Interview of Paul Baran

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James Pelkey: There are obviously a number of subjects that you can be very helpful to me given that you have some understanding what I'm about to do. One of them is that I hold the view that ARPA, and therefore Arpanet, were critical, both as a source of ideas, as well as the people who worked in the Arpanet environment later spun out into the commercial sector and became important. For example, the whole concept of communication protocols were unknown –

Paul Baran: Let's begin: ARPA was very unusual in that it accounted for about 60%, if I recall correctly, of all the computer research in the country, including IBM. So, if you took all the computer research going on, ARPA's budget accounted for about 60% of it.

Pelkey: And what time frame was this?

Baran: Oh, this was in the early '60s, after it was created, and so it was a base of tremendous power, and they were funding research in all the universities, and they sort of had a club. Major universities were members of the club and they would receive their funding faithful and, originally, in fact, the first director of computer research was Dr. J. C. R. Licklider, who was a very competent researcher himself. ARPA was a little different that other government agencies in that it was managed by 'honest to goodness' scientists themselves. So you had people who were able to distinguish bullshit from real work, and they had a lot of money and were very flexible in what they allowed people to do. And the secret in funding good research is that you don't get preoccupied with the crap and you look the other way when people spend the money, in ways you think unwisely, and eventually something good comes out of it and you focus on that. So ARPA was funding all the research -- not all but a significant piece of it. It was the defense reorganization in 1949 that created the Department of Defense that pulled the individual services under the Department of Defense, and it took a long time before it actually was implemented, because you had these very institutional structures. So each of the services had their own research activities, which was ok. However, when the Department of Defense really took power, which occurred in the McNamara administration, when Kennedy came in, and forced integration of the Department of Defense, reducing the role that the other services played, including research. And the role of the Department of Defense in research was greatly beefed up through ARPA. So ARPA was the fountain for all the bucks.

Pelkey: Now, originally Larry Roberts was at ARPA.

Baran: Larry Roberts followed Licklider. Now this was a position that sort of worked back and forth as Licklider was from MIT and Roberts was from MIT. The job sort of got passed around, and its part of a club for the major universities to guarantee that they'll always be funded, and its something that people look at and smile. It works, but it means those who come from the Podunk Universities never get any funding, or rarely do.

Pelkey: Right.

Baran: And those from places like MIT can be guaranteed continuity, no matter what, which is necessary for good research.

Pelkey: Now, the Air Force, when you were a t RAND led to the blocked message –

Baran: Yeah, Distributed Adapted -- let's back up on that one a little bit. RAND, I think probably did the best damned research in the county, best output I've ever seen per buck, for the government, and RAND got their money originally from only the Air Force. Back in a little history, RAND was created at the end of World War II to preserve the operations research capability that was developed by the Air Force for the first time. They felt that was a national resource and they wanted to preserve it. So RAND was created inside Douglas Aircraft. Only it didn't work very well because of the constraints of the overall organization. It was not a good place to do research. So, Ford Foundation put up a little seed money and RAND was then set off as a separate not-for-profit company, and at the time it was funded to work for national security. And RAND was a neat place. It was multi-disciplinary, and the reason its output was as productive as it was, it had the neatest way of allowing people to do pretty much whatever they wanted to do. They picked very good people to start with, and were able to pick those they wanted, and they guarantee them continuity and no interference, and then they'd restrict the output flow, so any briefing had to go through a tough review process. Before anything became a RAND report, it went through a very very careful review process, so all the failures, all the nonsense got filtered out, and as a result, you know, my God, you got some very high quality output, unlike the situation in government research today where you have to write a big, thick report, even though the project was a failure, where most of your effort is describing what you did, rather than getting on. So it was the ability to bury bad work easily that I think made for a lot of their success. Ok, so RAND, at the time, was funded by the Air Force, and the Air Force was synonymous with the national defense, because what the hell was national defense then: You had airplanes and they carry a bomb and that was national defense. Ok? The idea that is was a Department of Defense issue didn't come until the McNamara Administration.

Pelkey: Which was Johnson's Administration?

Baran: No, it was Kennedy's. It also caused the ruination of RAND, because the people from RAND who staffed the McNamara Administration wanted instant results and wanted all the things that they would have objected to if they were just playing the other role. But anyway, in 1959, I joined the Computer Science Department, and pretty much had the option to look around and see what is the most important thing I could be doing with my time. And the way RAND works is that every week they have a newsletter, passed around internally, with requests from the people in government and other places saying: "Wouldn't it be nice if RAND studied this or studied that." And if anyone were interested, they'd write back and say: "Ok. We're going to be doing something in that area." Otherwise, and this occurred in most cases, they'd write: "Thank you, but that work is not appropriate to our interests," or something like that. So you had freedom on what you were doing, and what concerned me, in the late '50s, was the vulnerability of command and control. Here we had this whole goddamn system, dangerous as hell, and if something went wrong, how do you turn it off? An awfully dangerous situation! And it wasn't just our problem, you know, I'd feel much better if the Russians had a better command and control system, and even proposed it at the time, but there was a question whether we wanted to keep things secret or not? Or whether the objective was: "Ok. We have a distributed missile force with airplanes and can somebody out there be crazy enough to go after our command and control communications? What will happen?" Well we looked at the AT&T system, which was

then used for much of the communication, and it was horrible. A couple slices and there goes all the communication. Bad show. So we looked at some ways of building networks that were tough, where you could chop them up and they would survive.

