
# Interview of Frank Heart

Interviewed by:
James L. Pelkey

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**James Pelkey:** I understand you were at Lincoln Labs and in contact with Wesley Clark and were aware of some of the things that were happening at Lincoln Labs that predated your involvement at BBN.

**Frank Heart:** Right, a lot of the players in the Arpanet game were at Lincoln in one way or another. I worked at Lincoln and Wes Clark worked at Lincoln and Larry Roberts worked at Lincoln, and so over a period of time I got to know those people.

**Pelkey:** Were you at Lincoln when Larry was doing his experiments?

**Heart:** Yes. Well, wait now. I'm not positive on the dates of that, actually. I'd have to go back and look. I went to BBN in December of 1966, so we'd have to get the dates right to figure out exactly when that happened. I wasn't directly working in the same group with either Larry or Wes Clark. Larry Roberts worked for Wes Clark in a group there, and I knew them and worked with them, but it wasn't a direct working relationship. We weren't in the same groups, and I was off in other pieces of Lincoln working on communications problems, on seismic arrays and on pointing antennas and so forth, at that time.

**Pelkey:** The issues in communications, were you dealing with the issues of the telephone networks at this point in time?

**Heart:** I had been involved in computers and communications for a long, long time, because many things Lincoln did were involved in communications to computers. All the seismic arrays communicated back from data they were taking to computers, and all the antennas communicated back to computers, and the whole SAGE system, of course, early, was built on computers communicating with each other and with radar sets and with other things, so there was -- a great deal of work had already been done long before then on data communications between sources of data -- whether they be seismic arrays or radio telescopes or radars or other things -- and computers, and between computers. So that was a well mined area, in terms of simple the technology of using modems and connecting data sources to computers. I had built a half a dozen different systems, either in terms of seismic areas or radio telescopes or radars, or connection between computers in the SAGE system, so that was an area I was involved in a lot.

**Pelkey:** Where, at this point in time, did the modems come from?

**Heart:** Well, there were different sources. It depended. A lot of them came from the phone company. One, we used phone company supplied modems, and there were some other companies making modems. I don't recall, certainly, the exact names of units that were used. I tended to be more involved in the work that was done inside the computers to cope with the communications, rather than involve myself in channel design or in modem design, or in worrying about satellite link calculations or things of that sort. I was always the guy -- I tended to work on systems projects where I might be in control of a project where the goal was to get a seismic array and have all this data get back to a computer, and there might be many sub-groups, one of which would worry about getting modems to exist, or buying them. So I tended not to be a designer of modems, for example, or things of that kind.

**Pelkey:** Did you know J. C. R. Licklider at the time?

**Heart:** Oh, sure. All those people knew each other.

**Pelkey:** Were these concepts of the limitations of the communications networks -- be it the speed of modems or the nature of computer communications –

**Heart:** Yeah. There was a constant pressure on the technology. The technology, even at that time, was changing pretty rapidly, and as people began to build more real-time systems, they began to want increasing speed modems, and they worried about error control and they worried about all the other things you do when you send data. However, one thing about radar data, or seismic data, or other sources of continuous data, is you cared a lot less about the loss of a bit or two. In other words, if you're getting a radar picture every three seconds, the fact that one of those radar pictures is missing a few bits is a bit irrelevant, so there wasn't the same concern with those kinds of transmissions that there later was

  

with transmissions of digital data where you were sending a program or you were sending something else where you really minded missing a few bits. So that was a distinction.

**Pelkey:** Why did you go from Lincoln Labs to BBN?

**Heart:** I was extracted. I went to a summer study, an Academy sponsored summer study on Cape Cod in a beautiful place near Woods Hole, and there I met Danny Barbaro, and Danny Barbaro worked at BBN, and we became friends over the period of that summer study, and we worked together a lot, and BBN had a problem in that they were involved in a large project -- a so called 'hospital project' with Massachusetts General Hospital, and that project was in trouble. BBN had made a deal with General Electric to build a thing called MediNet, and Jordan Baruch, who was running the project at BBN, had gone off to MediNet, leaving the project in the hands of relatively young people. So they wanted someone to come help. So they extracted me over a period of -- and I found it a very hard decision. I had only had one job in my whole life, at Lincoln Laboratory, and I had been there 15 years, so it was a very difficult extraction. I finally decided to accept the offer and go to BBN. The reasons are complicated. There's all kinds of reasons. People think they should have more than one job, sometimes, and there's also the fact that BBN was a commercial organization. There was some chance of making more money out of it, and also I was interested in the life sciences at that time -- I still am interested in life sciences -- and Lincoln was not involved in Life Sciences. In fact, it was a bit of a problem for some people. Wes, among others, would have wanted Lincoln to be in life sciences more, and wasn't able to do that. So I went to BBN for a complex of reasons. Mostly, they came chasing me. That was the main reason.

