Interview of Robert (Bob) Metcalfe

Interviewed by:
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Jim Pelkey: I know of your experience of having gone to Hawaii and seen ALOHA [ALOHAnet]. Was there something that happened before that experience that was formative in your thinking about communications and data communications and networking?

Bob Metcalfe: Yes. ALOHA was relatively late. I was at MIT and I was a computer guy there. I graduated in 1969, a year late; I got a degree in management and a degree in electrical engineering, and got accepted to graduate school at Harvard. I went there in Applied Mathematics. I was going to go to the Business School, but from the Graduate School of Arts and Sciences Applied Mathematics side, so I started studying decision theory. Then my NSF traineeship ran out, so I went out looking for a job. I shrewdly did not look for a job at Harvard where I knew I would get paid $2/hr. Instead I went back down the river to MIT and a friend of mine was at MIT Project MAC (which is now called the Laboratory for Computer Science there) and I said I'm looking for a job. He said, "That's great because we've got some openings.” He basically interviewed a few people. They asked me if I wanted to build a memory or work on connecting to a network.

Pelkey: This is 1970?

Metcalfe: This is 69-ish. I'm a little in doubt as to when exactly this was. I should know exactly but I think it was '69. It might have been '70. I said "Network," but I didn't know what a network was. I had no idea what a network was. I had never done any data—I had done operating systems. I had done languages. I did artificial intelligence, but I hadn't done any networking. The reason I was interested is that I was at Harvard and I was looking for a PhD topic and I was told by the people at MIT that networking was now hot because ARPA had just finished letting a lot of money to do ARPANET so they were out scouring the landscape for people to do work on it. I saw this as a way of getting, eventually, a topic for my PhD in computer networking, so I chose it, instead of building a memory, to build a network card.

Metcalfe: In those days we had PDP6s and PDP10s. The 6 was the predecessor of the 10. Harvard and MIT both had PDP10s, so I, having started work at MIT and wanting to—it was 1970, the fall of 1970. ARPA was starting up. I got this job at MIT in networks, but I needed to tie it to something I was doing at Harvard, because I wanted it to become my PhD eventually, so I went to Harvard and discovered that they had a PDP10 and ARPA had given them the money to put it on the ARPA network, but they didn't have anyone to do it. So I said to Harvard "I'll do it. I studied digital electronics at MIT. I know how to do stuff like that. I know how to write computer programs. I'll put this PDP10 on the network." Harvard was reluctant, so I went up to MIT and did some wheeling and dealing and I came back to Harvard and I said, "Have I got a deal for you!" They were reluctant because they didn't have any facilities for building this hardware that I wanted to build, none of it. So I went to MIT who also had PDP10s and I got them to agree that I would, as an employee of MIT, do this for MIT, and MIT would give Harvard a copy of what I built.

Metcalfe: I went back to Harvard and I said "Guess what, I'm going to get you this, okay?" And Harvard said "No." They said "You're just a graduate student. Of course this is a very important project to us, and we can't trust you to do it. We have to ask somebody who is very responsible, like a company, to do it. So even though you're going to do it for free, ARPA has sponsored us to spend $25,000 to have it done by Bolt, Beranek and Newman [BBN] to do it instead of you." I said "I guess that's reasonable. I can understand that. They'll be supporting it and documenting it and all that stuff, and, who knows, I might graduate." Then Bolt, Beranek and Newman turned around and gave the job to another graduate student at Harvard, who they hired part time to do this, a guy named Ben Barker, who is a big shot at BBN now. So Ben Barker was just like me, only he was going to get paid from BBN, who was going to take this big fee.

Pelkey: Did you know Ben at this point?

Metcalfe: He was a fellow graduate student. I knew of him. He was ahead of me, older. So I went ahead and did this anyway, only I did it for MIT, which points up one of the major differences between MIT and Harvard. MIT teaches its people by letting them do things. So, anyway, I did it for MIT, built a piece of hardware, which in fact I have upstairs and I can show it to you, if you're interested…

Pelkey: I'd love to see it.

Metcalfe: …because it worked for 13 years after I left. I built a device for connecting a PDP10 to the ARPA network.

Pelkey: To the IMP [interface message processor]?