What I used was what was known about early models of neural cells, organized in a distributed fashion, and I knew that type of structure is basically pretty robust. I didn't realize how robust till I got into it, and by saying: "Ok. Let's connect each station or point to its neighbors." And then I varied the degree of redundancy and laid down attacks against it, and found a couple of things. Once, you need a network of certain critical mass size where it no longer pays to try to slice the network, cause the probability of doing that is less than going after it uniformly. And that occurs when you have networks of about 15 or 20 nodes wide. So that tells you about the critical mass in these types of structures.

The next thing I looked at was laying down various size attacks, and if you had a redundancy level of about two or three times the minimum, just to connect the nodes together, you end up with a very tough network. I'll show you some curves sometime, but the network had the property of holding up very very well, and by that I'm saying: if the station survives, its able to communicate. So the implicit algorithm was that if you couldn't communicate, don't do anything dumb, because if you can't trust your communications, you know the rest of the system is probably not going to work.

So this was about 1960 or so, or '61. The first system proposed was using the ground wave of broadcast stations, saying: "Well, if you have a nuclear lay down and the ionosphere is messed up, but the ground waves propagate very nicely." So you can go from broadcast station to broadcast station, form a network and show there's enough communication to support what was called then Minimal Essential Communications. Well, I took this *(presentation)* out. The way RAND works is that first you present your results and then you have excellent contact in governments, and you go around and speak to people who would be interested or affected in any manner, and the response back from the generals was: "Well, look, that can take care of the President, but I have to communicate to the troops. I have to do this. I have to do that. I have to do this. So, you know, we need a communication system with a lot more capacity." So I said: "Great. Back to the drawing board." And then I was saying: "Ok, what can we do to increase the capacity?"

Simultaneously with this I got involved as a member of a Department of Defense committee that came in about the time of the Kennedy Administration -- well it started with the Eisenhower Administration but it didn't get implemented till then, that each of the services had proposed a big communication switching network, and it would have bankrupted the country. These were huge switching centers about the size of this building, and so this group would get briefings and poke at all the details and what struck me was, I was saying: "Why do we need all that crap?" And a good part of it was just recording all the traffic that came through the switching center, so the person in charge could always show that it was not his fault that the communications got lost. And this is the transition from the torn teletypewriter tape messages. Before, you know, just when electronic data communication was just coming in. So, I was in Santa Monica, and this committee met every other week, in Washington or was visiting a contractor. This part went on for about six months or a year, something like that. So I had a lot of time on airplanes. And as

you know that's great time, so I started saying: "Well, gee, on one hand, I knew about networks and the robustness if you connect them in a distributed fashion, and I saw all this crap, this utter crap, that was being done, and, among the things that the committee found was that even though the services were building networks, they had absolutely no way to talk to one another. That the information was kept so compartmentalized that the *(communication)* standards were just idiotic. And that committee found things like, if somebody laid down a standard, say of 2400 bits per second. Well AT&T interpreted that as 2400 bits per second plus some other data on top for control, giving one rate. Somebody took 2500 -- 2400 less something. And we had all these crazy data rates, so someone said: "Oh, what the hell. Let's pick a standard, and we'll call it -- we'll start with say 2400, 1200, 600, just took an arbitrary number, and that's where the number came from that you see now.

Pelkey: Is that really true? Now when was this?

Baran: Oh this was about 1962.

Pelkey: And was out of –

Baran: -- the DOD committee.

Pelkey: DOD committee.

Baran: Yeah. Ok, that was part one of the thing. The hell was you know they had the muscle, you know, we to turn off these hundred million dollar programs, and you know, which one do you turn off. And we tried to get some semblance of rationality to it. Next were the Codes, that there are a zillion different Codes. IBM had EBSIDIC. International Business Machines had this one, and nothing can talk in teletypewriter Codes. So the Code that looked like it made most sense was an eight bit Code used in the Signal Corp system, and it was proposed by, I guess, he was then Lieutenant Lubbert, Bill Lubbert.

Pelkey: L U?

Baran: L U B B E R T, I believe. He was over at West Point. And it was called Field Data and was used for -- but it was eight bits, it was characteristic, and it was logically organized, and so that's the Code we preferred. We couldn't get rid of EBSIDIC, of course, that was IBM's thing. But we were able to compress the number of things floating around, and Field Data then became ANSI. It evolved down to that one. So I think that, probably out of this committee -- it may have been going on in other places as well, you never know, but I do know in this committee, before it was done, we picked Field Data and we picked the 75 x 2nth series to get rid of all these different standards. And so, sorry for the tangent but its –

Pelkey: No, no! And so, out of that process came ANSI? The standard –

Baran: Well it became what became the ANSI standard. In other words, the foundation was really the Field Data, was the basis for that. Of all the Codes, looked at, and I guess the guy that did that was a guy named Morris Rubinoff, a professor at the University of Pennsylvania, who'd

come in every day with these different lists of crazy Codes that people were using. There was no -- everybody had their own. There was no communication.

Pelkey: Isn't that crazy?

Baran: So that's where some of those numbers came from. Ok, back to this business of –

Pelkey: So you're on an airplane –

Baran: So I'm on an airplane, so I look at all this stuff and say: "What do we really need and what don't we need in the communication system?" And concluded that we really just need a very small box of equipment that just handled the transmission to get through a network, and we didn't need all the other crap of recording and duplicate backup, and that was really designed for an earlier era. And we don't need these huge switching centers. And something small could be built, probably. So the next part was studying the protocols, ok. Several things had to occur, and that you had to be able to find your way through a network after someone chopped it up. And it was much more economical to build such a network out of unreliable parts, because if somebody is going to chop it up anyway, why build it reliably?

Pelkey: Right.