**Pelkey:** Where did you do your schooling?

**Heart:** At MIT.

**Pelkey:** Did you get a PhD?

**Heart:** No, just a master's. That was enough, at the time, for me.

**Pelkey:** So when you went to BBN in December of 1966, the process of having to deal with this Arpanet was yet a year away?

**Heart:** Yes, and there was no -- at that time, when I went to BBN, I knew nothing about any plans that ARPA had for an Arpanet. That was a completely unknown phenomenon at that time. I went down there to work on life science computer systems -- was the reason for going there. I arrived just in time to officiate at the funeral of the project that they wanted me to come fix. I did do that, I officiated at that funeral, and then I went on to other things, and among other things, along came the Arpanet ideas.

**Pelkey:** Do you recall when you started to get involved in that?

**Heart:** Well, it was fairly late. I was not involved in the early work. For example, Bob Kahn was at BBN at that time, and he was actually involved in this before I was. We were in different pieces of BBN, slightly, and Bob was involved in some of what I would view, at this point, as theoretical studies of Arpanet error control, in particular, and he had been doing some work for ARPA in that area. I was not directly involved in that, actually. I first heard about this when ARPA began thinking about the procurement. It was probably in early '68 -- was the first time I really knew anything about this. I began to hear about it from people at ARPA, and then we began to track it and watch for what was happening, and pay attention, and then we began to talk to the players and understand who else was thinking about it. Finally, an RFP came out after a long time, and BBN decided that I should lead the team that responded to that RFP, and I did that. That was a very busy time, and a number of people helped with that -- Will Crowther, in particular, was another key player, technically. Will had followed me from Lincoln to BBN, as did Dave Walden, and so those people both were at Lincoln.

**Pelkey:** Had they worked with you before?

  

**Heart:** Yes, they had both worked for me at Lincoln, and so –

**Pelkey:** And they came well before this RFP?

**Heart:** Again, we have to be careful with the dates. I can't, out of memory, tell you when those people showed up at Lincoln. Crowther was there certainly in time to help with the answer to the RFP, so he was there before that RFP had to be answered. I have forgotten the exact date that Dave –

**Pelkey:** It was July when it was issued.

**Heart:** No, I say I've forgotten the date that Walden came to BBN.

**Pelkey:** Excuse me.

**Heart:** So there was a set of people that worked on that RFP, and that included people like Crowther, it included people like Bob Kahn, and there was a team put together at BBN to respond to the RFP, and we worked very hard. Severo Ornstein was involved in that as well. He also followed me from Lincoln, so a number of people had followed from Lincoln. That was very pleasing. I didn't raid Lincoln; they all came by themselves.

**Pelkey:** That's a great compliment.

**Heart:** Another person was Holly Rising, who came from Lincoln.

**Pelkey:** Was the process of responding to the RFP a team effort, in terms of the group of you?

**Heart:** Sure, it was a very, very active team effort. Different people worked on different things. Ornstein had a great deal to do with the hardware design. He was instrumental in interacting with Honeywell. We had the problem of picking a computer, among other things. It was kind of interesting that a number of teams ended up picking the same computer. I think that at any given moment in time, if you are looking really hard at performance of machines, there's always only one or two that everybody notices is the right one, and in this particular instance, Honeywell happened to be the place that had the right one with the right characteristics at that particular moment in the right price range. So we, among several of the other groups, ended up picking the Honeywell machine, and that was a very difficult interaction, because we wanted some special things, they were dealing with several other bidders, they had their own troubles, and it was a complicated procurement problem. Ornstein was involved in the design of some of the special equipment that had to go with the computer and some of the special boards that had to be built for it. Crowther and Kahn and others were responsible for thinking about the system design, the software design. Bob Kahn also continued his interest in the error control aspects of the problem, and he also worried a great deal about routing. There were a number of people that -- that was, again, one of the critical problems was to think how to do that, and Crowther and Kahn both worked on that problem, as did some other people. We even had some consultants come and help with that problem eventually, but that was -- there were several technical problems that hadn't been dealt with ever before, and among them was -- the error control was particularly important, and the routing issue was particularly important, and the question of performance was critically important. An interesting thing about performance is that, at that time, very few people understood how to build real-time computer systems. In other words, there were a lot of people using computers in the life insurance industry or in other things where you want to get it done that night, but it didn't matter if got done that microsecond. There really had not, however, been very many real- time computer systems built as of that time, and there were not very many places that really knew how to do that very well. Lincoln had been one place where many such systems had been built, and so a lot of the know-how in doing that was rather special, and people like Crowther -- I keep using his name because he was a very key player -- people like Crowther knew how to extract the last ounce of performance out of a computer, in terms of having very, very tight machine language loops and so forth, whereas many other groups that tried to build systems would use the existing operating system, or would use some higher level language, which was just not workable in those days. Now, with very, very large memories and with very, very powerful machines, you can get away with building real-

