn't happened as effectively as we might hope.

Pelkey: Is that a function of leadership or a function of --

Roberts: It's also a function of government policy, and that's a function of how the leadership works, and to some extent --

Pelkey: Farber's group was funded by NSF, which then got pulled into what MIT was doing.

Roberts: But MIT also has the problem of, as the field develops, it can't develop a big enough team to do a big thing and carry it through, and as you really need to carry it into commercial fruition, anything you do. Multix never got anywhere. It showed the field where it was going, but it would have been much nicer if somebody had picked it up, and gone forward and had a product. They never developed a good path from the university outwards, and the team size got larger and larger, so that universities have to stay in the one man, to five-man level. Hopefully, they will always do that, they will always have the funding to do that and keep growing but the bigger projects that we need have to be done elsewhere in large part. Venture capital has grown up help with that, in part, and so new companies are one of the more effective ways of --

Pelkey: Venture capital is helpful on projects of 10 to $30 million dollars funding size, but they're not good at projects that are $50 million plus in funding size.

Roberts: I know. I've noticed that.

Pelkey: It doesn't happen; to be able to manage or take that kind of risk; as well as the time frame. $50 million are generally longer terms projects than $10 million projects. Venture capitalists fund development, not fundamental research.

Roberts: That's right, but in many cases you don't need the research. For example, what we're doing with the fast packet. We're just doing development.

Pelkey: Bell Labs did research. We could argue how effectively, but with divestiture where Bell Labs is going to be, now we're not funding it by every one of us putting 25 cents in our telephone bill. We've taken that long term fundamental research facility in the United States and changed the character. In terms of the United States being a fountain of creative ideas providing the great economic growth of the future, how do we deal with this? Where do we get research done for future economics in our society? You, as much as any person in the United States should have an informed view of that. What's your opinion?

Roberts: Well, I tend to believe that the government needs to do what it did and do it more cleanly, perhaps with venture capital and some other technique, but focused, organized -- project organization like DARPA was such that you go out and get it done at a high level, and fund MIT to do whatever its doing, or Rand or some place, and maybe it's not all universities, but there certainly should be enough of that to train the people and give them things to work on, and then the real projects to develop, whatever it is, needs to be elsewhere. But that has to be going on, and there have to be some of those things happening. For example, one might, if one had undertaken to develop a fast packet switch at this point by the government in a commercial organization, and made sure that it was developed so that it could be a product, then the world would be buying it today. The world is ready to buy it, but nobody has built one. So the real issue is that nobody undertook initiative, because, as best people could figure it out, it was going to be a hundred million dollar activity, as most switches are, unfortunately. I've sort of reorganized it so maybe we can do it for 20 million, but even that's heavy for venture capital. So my guess is that the government could be very effective in some of those areas if you wanted to get involved, but it doesn't have the structure or organization to do that, and most industry doesn't either.

Pelkey: So you concur that it is an issue for our society?

Roberts: Oh, it's an issue, and I keep on finding ways to get around it with venture capital and other corporate funding, or something to try to make things happen, but it's certainly an issue. My belief is the only reason the country got to where it has is because of all the ARPA funding of the universities. That's not there to the same extent.

Pelkey: I agree, so therefore, qualitatively, in a general sense, we are not preparing the basis for the next generation of people, and infrastructure and technology, and everything else that's required to be able to create that kind of growth.

Roberts: So I think that's going to be a big impact on our economic status in the next 20 years.

Pelkey: I agree with that, and this book is about that issue. I thank you very much for your time. You've been very kind with it. After you read this transcription, if anything comes out, I'd appreciate your comment

END OF SECOND INTERVIEW