Baran: So, ideally we would have packets, fixed length, and have some way of detecting whether you had an error or not –a CRC. You had a flag that indicated, that you had an indication of who it went to and whom it came from, and at that time it was easier to keep them the same length, because the original design was to do all this in hardware. And I saw no reason why this thing couldn't run at 1500, 1.5 megabits per second because AT&T at that time was just starting its work on T-1, and saying: "Hey, if you can do T-1 on existing telephone lines, then that means it's possible to build 1.5 megabit links very cheaply." And we could also use satellite links; we could mix it up together. And one of the characteristics of packets was there was no reason to have everything synchronous. Each link could run at its own rate. So, some very interesting properties, unexpected properties, came out when we started to doing the algorithm, which is pass it on and just, if the busiest path was busy, second best. We had learning from the flow of traffic, and whatever we did in that design, I want to have no centralized node, so that you always know how to send traffic efficiently.

And then another interesting characteristic is that it had virtual circuits, because if a path existed and you had something you'd find it, and the rest of the time it was free for everybody else. So now you can do averaging across a big net. Neat. So it had the reliability feature; had the economics of using the resources across the country; had the capability of using very unreliable links, which I don't think has really been promulgated; and it looked like it could be an universal medium for teletypewriter data, facsimile, and, possibly one day, voice. Ok, then, the next part was, how do you keep people out of it, and the secrecy part, and it had a very nice crypto feature, because your taking different paths, which you can guarantee with a very high reliability of not losing any packets. Only the end station would have the entire message, which said: "Well, gee, if you have a crypto system that depended on all the previous information being correctly received, its pretty damned hard to listen and get the whole message, so it had that nice

characteristic. And you could send single packets, now called datagrams, over the virtual circuits. It had all these characteristics. Now the thing was -- it was picked to death. Every time we went out to a briefing someone says: "Well, how do you do this or how do you do that?" So I ended up having to write a big thick stack of papers. How do you build the switching node and the multiplexing algorithm, because now statistical multiplexing made sense. You'd have a box, a separate unit, to do what you called a multiplexing station that hooked into the switching nodes –

Pelkey: But you didn't call it statistical multiplexing?

Baran: We just called it multiplexing, but it was statistical. You could show that you had limited capacity but you used it very efficiently, and we had so goddamn much extra capacity anyway, you know, that it was not a big deal. And, so running through the numbers on the system, what is it going to cost, the ten year system cost cause the military was doing it, and this was about 1962. I got off in a lot of other things while this thing was going on. We had the world's slowest publishing system. They'd put it in. The editors would get around and change it. So I learned, at RAND, better to keep half a dozen different projects going then get frustrated waiting for somebody else. I had no pressure to get that out, but meanwhile, I was going around with briefings and getting objections, you know, why wouldn't it work? And that some people thought it might work and was great, and others thought no way could it possibly work, and that included AT&T. Now, AT&T was split; people in Bell Labs, the digital people, understood and thought it would work. The people in transmission, analog transmission, had a mental block, and this even occurred in the communication department in RAND. Digital people can understand what was being said. Analog people, conventional transmission people -- I remember one meeting over at AT&T, and a very senior guy says: "Now, did I hear you say that you open the switch before all the traffic goes through?" I'd say: "Yes," and he nods his head in disgust and looks at this guy next to him, and said: "Well, here's how a telephone works." So I found it was necessary to learn all the Western Electric part numbers, you know, to give me a little credibility.

By 1965 a formal recommendation from RAND went out to the Air Force recommending they build the system. And the Air Force then got MITRE in to review it and MITRE reviewed it favorably. Then a committee was formed, and was about to come out recommending the Air Force build the system. And then the DOD General Counsel says: "Sorry fellows, this is now the purview of the Defense Communications Agency." Well at that time, the Defense Communications Agency was newly formed. It had one admiral, one general –

Pelkey: This was around '67, now?

Baran: Oh, this was around '65.

Pelkey: '65.

Baran: '65 or so, '65 period. And it was totally incompetent. It was just getting started. It had no technical competence. Nobody there knew anything about digital, and I advised my friends in the Department of Defense: "Do not proceed. It will not work. They aren't capable to pull it off." If was very sophisticated, and so then I guess it was about '67 or so, I could be off a year or

two, about a year or so either way, and they talked about it with the people at ARPA, and they're digital types, and they liked the idea. I had a meeting with Larry Roberts, I guess Elmer Shapiro of SRI was there, and Len Kleinrock, Keith Uncapher at RAND, and I was pretty busy on other things, and Larry Roberts got very intrigued by it, and one of the things that the group, I don't know whose idea it was, said: "Hey, let's run an experiment to see if the idea works, a little demonstration," and so I said: "Fine." So one of the outputs there was, I guess at that time was: "Let's see if the damned thing works. Let's do it in software, because we don't want to put a lot of money into it 'till we see if it works first, and let's do it at a low data rate, because we didn't have high data rate telephone lines, so instead of one and a half Megabits we'll try it at a low speed." And then Larry Roberts was in a position of the 'giver-outer' of money. Now this is important to understand! What happened, you know, is that the program -- well it wasn't really -- it was sort of informal, did the definition of this experiment, and they went out and they had competitive bids. Bolt Brannick Newman won the bid to do the programming on minicomputers to be the nodes, or the IMPs.

Pelkey: Now, if I understand correctly there were four nodes. There were BBN's in Boston, University of Utah –

Baran: Well, I don't know that they –

Pelkey: Was this –

Baran: Yeah, could be. It grew much faster than that.

Pelkey: UCLA and UCSB.