  

time computer systems with higher level languages, but in those days it was death to do that. So it was very critical to be able to design the system in a way that could take advantage of every bit of the performance of the machine, because there were tight constraints on the performance in the RFP, and one had to be able to show that one could meet those performance criteria. An example of this is -- you probably know that there was some other work going on at the same time in England at the National Physical Laboratory, and I can recall a couple of years into the project, going over there and telling what some of the performance figures were for the machine, and they literally believed we were liars. They did not think that we were just bad guys, they believed we were lying, because they built their system using the higher level language and the operating system, and their performance was just off by enormous amounts. They had a lot of the same technologies built in, but the performance was just completely different, so that was a rather important issue, and that had come directly out of the Lincoln background. That was one of the things that the people who worked at Lincoln had learned, that when you're building radar systems, or the SAGE system, or systems to handle seismic data, or radio telescope data, the performance was very critical. That was not a thing that was everywhere understood.

**Pelkey:** Right, and a lot of the other teams that were bidding this didn't have access to the same talent.

**Heart:** A number of them did not. Again, this was not a unique -- I'm not suggesting that it was a unique situation, but it was one of a very small number.

**Pelkey:** At this point in time, were the group of you aware of Donald Davies and his work, and did you read that and Paul Baran's work.

**Heart:** No, no -- well, Baran's stuff was known and referenced. All the people who had gotten the RFP knew about Baran's work. There was not much known about the work in England. None of that work had really -- I never read a single paper from the English group prior to the RFP being answered, so no, that was not well known here.

**Pelkey:** Even though close to then, at the Gatlinburg conference, they made a presentation?

**Heart:** Well, yeah, but there just wasn't much detail. There just wasn't much known about it. It's all in the details. It really is. It's the details that are the -- it's not the general idea. People can write all kinds of paper machines, and it's the details that matter, and this was a different system being built.

**Pelkey:** My sense of it is that in this area of, as you say performance, but also in the case of error control, routing, and maybe there were some others –

**Heart:** There were probably a few others. Let me mention a couple of others. Another very critical one that was, I think, not understood hardly anywhere and came somewhat out of the Lincoln work, was the question of monitoring and how you did, essentially, servicing a network when it broke; how you took care of monitoring and isolation of trouble. When you build a big system--and in fact, this is a thing which is plaguing the industry to this day--it's not something which has been ever understood; it's not understood by many people now, even after all these years. Great attention was paid to how do you isolate troubles and debug the network, and an example of that was at every point in the Arpanet it was possible to loop things. You could loop the modems and you could loop both sides of the modems and you could loop on the telephone line side as well as on the computer side, so that when someone called up and said something wasn't working, you could, from a central place, go and do all this touching the network to isolate troubles, and that was another technology which I had learned at Lincoln, and which was not widely in vogue. There were a few. I'm not sure I can get them all just sitting here, but there were three or four or five key things that made this system very different, technically, from most systems that were around, and that work had never been applied to digital communications before.

**Pelkey:** I'm of the understanding that Leonard Kleinrock, as an example, had some influence regarding the measurement.

  

**Heart:** No, that's a different topic. He was never involved in any of the issues of how you did debugging of a network trouble, or how you did localization of a trouble, or how you built a network to allow you to do that. He did none of that. Kleinrock's group got involved in, as you say, measurement of the performance of the net. They were involved in what was its performance. They wrote host programs that would essentially try to use the network, and measure actual performance. They were not involved at all in the design of the network or of the subnet, and they weren't involved at all in the question of how did this subnet police itself to locate troubles. It was a completely different problem. It was a measurement and analysis of performance problem that Kleinrock was involved in. He had nothing whatever to do with the early design of how the network monitored itself and found troubles or found broken pieces. He wasn't interested in the maintenance issue at all. It was completely different.

**Pelkey:** At some level, there was an interface that came to be defined within what came to be known as the subnet, that was, in fact, your responsibility.

**Heart:** That's right. BBN had a contract to design, build, install, and operate the subnet, and that included making it work when it broke and finding the troubles when it broke, but the point is, you had to build in stuff. It's like what's called now 'built in diagnostics' There's a new term for it that's been invented.