Metcalfe: [*Affirmative*]

Pelkey: So it was a board that went in a 10 and connected to the IMP.

Metcalfe: Exactly. And one of the first people I called for advice on how to do this was Bob Kahn, who was then at BBN. I don't know why I called and, I forget the gist of it, but I do remember though, sort of doing the preliminary stuff, what you do and so on, I called Bob Kahn. We met and he was very helpful. So that's how it got started, and that was a routine, then—now it’s a routine, then it was a major deal for me, was to build this thing that's upstairs. I had to do a lot of other stuff too. I actually had to build the thing that you plug the thing into in the PDP10, because the PDP10 didn't have TTL [transistor-transistor logic], if you know what TTL is. It wasn't built using TTL, yet the modern thing in those days was TTL, so I had to build a TTL I/O bus for the PDP10 and then I had to plug…

Pelkey: Your board...

Metcalfe: …into the I/O bus. Then, I worked on the operating system drivers for it all. In fact, one of my partners in that project, who did a lot of the software, was Bob Bressler, who was at BBN until recently and is now at 3Com Corporation. He worked at BBN for about 15 years or something.

Pelkey: Was he a graduate student at MIT?

Metcalfe: [*Affirmative*] He was a graduate student at MIT while I was a graduate student at Harvard, but we were both employees of…

Pelkey: Were there any other members of your team that did this project?

Metcalfe: There's one other guy at 3Com who also worked with me. The other guy at 3Com, Kits Jarvis is his name, he took the memory project. Remember they offered me memory or networking, he built the memory, but he didn't work on networking though. Now he's at 3Com.

Pelkey: Anyone else?

Metcalfe: No, I don't think so.

Pelkey: So when did you complete this project, '72?

Metcalfe: Well that hardware project was done well before that, in '71, early '71. I'm a little confused about this, but yes very early '71, and then we put the—then we wrote the software.

Metcalfe: Now, we also worked on putting Multix on the network, although I wasn't as involved in that. Then I started writing my PhD, about the ARPA network, about the IMP interfaces and about how the IMPs work and host protocols and so on. That was my PhD thesis, which was intended to be done in June of '72, in time for me to graduate.

Metcalfe: June of '72 came around and I submitted it and all that stuff and I went out job hunting and I got lots of job offers because when you're in networking, guess what, you know everybody, so I got nine job offers, I remember. One of the reasons I got that was that ARPA, under the directorship of a guy there named Steve Crocker, who you should also talk to—Crocker named several of us to be ARPANET facilitators, which meant we would go around the world teaching other people how to get on the ARPANET. So, I got to travel and visit all these places like Tinker Air Force Base and SRI and [so on], which is how I got all these job offers.

Metcalfe: Having traveled all these places I was known to them and they wanted ARPA money too, and so they said this guy's at MIT. They got $2 million from ARPA, so we want this guy so we'll get $2 million from ARPA. So I got all these job offers and I was forced to choose the job offer that paid the most, offered the best weather and the best colleagues, namely, the work at the Xerox Palo Alto Research Center, which is where I went in July of '72.

Metcalfe: Only one small hitch, which is, when I showed up in June of '72 to defend my PhD thesis at Harvard, it was rejected, and I was thrown out on my ass <*laughter*>. But, imagine the scene: here's this graduate student who did all of his work at MIT, shows up to defend his thesis among a bunch of professors for whom he had carried no water for the preceding three years...

Pelkey: Being asked to approve your thesis…

Metcalfe: …and make a judgment on the intellectual content thereof, and there was sufficient doubt about the intellectual content of my thesis and the sufficient lack of water carrying on my part, that I got blown out of the water by them in June of '72.

Pelkey: That must have been a great day in your life.

Metcalfe: Yes, but I went to Xerox anyway. It was too late. I had accepted the offer, I had made moving plans, and I was on my way. So, I went. I was recruited there by Jerry Elkind, who is now a Xerox Vice President. This was at the Xerox Palo Alto Research Center, Computer Science Laboratory, and also Bob Taylor and Jerry Elkind were the dual heads of the Computer Science Lab. By the way, Bob Taylor is a former head of ARPA, preceding…

Pelkey: Crocker?

Metcalfe: I'm sorry. It was Taylor, Roberts. Crocker worked for [Larry] Roberts.