Baran: Yeah, now, Larry Roberts also had an interest in resource sharing, and he viewed the real feature of this network as being able to share resources among the universities so that everyone didn't have to build their own computer. You could use the facilities that were tailored to their needs. So he had a double interest in this. And, let's see, I think we started this thing -- Licklider was in charge of ARPA Information Processing Technology and then Larry Roberts came in and I think he was the big 'giver-outer' of the dollars. And when the Arpanet was built, ARPA would have a meeting, it was either once or twice a year, where all the ARPA contractors would meet in a room, or a representative from each contractor, and discuss each of their research programs going on around the country. Roberts is telling everyone that they will be using the Arpanet. And there were grumbles of over my dead body. We want our own computers. And it was very clear that if you wanted to get ARPA money, you had to use the Arpanet.

Pelkey: And when do you recall what time frame this was?

Baran: Oh, gees, I don't know, pretty early, I'd say about –

Pelkey: '69?

Baran: '69, '70, around there, yeah, sometime around there.

Pelkey: But as an aside, do you know where Larry Roberts is today?

Baran: Yeah, he's floating around here somewhere. He's head of DHL.

Tape side ends.

Baran: He's been there a couple of years, yeah, out here somewhere. And that he's been busy pushing their high-speed fax proposal. You might have seen it around.

Pelkey: Yeah. So during this period of time, Larry was really the sponsor, in the sense –

Baran: Larry was the guy that made it all fly –

Pelkey: -- and, and the missionary –

Baran: He did a lot of things. He wrote some of the old code himself -- the first electronic mail stuff was what he did. Now, here's a guy that should be in the job of administrating R&D, but since the background of their researchers themselves, that he'd get in at the hands level –

Pelkey: He can't control himself –

Baran: He can't control himself. But at the same time, it's a good thing but it's also a bad thing, because he was not balanced in what was sponsored and what wasn't; if it had anything to do with the Arpanet, great. So, I don't know what else got slighted, but he's a good guy. He got things done. He was probably the most disorganized guy I've ever seen run a meeting, but he's very effective.

Pelkey: Now I understand from the other conversation, that early on, the Arpanet was just four nodes, and that there was one Christmas in which the net went down and they couldn't get the net back up, because they were still at the stage where the protocols had yet to be defined at some level?

Baran: No, behavior, well you're getting very very complex behavior, and this is particularly true if you start doing any centralization. I view networks of two types. Those where each node knows everything going on in the network; and these are basically unstable networks. There's another type of networks that are blind. It can only see its neighbors, and follow a simple algorithm. These I think are basically stable. It's a bit of prejudice, but you can pick that one through a little bit….

Pelkey: It's a robust model.

Baran: -- because it's saying the degree of complexity of cooperation you need to make the goddamn thing work is so great, that if you build a big network, that you can't really trust it. You have bad information and most people don't know how to program with bad information.

Pelkey: Although right now with parallel processing and thinking machines, and so on –

Baran: That beginning –

Pelkey: Now we don't know how to program those now, is because we learned how to program these big, complicated –

Baran: Right.

Pelkey: So it'll take –

Baran: Right. It's distributed type processing. Yeah, that's true. When they're smaller, it collapsed many times, even when it was much larger, there'd be days -- because it was not built as a reliable network. It did not have adequate redundancy for the reliability we're talking about. See, the characteristics that I do were not the characteristics of the Arpanet. The Arpanet is, I describe it as an experiment that's gone bad, because its useful, and at the time, there's no way to turn the goddamn thing off, because after insisting the researchers use it, when it came time to shut it down –

Pelkey: It was not longer an experiment.

Baran: Well, a lot of people are using resources over here and resources over there, and they can't get along without it.

Pelkey: I was also told that when it was first conceived that, it was really thought of as kind of computer-to-computer communications –

Baran: Yes.

Pelkey: -- and that what happened, maybe because of Larry's insistence that people use it, is that shortly it became like 90 to 95% terminal traffic.

Baran: Well, yeah. It became people-to-computer but the messaging part turned out to be the most interesting part.

Pelkey: And, as a consequence, you used to have minicomputers that sat as these node concentrators, or 'packet-izers,' that would get hooked to a host. But when you the idea of all these terminals, you didn't want all these terminals to be hooked to the host.

Baran: A big –

Pelkey: -- a big host, and bring the host to its knees –

Baran: Right.

Pelkey: So they started thinking about hooking the terminals directly to this node packetizer –

Baran: Right, so it became the TIP –

Pelkey: Right.

Baran: Terminal Information Processor. Right.

Pelkey: And that, in fact, had a big influence on, one, I how communication protocols evolved. In fact, the statistical multiplexer industry, and I suspect also for local area networking industry –

Baran: Yeah, that happened because the Arpanet became international very early, and an international committee was formed, and it went through the CCITT approval process faster than anything I've ever seen. You know, just a couple of years.

Pelkey: What time frame was this.

Baran: Oh, this was in the early '70s. And things were agreed upon such as the format of the packet. That's where X-25 came from.

Pelkey: So there are no other experiments that –

Baran: Yeah, there were experiments all over the place.

Pelkey: But, in terms of protocols, I'm speaking in terms, again, this concept of protocols, because –

Baran: Well you didn't need them unless you had a network of this type.

Pelkey: Right. But people who understood how to build those networks, going back to these kind of point-to-point statistical multiplexers, those networks are trivial compared to what was happening at Arpanet. So the knowledge and skills that were being developed by people who were associated with the Arpanet nodes, and programming these IMPs and so on –

Baran: Well, it's interesting, that one of the, probably the key people here, and I think one of the guys that probably deserves more credit, is a guy named Vinton Cerf. Vint Cerf was over at Stanford as an assistant professor and –

Pelkey: Do you know where he is now?