**Pelkey:** But at that time, it was a new concept.

**Heart:** At that time it was a very -- well, not, again, 'new' is too strong, because it had been used in certain things in Lincoln and the SAGE system, but it was not a well-understood concept. It certainly wasn't a prevalent concept, and certainly had not been applied to the same degree with anything of this kind. There's not much new under the sun, it's a question, however, of the degree to which it's understood and used by people, or whether it's just theoretical in some paper. New is -- it's tough to find really new things.

**Pelkey:** Then there was the process of, after responding to the RFP in September or October or something, there was the selection process where it got narrowed down to four and then got narrowed down to two –

**Heart:** We weren't really involved in that.

**Pelkey:** Right, but did you see anything? Did you know what was being –

**Heart:** No. Well, we would get a certain amount of scuttlebutt, but the government tried to be as absolutely pristine –

**Pelkey:** Did you ever have to go back and –

**Heart:** Oh, we had discussions. They would come back with questions, or they would come back and want clarification or that kind of thing, but there was no involvement in the selection process.

**Pelkey:** So once you submitted your response –

**Heart:** As I say, there were interactions where they would come and they -- they probably came and visited, and they probably came and talked to us and they came and asked us to explain how we were doing things. They came and asked questions and they came and asked us how we handled thus-and-so. There were a variety of interactions, but it was all at their behest, in terms of them wanting us to respond and produce things. They went to great lengths. This was the first large thing they had done in a long time, and they were being very careful about doing it very, very closed.

**Pelkey:** I understand it was prior to Christmas of 1968 you were notified that you had won the contract.

**Heart:** I don't really remember the exact date. If you won't quote the source of this, I'll tell you a slightly funny story about how we heard about it. One way -- there's a thing which used to happen -- it may still

  

happen -- in that the Congressional people are told that something's being done and get to announce it, and so we got a telegram -- I won't say from whom -- saying that 'you've just won the Interfaith Message Processor project. I don't have a copy of the telegram, but it was a funny telegram.

**Pelkey:** When you finally did learn that you had won it, was there a sense of exhilaration?

**Heart:** Oh, sure, people were very happy. You're always happy when you work very hard on something and win a big contract. I don't think that's different, though -- that, at that time, is not different than when that happens now when there's some big thing. It wasn't different in that sense. It was a big effort and a big, big opportunity. I don't think anybody really quite realized, at that stage, how really big it was going to become. There was no way, at that early stage, to really have an understanding of the true import of what had occurred. It was to build a four-node network, after all, that contract. The exhilaration, in other words, wasn't more than one gets even today when one bids a large thing which you work on for many months and you win. I don't think it was different; it was just another one like that, because one didn't know it was going to be a revolution at that time.

**Pelkey:** Was there an awareness that there was some resistance within the overall ARPA community to people hooking up their machines to some kind of network and potentially giving up some control of those resources to other parties who wanted to access those resources, or that maybe they wouldn't get the funding that they might have gotten, as a consequence of having this shared view of the world?

**Heart:** I'm not sure I can do justice to that. I can say a couple of things. I think everybody understood that it was going to be very important to have the cooperation of the host organizations, so that was understood from the outset. I think that if you want to ask what was one of the single most critical things that was working in ARPA's favor, and one of the things that was a go/no-go question of success or failure of the whole project, was the fact that Larry Roberts was on top of the money, both to build the subnet and that was funding the host organizations. That was an absolutely critical issue, the fact that he was in control of both side of the problem. I don't think anybody really felt there was much of an issue of cooperation, or lack thereof, or the fact that there was resistance. I think everybody knew that it was going to be a new thing to them, that there would be an introduction difficulty of various kinds -- different, probably, at every site. I don't think that there was a view that that was a big deal. I think it was more a realization that there would be troubles, and they would be coped with. I don't think anybody saw that as a great threat. I probably saw more of a threat, frankly, in whether or not one could get the phone company to behave in a responsible way. We probably put in more energy struggling with the phone company and struggling with getting them to do special things and struggling to have them do things on a countrywide basis. That was more of a threat, whether one could get adequate cooperation from the phone company, because Larry Roberts didn't control AT&T. Although he was supplying money, they were a big place, and his money was only a little bit of money in their terms.

**Pelkey:** My understanding is that AT&T -- Bell Labs had looked over some of these concepts and had passed on it.

**Heart:** Essentially, that's right. I wasn't involved in those conversations that Larry may have had with AT&T, so I don't really know much about that, but I think that the nice part was that when they once did get involved, they put up a real person, they paid attention, they worked with us closely, and it was a bit of a miracle to me, and I was very pleasantly surprised. I had gone through the period, with the SAGE system, of having Western Electric be a very large contractor there, and I realized how very tough that all is. You know, all the different phone companies had to be dealt with, and if we had to deal with each one separately, we would have been just in terrible trouble, so it was very critical that they come up with a way of coordinating that, and they did. That was very important.