Pelkey: Where did [J.C.R] Licklider come in?

Metcalfe: Predecessor to Taylor. It was Licklider, Taylor, and Roberts. Taylor will tell you the story about how HE invented the ARPANET and Larry Roberts was opposed to it, if you ever want to hear that story, and it's credible, actually. And it's a detail of history. Once Larry Roberts took it over he then became the father of it.

Pelkey: Right.

Metcalfe: Taylor tells an interesting story about how Larry's initial ideas about all of this were wrong and how eventually Bob Taylor straightened them all out and then he went on to—it's a great story.

Pelkey: It sounds like a great story. Where's Bob Taylor now?

Metcalfe: He's the head of the DEC Palo Alto Research Center, right here in Palo Alto, with, essentially, many of the same people from the Xerox Palo Alto Research Center that he took with him. So, then it became—so my thesis had been about the ARPA network, but it was in the next year that it became about the ARPA network AND the ALOHA network. In other words, to finish it, one of its problems was that it was not mathematical or theoretical enough, and I couldn't—I found some, but not enough mathematics in the ARPA network, but I found gobs of it in the ALOHA network. So the way I beefed up the intellectual content of my thesis was to do a lot of mathematics about how the ALOHA network at the University of Hawaii worked.

Metcalfe: The way I got started on that project was, while being an ARPANET facilitator, I would go to Washington frequently, and I used to stay at the home of Steve Crocker. Not because they wouldn't pay for my hotel but because Steve is a super guy, so I used to stay at his house there. I was sleeping in his living room on his couch and he had a table—this is a key event because Ethernet wouldn't have happened, or it would have happened but with somebody else, and on the table was a copy of the proceedings of the Fall Joint Computer Conference. In it was a paper by Norm Abramson from the University of Hawaii on the ALOHA system. Mind you, at the time I was a graduate student dying to find some mathematics to put in my thesis. So this is right around the time I'm going from MIT to Xerox.

Pelkey: And after your PhD has been turned down?

Metcalfe: I can't quite get the timing on that, but this is when this one event happened. I was reading this ALOHA paper and I read the ALOHA paper and, having studied probability and statistics and all that stuff at MIT and having kind of liked it—probability theory stochastic systems and so on—I'm reading this paper about how the ALOHA network worked, statistically.

Metcalfe: The model Abramson used was infuriating to me. Infuriating, because it was based on a model that was tractable but inaccurate. In other words, you assume a bunch of things. This is Leonard Kleinrock’s favorite technique, too. You assume a bunch of things about a system that make the mathematics do-able, but the assumptions are highly questionable. So I'm reading Abramson's work and it struck me the same way, which is: assume that you have an infinite number of people sitting at keyboards, and they just type. No matter what happens they just keep typing. Even if they get no answer they just keep typing. Let's see how the system performs.

Metcalfe: Well, when I read that I said "But people don't. They DO stop typing." I mean, if they don't get an answer, they wait. This is not accurate. Now it was Poisson processes and exponential distributions and all that stuff that you can just math to death, and it all works out in a beautiful closed form formula. The trouble was, in my mind, that the ALOHA system was not being properly modeled.

Metcalfe: So I began fiddling with that and then, when I got to Xerox and when I was working hard to put some more math—I did some math which led to a paper that I got to present at the University of Hawaii at a systems conference there on a slotted ALOHA system with blocking, and it modeled, it attempted to model, what happened to an ALOHA system when people would only type if they got answers and then they would stop and wait.

Metcalfe: This had a dramatic effect on how you observed the system would perform. And in the process of doing that modeling, which became part of my thesis, it became obvious—the ALOHA system still had, even when you modeled it the way I did, some stability problems. That is, when it got full, it got a lot of retransmissions. That is, the ALOHA channel, which works by a process of randomized retransmissions—even when you modeled it the way I did it still had a stability problem. That means if you overloaded it too much it would slip off the deep end. But in the process of modeling that with a finite population model, meaning people stop typing when they got not answers, I saw an obvious way to fix it, that is fix the stability problem, which I then put in my thesis.