Baran: Yeah, he's in Washington and I could dig up his number. And Vint wrote the TCP/IP protocol. It might be said that the good software was written by people working on ARPA research projects.

Pelkey: And when did he write the TCP/IP, do you recall?

Baran: It went threw a couple of -- I'd say about '73, '74, because we were working together over at Cable Data Associates. He served part-time with us while he had gotten research funding from ARPA, and –

Pelkey: I would very much -- if you could look, I would like to find him –

Baran: Oh, yeah. He's a neat guy.

Pelkey: -- because TCP/IP was obviously critical in this history.

Baran: Yeah, he has a hearing impairment, so when you speak to him, he had a hearing aide, so you might be –

Pelkey: I'll be doing mostly listening.

Baran: Ok. He's a good guy.

Pelkey: But this issue of communication protocols, in the data sense, really Arpanet was the first place where you start to get real experimenting, because before you had modems. You only had, really, leased line modems.

Baran: Yeah, well I think the first place for protocols was the work on Distributive Adaptive, you know, that message block system, cause there you needed -- we developed a protocols.

Pelkey: What's this one?

Baran: This system that I described, the original packet switching system, '62, '64, and there we had -- we developed the protocols of how do you route traffic through the network, and what happens when you chop up the network, and we simulated a lot of that. And it became a neat benchmark program for the speed of computers, because you had so much parallel activity.

Pelkey: Right.

Baran: It really gobbled up computer time. And, so that was, you know, I'd say an early simple, but very effective protocol.

Pelkey: Yeah. Now from the ARPA experience: two kinds of questions? One is the people side of things, my belief is that when you get pools of people that work together, in a very intense situation, and that pool for whatever reason breaks up, and they subsequently come in contact with other groups that were intense, you get this commingling of ideas. Clearly at Bell Labs there was an awful lot of communications talent that then got out into the industrial sector or came in contact with the industrial sector. The second issue is that patents, while standards evolved out of Arpanet, from what I understand, patents weren't an issue at all. They became public domain and –

Baran: Yeah, well, the early stuff on packet switching –

Pelkey: Was funded by the public sector, so it was –

Baran: Well, it was two things. RAND would put everything in the public domain. But should we patent it? We figured what the hell, or keep it secret was another choice. No we assumed that if the other guy had a robust, reliable communications system for command and control, we'd be a hell of a lot better off. So there isn't a hell of a lot to be gained by doing that, so at the beginning I had no interest, you know, I think it was consensus why bother patenting it, and at that time ARPA felt the same way. I think most of the work was from the academic community, and I think they shared the same feeling. It was not viewed as a defense network. It was being funded by the Defense that was viewing it as an application that they wanted. Then DCA, at that time, became more and more competent in the '70s, and after a while they became very competent, and they built their own version. Larry Robert, and this put us in a little awkward position, about 1972 –

Pelkey: Left to start Telnet.

Baran: Yeah, but the background of that is that Keith Uncapher, who was over at RAND, was asked by ARPA, you know, what to do with this experiment that had gotten out of hand? How to, you know, divest it? So Keith called me up and said would I be willing to work as a consultant with them on a study on the divestiture of the Arpanet? And I said: "Yeah, that should be fun." And then about a month or so later, he was all disgusted because, and I think this is one of the Mansfield committee things, that they had a limit on each of the federal research centers, so where as ARPA could give RAND all the money it wanted to do this work, it would exceed federal research center limitations, so RAND couldn't take the money, couldn't do the project, so I said: "Oh, what the hell. I'll start a company, if you don't mind, RAND, and do the study, if ARPA doesn't object, and ARPA wants it." So that's when Cable Data first got started, was doing a study on the divestiture of the Arpanet. And Vint Cerf worked on that before he got into some of his other things.

Pelkey: And Larry Roberts was there and –

Baran: Larry Roberts was not. Larry Roberts was at ARPA.

Pelkey: Ok.

Baran: Now, we're working on this contract –

Pelkey: Who else was involved in Cable Data at that point? You and Vint and –

Baran: Yeah, and Steve, at a distance. Steve was working in lumber, in the paper industry, and he was interested in our doing something together.

Pelkey: This is Steve Millard.

Baran: Yeah, Steve Millard. And, let's see, Ed Parker was with us at Cable Data. He was a professor over at Stanford at the time, and a couple of other guys. We had a small -- it was a fun group. It was a way to pay the rent and talk about things we wanted to do together. There was no venture capital at that time. So this was about –

Pelkey: Did Equatorial Communications come out of that experience?

Baran: Yeah, it came out around '76 –

Pelkey: So Equatorial came out of that. Telebit came out of.

Baran: Yeah.

Pelkey: 3Com didn't. 3Com –

Baran: No, 3Com was seperate. That's Bob Metcalf's thing that they were doing.

Pelkey: Packet Technologies.

Baran: Packet Technologies, yes. So the idea was to start companies and get them going and spring them off.

Pelkey: You and Steve were the only two that were continuous through the -- I mean, this is what? This was founded in the early '70s?

Baran: Yeah, I think Steve still has the list of all the guys. Cable Data Associates was dissolved, I think in about '84, sometime like that. It looked like Packet was going to make it very big. Equitorial looked very good. Then we got hit with double taxation because Cable Data was a corporation.

Pelkey: When did you found Cable Data?

Baran: '72. So it did very well.

Pelkey: And you were no longer at RAND?