**Pelkey:** Now, in January, you begin work, and the team is largely intact, although I'm led to believe that Bob Kahn -- somewhere after the proposal was submitted, he was going to go off and do other things.

  

**Heart:** Bob was on that team for a long time. He was on that team until he left to go to ARPA. He was a full-fledged member of that team pulling his weight for quite a while. Again, I'm not good at exact dates, but he was a part of that team until he really went off.

**Pelkey:** Now, in 1969, when the proposal got changed so that you were going to deliver your first one to UCLA over the Labor Day weekend, somewhere along the line, BBN 1822 got created. Do you recall when that was? Was it 1969?

**Heart:** Again, I'm not able to really do justice to that. The issue for BBN was that it had to solve several problems. It had to get computers, it had to build the special -- it had to get the special hardware built that was needed for those computers, it had to write the code and design the code that went into those computers, and then it had to make arrangements to get those computers connected to the hosts that were the first four sites. So a spec had to be written that could be given to those sites, because they had to do things on their end, and so one of the early tasks, along with these other early tasks -- I mean, there was a set of tasks, all of which were equally important, all of which were required -- and at some point in that process, the first drafts of 1822 were being written, right from the outset. It was one of the early critical paths, but I can't tell you what date that report was really put together, I'm afraid.

**Pelkey:** Because that was the document by which these other sites could build the hardware and the software that would go into the hosts to interface to the IMP.

**Heart:** Exactly, and that was the spec they had to have. It probably went, actually, through a couple of stages. The first ones were probably draft documents that got adjusted over time, but I don't recall the exact dates those documents came out. It was very early, because it had to be very early. It had to be available in time for them to have several months to go put together things they needed at their end, in both software and hardware.

**Pelkey:** To hear UCLA's side of the story, they never thought you were going to make Labor Day, and when you freighted it out and were there on the 30th, they were a bit taken back.

**Heart:** Well, that was true for all the sites. I think that it was a very big deal, and we, of course -- it was a big, big project, a very important project, so we were just working around the clock, and people were just putting in very, very long hours, and working very, very hard on it. It was a labor of love, at some level. I think that it was critical to get them out there. It's a little bit like a computer and a programmer. It's really hard to get a programmer to program something if he doesn't have a computer. If you tell him: "I'm going to get you a computer in September. Would you please write this program now," you really have a hard time getting his attention. You can do it if you whip him hard enough, but it's really hard. It's the same thing with this. We knew that until that machinery got into the field, people out there really wouldn't pay attention, and it's just exactly the same analogy as with a computer and a programmer. Until it showed up, they wouldn't really pay attention.

**Pelkey:** So you took this seriously because, 1) you knew it was serious and you had taken the responsibilities on, but –

**Heart:** And I always face things on time and on the money if I can.

**Pelkey:** Well, that must have been a very busy 1969.

**Heart:** It was . . . Larry also knew the hosts were going to be a problem, but again, it's really hard to get people to do things before the thing is there for them to do it with, so no matter how many times you said it, you couldn't really get their attention. So the surprise -- in retrospect, it was sort of fun to deliver it, but we knew we had to get them out there before anything was going to happen.

**Pelkey:** Were you interacting heavily with Larry Roberts at this point?

  

**Heart:** Oh, yes. Once the contract was let, we interacted very heavily. He was a very -- again, I can't overemphasize. I don't know how much you're going to try, in this book, to worry about the sociology, but a critical thing was the degree of control that Larry had, on the one hand, and that I, at BBN, had on the other. Many projects are done with the auditors looking over your shoulder, with seven levels of management, with nine levels of approval, with lots of forms. Larry had none of that and I had none of that. He, at his level in ARPA, was very much in charge. Almost nobody was looking over his shoulder, really, at all closely, and at BBN I was a free agent. I really was. There was nobody looking over my shoulder either. So projects like this that are this hard, it's very critical not to have too much back seat driving, and that's one of the things about this project that was very unusual. Today in the government, it's hard to find projects of a similar sort.

**Pelkey:** During that year, were there points in time, before you delivered your first one, that some of the things in the RFP, as you went to really implement them, became serious issues?

**Heart:** There's one very large one. There was one big change that took place. The RFP had asked for there being one IMP per host, and that was the design we wrote the answer to. Almost instantly upon getting the contract -- instantly, literally, days almost -- it became clear that every single one of the sites were saying they were going to have more than one host, and so that was a big shift in the thinking, and it made a major change in many, many things. You can just imagine what that does to software design, hardware design, packaging, just everything. So that was a very big change very early.

**Pelkey:** And once the IMPs got up and working, there was an incredible amount of intra-IMP traffic. It was kind of like the first local area networks at these sites.

**Heart:** That's right. It became an easier way to connect than any other way, because the protocol now existed. In other words, if you had four computers at the site, and they all wanted to interact, left to their own devices, people would have worked on -- what, four times three -- it's whatever the combination is of all those two-way connections, whereas now that they had a standard, it was much easier to connect through the IMP than it would have been to go direct, because of the existence of the 1822 standard.

**Pelkey:** A personal opinion, during this period of time, do you recall any intent that electronic mail was going to be an important part of the network?

**Heart:** No, nobody, at that time, realized the degree to which electronic mail was going to be important. That was a complete surprise to everybody everywhere. They knew it might happen. It wasn't that they had never heard of electronic mail. It wasn't that the concept hadn't been thought of, but no one imagined anywhere in the system -- at ARPA, at BBN, anywhere -- that it was going to be the smash hit that it was -- no, none at all.

**Pelkey:** The network implementation of E-mail, as I understand, came out of BBN because of Tenex. I forget the two gentlemen's names who worked on it –

**Heart:** Right, but again, people had worked on electronic mail between other things. This was not the invention of the idea of sending a message digitally, but it's just that it was a smashing success that was a surprise; the degree to which that just took off was a surprise.

**Pelkey:** So then you delivered the four sites, and you, BBN, were the fifth site?

**Heart:** Again, now I'm not sure. I think BBN tried to get in that loop as soon as there was a circuit, but I can't remember the date at which the circuit, the cross-country link, appeared relative to when the first four sites appeared. I'd have to go back and look at that if you want. There are pictures in –

**Pelkey:** I've seen the pictures, but I don't have that one picture. I have the one where they have Rand and they have some of the other sites on the west coast.

**Heart:** [Leafing through some papers] It's not in this thing?

  

**Pelkey:** One of the next big issues was the TIP.

**Heart:** The issue there was -- well, there were many things going on. The thing was now on a very steep up-slope of interest all over the country, so there was a lot going on, and you can't sort of pick one thing out from the other. There was an enormous amount of energy now going on, at the host level, in trying to work on the Network Working Group, in trying to work on protocols. There was a lot of different things going on, and it begins to get very complicated because the number of people all over the country that were involved in that began rising very rapidly. So it's a little hard to pick the pieces apart, but the work on the host end had been very, very diligent. The Network Working Group was worrying about it, and they were worrying about the access of terminals through the hosts. The question was: "How do people get connected?" Well, you go through a host, and so you have to be on a terminal connection to a host. Well, 'what about the people that weren't at a convenient place for a host?' became the problem. So it began to be realized that it was going to be important to have another kind of host, and the TIP was invented to satisfy that need, of being 'a host for thems without hosts' -- was what it was. That was the basic idea. Now, once the idea became invented, then it became obvious there might even be places where there were hosts where you still wanted a TIP, because it didn't use up host bandwidth, it didn't use up host resources, it was a more direct access, it could be standardized, so there began to be other reasons for its use, but the first reason was the idea that you wanted access for people who didn't have access to a convenient host. That was the reason that got invented.

**Pelkey:** The scenarios, were you involved much in the scenarios?

**Heart:** What do you mean by that?

**Pelkey:** This thing that was held in October of '72 that –

**Heart:** Oh, the conference that Bob -- oh yeah. Bob was certainly the key player in that, no question, but I was involved, sure. Everybody in the group was involved. It was a big effort.

**Pelkey:** Did you go to that?

**Heart:** Oh yes.

**Pelkey:** What was it like?

**Heart:** Gee, I don't know that I have any -- I think Bob's always viewed that as being more of a watershed than I probably have. To me, that was a conference, and it was an interesting and important one, but I didn't personally feel that it changed -- that much changed because of it. It happened. It created some enthusiasm and some interest. It got some exposure, but I didn't personally -- I know Bob's always felt that was a very critical event. I probably disagree slightly with the degree of criticality he assigns to it, but it was a very -- I think it was viewed by the industry as kind of the first major exposure, and they really got a look at it, so that was kind of interesting and nice, but I don't attach the same level of importance to it.

**Pelkey:** The bake-off that happened a year earlier at the BBN facilities, where each site had to connect to each other's site, was, from the actual working of the network, maybe a more important event.