Baran: No, I left RAND in '68, went over to the Institute for the Future, after I got that started. It's a not-for-profit, and they're still here, down in Menlo Park. Once you start these things they go on forever, even though the original need disappears. So that was from about '68 to '70. Then I sort of helped them as a consultant while I started doing Cable Data, and then spent about two years, I guess from about late '72, to '74. After that, I started working on developing technology like the printer and some other things. Yeah, these are companies that, so yeah that bell is the game plan.

Pelkey: During this point in time, did you ever run across a guy named Mel Doelz?

Baran: Doelz Systems?

Pelkey: Well it's Networks now.

Baran: Doelz Networks.

Pelkey: Ok. So Larry Roberts did eventually leave, as I understand it?

Baran: Yeah, He left. It put us in a very embarrassing position because there were three companies that wanted to see our plan for divestiture. Each was saying: "Hey, you know, instead of giving out one big piece to one company, you can break it in pieces and people can build their own little parts. All you need is a clearinghouse mechanism with interconnect standards.

Pelkey: And let it go clone itself.

Baran: And let people go interconnect and that way everything will start building and adding onto the same network, rather than a bunch of small networks. It would be competitive because the real beauty of the network does not exhibit itself until it's big enough.

Pelkey: Right.

Baran: Well, Larry Roberts had other ideas because he was pushing to start it under Bolt, Beranek and Newman, and to argue Bolt, Beranek and Newman (BBN) had developed the software; well they were digging their heals in about not providing this information to the competing companies.

Pelkey: Do you know who was the contact at BBN at that time, who worked on this?

Baran: There were all sorts of levels of guys: the technical guys -- one of the key guys, a programming guy, actually went down to ARPA later, and, who was at ARPA for many years, he just left recently, Bob Kahn. And a lot of people that worked on the protocols. So this posed a bit of embarrassment and was on the edge, the ethical edge, you know. So I made myself most obnoxious during that time because here were two, at least two other companies, that wanted to be in the business, and here the government had paid for the work, and only BBN seemed to have it.

Pelkey: Who else was interested? What other two companies were interested?

Baran: One Company was a start-up called Packet Communications Inc. I remember a guy named Lee Talbot. The other company was, I think, NSS. It was a timesharing company in Connecticut. I think there was somebody else out there too, but, so –

Pelkey: But BBN was unwilling to share it?

Baran: Yeah. And I thought ARPA should be providing the information, and I didn't see them providing the cooperation, and it was Larry's plan to leave and start his own thing, so that was not a good thing.

Pelkey: It wasn't a good thing in the sense of BBN not sharing –

Baran: Well, the aura of bad taste went out about the whole goddamn thing.

Pelkey: Bad taste because of Larry leaving?

Baran: Yeah. It's self-dealing.

Pelkey: Self-dealing in the sense of Larry taking his know-how and knowledge and going off and starting –

Baran: That part's of it ok, but as long as you let others, you know, compete –

Pelkey: Have the knowledge –

Baran: Have the same knowledge that was developed under government money.

Pelkey: Right.

Baran: And, so that's been a little sore point of friction between the two of us.

Pelkey: Understandably.

Baran: I have high regard for Larry. He's a very brilliant guy, but I didn't think too much of –

Pelkey: He didn't act correctly at that point.

Baran: I did not think he acted fully correctly. So that's pretty much the Arpanet. By this time, it's taken on by itself, took a life of its own.

Pelkey: I'm sure I'll have other questions in the future, but that's been very helpful. Let me switch if I might to sometime when you were at Cable Data Associates, and this relates to a conversation we had briefly on the phone, which was after the Carterphone, when the DAA was created and the telephone company –

Baran: Ok, let's roll on that one, ok. I was over at the Institute for the Future and at RAND, at the time, we were getting concerned about the changed definition of national security. Here we are in the '60s and people were getting more concerned about non-military issues. What about pollution? What about --? Well you say: "Well, gee, if you look at the problems we find ourselves with, they have such a damn long lead time for solution, there isn't a hell of a lot we can do about some of these, but how about working on problems before they become problems? Our methodology for long range forecasting sucks. It always has. It's been the domain of the

charlatans and the sooth sayers and the -- ", so the idea that some of us had was, well look, maybe its worthwhile just trying to work on the methodology of very long range planning, because we don't know very much about it, and we'd like to find out what works and what doesn't work. Who have been the people that have been good at it and who are those who have been wrong. Let's go back and see what's gone on and start to explore with tools and see whether we can get a base. It's going to take many years, so we figured, well, gee, you know, if we're doing three or four year planning now, if you can add a year or two to that planning cycle, it'd be a big payoff. So we thought of doing it at RAND, but given the filter on the output at RAND, and that we know we'd be producing garbage, it wouldn't be fair to RAND. So we got a little money from the Ford Foundation and we started at RAND to see if it was feasible. Then I, by a fluke, raised some money at the D. Vining Foundation –

Pelkey: What foundation?

Baran: The Arthur D. Vining.

Pelkey: Vining?

Baran: Yeah. V I N I N G. It's the old Alcoa money. And so, together with the National Industrial Conference Board, that was very supportive, we put together a very prestigious board. Had the chairman of US Steel and the chairman of AT&T and I had a discussion with Harvey Burk over at the Harvard School of Government telling him what I proposed doing; he's on the RAND board. He says: "No, you don't want to start a not –for-profit venture. If you're going to do work like that, pick the fuddiest duddy research organization, and do it there, because, to get any credibility at all." And I said: "Like where?" And he said "Like Brookings." So, we thought about it but figured no, that would be too much trouble, so we started this not for profit, and because we had the chairman of AT&T on the board and I had been a little bit of a, not a little a big pain in the ass to them, you know, taking pot shots and saying how vulnerable their system is and –

Pelkey: I'm surprised he joined your board in the first place.