**Heart:** Well, you see, as I said, there were a lot of things going on. BBN put a great deal of energy into helping the host sites get on. We not only wrote 1822, but we didn't just go and leave it. We went and involved ourselves with every single site in those days, talked to the people designing the hardware and software, helped them over rough spots, then went there, often, as well as having people at BBN and tried to test the connection. We put a lot of energy into working on the host side of it. Even though we couldn't do it ourselves, we were very heavily involved. So for us, the problem was getting those hosts on, and we wanted that to work, otherwise the network wouldn't be used and it wouldn't grow. It was an important issue, and of course ARPA also was very anxious to make it happen, and encouraged us to do that.

  

**Pelkey:** Did any of the people on your side get actively involved with the Network Working Group?

**Heart:** Oh, yes. There were a number of people from BBN who attended them regularly, all the time -- regular members. I went to a lot of them myself.

**Pelkey:** Because that, in retrospect -- not to minimize the efforts of the subnet and the implications of that, but -- the whole concept of what became the network protocols –

**Heart:** Oh, sure, it was critical. Again, in a big thing, many things are critical. You can't have a Space Shuttle without the rocket and the thing on top and the astronauts and -- you have to have the plant to make the fuel. It was very important, and without the efforts of all those people trying to hammer out a set of protocols, there wouldn't have been any use of the network. So you could have had the subnet sitting there, and it would have worked fine, but nobody would be using it.

**Pelkey:** In fact, that was a great source of frustration for Larry. Here, you had delivered your part, and the host-to-host wasn't happening. A number of the people working in the NWG said -- they were all graduate students, and somewhere along the line they expected the people from the east who knew everything to kind of take over and come in and say: "Here's how its done," and that never happened.

**Heart:** Well, I think it's a much harder problem; sociologically it's much harder. We had complete control of our resources -- we had money, we had people, we knew what we wanted, we had a plan - - we could go do it. With the host organizations, there were 20 independent groups, all of whom had slightly different views of the world, all of whom were putting in different levels of energy, all of whom had different degrees of interest. It was a much tougher problem, socially, to get that set of people to agree upon anything -- it didn't matter what it was -- so sure, it lagged, no question. It lagged a lot. It probably lagged two years, realistically. It would have been useful two years earlier. In other words, it actually lagged two years from when it would have been nice to have had it. I don't know, in retrospect, how that could have been done better. I don't know anything that could have been done to make that really go better, because if it had not been for Roberts being on top of the money source for all of the people, it wouldn't have gone at all. So I don't know now what I would have done to make that go better, realistically.

**Pelkey:** Now, around 1972, was there an effort within BBN to say: "This is something we ought to think about commercializing?"

**Heart:** Sure. It began to be obvious that there were possible extensions of this technology in lots of different directions, and probably the first real jolt that BBN got was the fact that several of the people who were in the project got very interested in commercializing it -- Lee Talbert and Ralph Alter and others -- and when they were unable to get BBN interested sufficiently fast, they went out and formed a company and left BBN to form the company. PCI, was it? Something like that -- and if there's anything to get an organization to pay attention to something, it's when several of the staff leave and start their own company and do it. So, without denigrating BBN's own careful analysis of that facts, nevertheless, that certainly was a jolt to their sensibilities, and they began putting more energy into thinking about that, about the possibilities of doing something else, and that was the genesis of TeleNet.

**Pelkey:** If I understand correctly, Steve Levy and Bob Kahn were the first couple of people involved with TeleNet.

**Heart:** Bob Kahn was really not a major player in the TeleNet game at all, unless I'm completely forgetting some chapter. In fact, we'd have to check and see what the dates were when Bob went to DARPA. Do you have that date convenient?

**Pelkey:** Actually, he went in mid '73.

**Heart:** Ok, well –

  

**Pelkey:** And Larry joined BBN on April 1st of '74.

**Heart:** Yeah, it must have been a year later. Well, what I was going to say was, Bob really wasn't involved in the TeleNet thing hardly at all. The TeleNet thing was really not something that the group, the technical group, was really first order involved in. The TeleNet thing was really almost a venture capital activity, in the sense that Larry wasn't involved at all, and that was something that Steve Levy really got going within BBN and then went to look for money for. The involvement of Larry was really later than the first beginnings of thinking about TeleNet.

**Pelkey:** Were you and any of your group –

**Heart:** Oh, yeah, we were involved, but peripherally. We were not prime movers in the TeleNet effort.

**Pelkey:** Now, were you still involved in terms of maintaining the subnet?

**Heart:** I stayed involved as a lead guy for BBN's activities on the Arpanet contract for many years. I'd have to look back again for when that changed, but it was a lot later than this.

**Pelkey:** So in '75 or '76, DCA took responsibility for it.

**Heart:** I was still involved directly during that period.

**Pelkey:** And did you stay involved subsequent to that.

**Heart:** A while; not a great long while, but a while.

**Pelkey:** Did the group of you that stayed at BBN -- Walden, and Crowther and Ornstein and yourself -- you as a team had accomplished a great deal with this project, did you take that and go with that into another communication project, or did you just go off –

**Heart:** Well, no. You know, the project changed. There were lots of additional things that happened. You mentioned the TIP, but that was only one of many things that grew out of that work. The whole multi-processor business grew out of BBN's involvement with ARPA and the Arpanet. The Pluribus machine was designed for ARPA with ARPA money as, among other things, a communications processor. So BBN's having gotten into the parallel -- you might say -- another thing came out of this whole thing. This is maybe being slightly flamboyant, but there was a long, long period of years when parallel processors were viewed as useless, irrelevant and so forth, and there's a whole other thread not on your chart, that BBN was involved in the parallel processing business for ten years before it became a world-wide, enthusiastic thing everybody did. That partly grew up out of the communications world of the ARPA contract for the Arpanet, because the Pluribus was built with ARPA money as, among other things, a communications process.

**Pelkey:** Was that meant to take over what the Honeywell machine had been doing?

**Heart:** It was intended to be a much higher capacity communications processor, and we in fact put many Pluribuses into the field as IMPs. In fact, they're in there now, still, many of them. Most of them that are still out there are in classified networks.

**Pelkey:** When was Pluribus done?

**Heart:** I'm very bad on dates.

**Pelkey:** Everyone; the whole group of you.

**Heart:** The date thing is tough.

  

**Pelkey:** Maybe when you get this transcript, you can just mark in the dates.

**Heart:** I can try working on the dates when you do this.

**Pelkey:** What I'm going to do is footnote that the extension of this was the Pluribus and it went on with this –

**Heart:** But BBN's whole involvement in parallel processors came out of the communications work, and the Pluribus was built as a communications processor. The Butterfly after it was built as a communications processor.

**Pelkey:** Leonard Kleinrock and Howard Frank got involved.

**Heart:** They were involved in two very different things. Frank was involved in the whole question of topology. Howard Frank really had a very narrow focus of his involvement in the Arpanet. He worried about the topology problem; what should the topology of the net be. Unfortunately, there's a kind of sad thing about that, which is that most of the time you know the answer for some other reason -- like, I want to give the money to these four sites, so I'll connect it there, and then I want to have one cross-country link to go here. Unfortunately, the topology was often driven by non-technical issues, and so the influence of the topology isn't always what it might be, but he did a very good job. Their programs were very good, and he played a major role in the topology. It was an important, but narrow, involvement. Kleinrock was involved much more broadly, in the sense that he was a bit of a confidant of Larry Roberts. He was involved with aspects of the network that were not just the things his group was doing, in that he was one of the people Larry talked to. So he helped Larry in other ways, but the ostensible job, and the main job Kleinrock did was his measurement job. They were tasked to measure it and see how it did, and they did a lot of work to do that. It's a hard job, and they had to influence us to get hooks built into the IMPs so that the IMPs sent out the proper things, and they needed to get things done to the subnet so they could collect data from the subnet. So there was a lot of cooperation between the groups, in order that they could get what they needed to do their job. They then wrote programs, and we obviously wanted to know what they learned to go attempt to influence the design; and they did influence the design at least a couple of times, where they came up with something we didn't understand or something we hadn't realized was happening, and the net changed as a result of that in at least a couple of instances.

**Pelkey:** Do you have any feeling for where the impetus for this network began in the first place?

**Heart:** Well, you probably know as much or more than I do, having looked into this. Certainly, at the time I first heard about the network, I did not know much of the history of what had gone on in ARPA prior to early '68. Really my involvement in the earliest conversations, I just wasn't involved. Therefore, I now know that story, because I've been involved in writing histories about it a little bit, and so I certainly know most of that story, but I wasn't originally personally involved.

**Pelkey:** Question of a different kind, given that BBN was a strong leader in networking, particularly with the DDN, a lot of the T-1 companies spun out of TimeShare. Why did BBN miss that event?

**Heart:** -- In making things like T-1 multiplexers and so on? I don't know. You can't do everything. I'm not sure there's any particular reason. The company's not had an easy time with market share. This is a very competitive business, even to this day it's a very competitive business, so in terms of BBN's involvement as a commercial activity -- we first set up Telenet. That was an early commercialization, and then after having sold Telenet, we're back being a Telenet competitor, mostly in the private network business. You simply can't do everything. I don't think there was any special reason.

**Pelkey:** I think we've covered at least the territory I wanted, and I greatly appreciate your time.

**Heart:** Done.

END OF THE INTERVIEW

  