Baran: Well, it was a fluky thing. He normally didn't join boards. This was H. I. Romnes, neat guy –

Pelkey: Who was that?

Baran: H. I. Romnes; very good guy, and a very good board member too. And we had General Doriot as a director and Daniel Bell. Neat board.

Pelkey: Great board.

Baran: And, so, I went to AT&T to see if we could get a contract, but it is sort of funny. It took a board decision on whether to have them let me be involved in any contract with AT&T. I heard about this later. Some people had said at the company, you know: "What, are you dealing with that guy?" The objective was to go right into the guts of AT&T and study management and

how they're reaching decisions and what are their assumptions and, what's the planning process. And let's try some new techniques on them. So it was a very very open kimono, which that organization never did in the past. And the other thing that they did simultaneously, they had Alvin Toffler go through their mail, so we worked together with Toffler. Independently, but sort of fun thing to compare notes once in a while. So here I was, you know, working in, and viewing life from AT&T's point-of-view and, I think it was very useful because they were able to get some inputs in how they are really perceived, and their strategy, and got the message to them.

Maybe we should turn the recorder off, but its ok. It's that they're getting into deep shit trouble with a perception problem, and that their real problem is going to come from the data communication entrepreneurs. Cause now, for the first time, they had a constituency who may have the means and interest to go after AT&T. The old constituency in the past was never big enough or had enough interest to attend hearings or doing anything, but now you have these new entrepreneurs coming along and that you're probably better off giving into them and not threaten the rest of your system.

Pelkey: This is in what year?

Baran: This is in 1970, '71.

Pelkey: Is this documented anywhere?

Baran: Well, part of it is documented, but part of it is not documented, though.

Pelkey: But I think that makes the point that the data communications industry was very different,

Baran: It was. We could see it.

Pelkey: And it was mostly modem guys that were –

Baran: Modem guys, yeah.

Pelkey: So it's like Codex and General DataComm and Infotrons and –

Baran: You could see it in the guys that wanted to build timesharing systems, and they felt they were getting screwed.

Pelkey: Ah!

Baran: Now AT&T had another problem in and around 1970, in New York City. AT&T, in many ways, is a very neat company. I wouldn't put this in anything you ever write,

Tape is stopped

Pelkey: So there was a data communication constituency that was emerging and you were –

Baran: Now back before then, lets back up a little bit. I had worked, before we got the AT&T contract, I was sort of a friend of the court to Bernie Strassburg who was head of the Common Carrier Bureau. He had SRI do a study on the Computer Inquiry I, and they were pissed off because they couldn't understand this stuff.

Pelkey: Who?

Baran: SRI was –

Pelkey: SRI couldn't understand it?

Baran: No.

Pelkey: The people of the FCC –

Baran: The FCC couldn't understand it. And they said, 'This is the first time they've gone out with a big contract like this.' SRI had a great reputation, and they're getting these reports, and they say: "This is bullshit." And could I act as a translator?

Pelkey: Fascinating. And how did you get to know Bernie?

Baran: I was probably taking pot shots at AT&T at the time. So I got to know him pretty well, you know, cause we were pressing around the other side through the government, because we wanted AT&T to build the goddamn network, the distributed network. We didn't want AT&T to say no. Our position in RAND was –

Pelkey: AT&T turned it down.

Baran: AT&T turned it down. Handed to it on a silver platter. DOD said: "How much money do you want? We'll give you the money. Build it." And AT&T said –

Pelkey: And this was in '72, '73?

Baran: Oh, no, this was in the '60s.

Pelkey: This was in the '60s?

Baran: Late -- yeah. Before, before the Air Force went out to build it themselves.

Pelkey: Before they went out with a RFP and gave it to BBN?

Baran: No, that was the Arpanet. I'm talking about the original distributed network -- the high-speed version of the network.

Pelkey: Ok.

Baran: That the plan, in '64, was to have AT&T do it, because they had the monopoly, that stuff was in it.

Pelkey: The high-speed network?

Baran: It was the national network; AT&T was synonymous with it. They had a monopoly. So, we couldn't think of, you know, better people to do it. But they didn't want to do it. Their position was: "Well, it ain't going to work, and second, why should we go in competition with ourselves?"

Pelkey: I'm confused on one point. Arpanet became the experiment that became a life of its own –

Baran: Right. This is before the Arpanet.

Pelkey: To prove the feasibility of the high-speed –

Baran: Right.

Pelkey: But the feasibility was going to go low-speed?

Baran: Yeah.

Pelkey: Because of costs?

Baran: Yeah. It was really the idea of can you send packets.

Pelkey: Which you really wanted AT&T to build?

Baran: Right.

Pelkey: They wouldn't build it? You then decided to go to an experiment with a low-speed –

Baran: That was a separate activity, saying: "Ok. AT&T won't do it. We didn't want DCA to do it, because they're incompetent.

Pelkey: And then Larry Roberts got enamored with –

Baran: So somebody, you know, people come through the door. You know, if you don't do it now, in another you or so. Government attitude.

Pelkey: I understand ARPA then went back, in the early '70s and offered the Network to AT&T again.

Baran: I don't recall that one.

Pelkey: I have that one in writing.

Baran: Ok. So that by now, it would be totally consistent, you know, what to do with the Network? And, so let's see, so I was doing that, for example, the sort of thing you have is a decision analysis, with very good people. But, as I explained, you know, to the lawyers at the FCC what it is about, and gave some tutorials, you know, what data communication is about.

Tape ends.

Baran: Here I was working for the FCC and along came this contract from AT&T, for the Institute for the Future, and we needed that work, so I told my friends at the FCC that I would no longer be able to be a consultant to them, and they say: "Well, we understand, but why don't you become a general consultant to us on research and development, because we're not doing a very good job with research and development at the FCC and we could use some help, and that should be clean and shouldn't give you any problem with conflict of interest." So I said, "Ok." And I said: "First of all, how much are we paying, what would have been the Chief Engineer salary." They said $25,000. And I said: "Well, that's not enough money to get the sort of person you really need for that top position." They said: "We know, but the Congress dictated that. It's in the legislation, and that was done purposely, because -- "

Pelkey: Because of the AT&T lobby?

Baran: -- Well, that was a different lobby. It was part of a Congressman's, at the time, I recall that about 25% of Congressmen had some interest or other in a broadcast station, or TV, a very high correlation. It was very important to their political position. So, there was a nice strong political constituency that wanted to see the FCC weak for some time, and so that was a constraint. So I said: "Well, no, until you get this problem fixed, there's hardly very much you can do," cause the people they had were simply, they were technicians. So I didn't do a hell of a lot more consulting after that. It was, you know, no point, you know, without any people there to be able to do anything.

Pelkey: But you, but this DAA –

Baran: Ok, the DAA thing, where the hell was I? I forget where I was, but sometime along in the process came the Carterphone decision. They wanted to prevent people from wrecking the telephone system.

Pelkey: Right.

Baran: -- and they're going to put dangerous voltages and foreign devices, I love the name of it, that could do untold damage to the national communication system and the personnel, the telephone people. And so, where the hell was I at the time? I forget when that was, but the National Academy of Sciences was looking into the issue, and the DAA was a rear guard action that gave them an unlevel playing field.

Pelkey: Right, and the National Academy of Sciences was looking into –

Baran: They were asked to look into whether the, you know, the DAA made sense or whether they –

Pelkey: By the FCC or by –

Baran: I don't recall. I can probably find the papers somewhere. I'll be straightening out some papers one of these years. It was a delightful thing that I saved because here was a piece out of Bell Laboratories showing how dangerous it is. The most strained example of this thing. If you put a voltage here, what are the probabilities of workmen coming across it and how many you're going to kill in a year and stuff like that shit, and it's the sort of thing that killed AT&T –

Pelkey: The flagrancy with which they –

Baran: The flagrancy which they tried to snooker.

Pelkey: Yes.

Baran: They got away with it for a long time, but what they didn't count on was the level of competency building up over time everywhere.

Pelkey: Right.

Baran: 'Cause once upon a time, communications was Bell Labs. There was no other place in the country that was doing anything.

Pelkey: Right. I guess GTE Linkert had a little bit –

Baran: A little bit, but –

Pelkey: Bell Labs still had 99% --

Baran: -- but not the same league, you know, that was –

Pelkey: To jump ahead and then have you come back, my understanding is that clearly the dial up modem business, other than through the acoustic coupler, didn't develop until you had a direct connect. You could have the leased line –

Baran: Yeah.

Pelkey: -- the leased line modem business could grow up –

Baran: The leased line was not a problem because you spring for the DAAs and it was a small cost of doing business.

Pelkey: Well, you had to use DAAs if you had a leased line?

Baran: Yeah, that's correct. It was a switched network.

Pelkey: So, once you hooked into the public network, you needed either this acoustic coupler –

Baran: Right.

Pelkey: -- and or DAA, and it wasn't until you had the RJE come into being that people didn't need the DAA and all that cost of the -- in that, at that point in time, the dial up modem business started to take off.

Baran: Yeah, there's a fuzzy area here. The modular jack came in for two reasons. Reason one was being able to connect to the phone line easily, and the other reason -- let's see, I've done some -- it could have been during the Cable Data days I was doing the consulting for somebody, I forget. We were in the consulting business then, in the early years before there was venture capital. But it sure made a lot of -- the other reason was economical.

Tape interrupts.

Pelkey: So that, my understanding was that there was a lobby of the modem companies –

Baran: Yeah, there was a lobby –

Pelkey: -- and AT&T was just stonewalling on a –

Baran: Oh, I know a good guy for you to speak to on this.

Pelkey: Who?

Baran: Phil Nyborg. He was Executive Director of the Communication Industry Association, and he is -- you've met Phil Nyborg.

Pelkey: Where would I have met him?

Baran: Yeah, remember he's the guy. He's on the sort of fringe of the venture capital business. He called you –

Pelkey: Oh, yes, yes.

Baran: -- and I said: "Be sure to call him back."

Pelkey: In fact, I'm having dinner with him in Washington, D.C.

Baran: Ok.

Pelkey: He was doing this new venture capital investment.

Baran: Right. Ok? Get Phil Nyborg to talk. He is a guy who single handedly took on AT&T. There are very few guys with the balls to do that.

Pelkey: So he was involved in the RJE –

Baran: Ah, he'd be able to give you the story, yeah. I think he came a little later, but he was fighting AT&T all the way, and he wouldn't take any bullshit.

Pelkey: And was he at FCC at this point?

Baran: No, he was with the Communications Industry Association, I forget the years on that, but he is definitely the guy to get the story out of.

Pelkey: Great. I'll talk to him about that.

Baran: He had a lot of guts.

Pelkey: Good, good. You've been very kind with your time today, since they've turned off the lights.

Baran: I think they're trying to tell us something, don't you think?

Pelkey: Yeah. I think so too, but you've been very helpful in my starting to understand some of these things.

Baran: Well, I think you understood very well, from what I've read of what you have written so far.

END OF THE INTERVIEW