Metcalfe: I submitted my thesis, and I got a new thesis advisor and, Jeff Busen is his name, and Jeff Busen had the right idea. He said "Okay, my job is to get you out of here," and I said "Yes, sir." So, anyway, we got my thesis accepted a year later and I got my PhD in June of '73. Indicative of how I got it—Harvard University did not publish my PhD thesis. It was published by MIT, Project MAC, where I had done all the work. So it was the thesis finished at Xerox, for a Harvard PhD thesis, published by MIT. MAC Technical Report #114.

Metcalfe: Now, when I went to Xerox, when I arrived, even though I was given time to work on my thesis, my job was to put Xerox on the ARPA network just as I had put MIT on it, so that's what I proceeded to do, only not with a PDP10, but at Xerox we were building our own ersatz PDP10, a fake one called MAX. And, so, my job was to put it on the ARPA network, which I did. And then, the thesis got done…

Pelkey: Right.

Metcalfe: …and MAX got on the ARPA network, and all that was stable, and then I was given this great job which was, okay, you're our network—you're our networking guru. And now, we're going to build a bunch of desktop personal computers, and we need a way to network them together. This is like ten of us doing this together. So we started designing this thing called the Alto…

Pelkey: Right.

Metcalfe: …led by guys like Alan Kay and Butler Lampson and then Chuck Thacker and Ed McWright and others at the Palo Alto Research Center, most of whom are now—some of whom are still there, but most of whom are now at the DEC Palo Alto Research Center. And we started working on this personal computer and I started working on how to network them together. And the predecessor system that we had also built used Nova 800s, a product of Data General. So we had, I think, we had 32 of them all tied together in a local area network. And this was a local area network built by Data General called the MCA, Multi-Processor Communications Adaptor, which was a, I believe, a 16-bit parallel cable that ran from one machine the other and carried data among them at about 1.5 megabits per second. And we made—did various—I was involved in this only to a little bit because I came in just as this stuff was getting done. We used those Nova 800s as communication processors, as word processors, as workstations, and the design of the Alto was to iterate, now. We had a whole generation of stuff based on the Nova 800s and the MCAs. Now we were going to build a personal computer from scratch, and so, in essence, we were iterating on the Nova 800s and the MCA. So, the idea came up, let's connect them all together. They had to be—we had the starting assumption that these guys had to be connected at disk speeds.

Pelkey: Who set the—who set that requirement.

Metcalfe: Well—I don't know, and I'm sure somebody will tell you who it is, and I can't remember, but the thinking was: okay, we're going to have all these bit-mapped displays…

Pelkey: Right.

Metcalfe: …with mouses and keyboards and keysets were sometimes talked about, but mouses and keyboards and bit-mapped displays and a 2 megabyte removable cartridge disk and, ah, 64–128K bytes of memory, I think, was its—and it was about as big as a box that fit under your desk, but it was a big square box, so it wasn't a desktop. And it was going to generate documents in bit-mapped form to be printed on high-speed laser printers, which we were also building one of. And, that would be a million bits and you'd want to send that and print it at a page per second, so that's a million bits per second, so RS-232, the telephone system, ain't gonna hack it, so let's use a high speed network. So the original motivation for a high-speed local area network was a laser printer. Fact. I mean, you should hear all the stuff that Ralph Ungermann thinks that they were designed for. But, local area networks, the original one, if you think of Ethernet as the original one, which you might not, there are predecessors...

Pelkey: Right.

Metcalfe: The principal motivation for Ethernet was to connect these desktop bit-mapped workstations to a shared laser printer at high speed. And we were at that time envisioning a one page per second 500 line per inch printer, which we build in '74, I think it was, we got it finished, roughly. And so that was what this network was for, and the thought was—and we had several ways of building it that we considered. That is this local computer network.

Pelkey: [*Affirmative*]

Metcalfe: But we decided, or I decided or we decided, and, you'll get a lot of—over the years I've accumulated lots of who did what and who REALLY did it and all this shit, but in any case—"I alone privately in my office, with no input from anyone else—in fact, over the objections of everybody else—"…

Pelkey: <*laughter*>

Metcalfe: …decided that the way to do this was to take a cable and build an ALOHA network on the cable. And, by the way, it is impossible to trace exactly who had what idea on which day. It is a fact, however, that on May 22, 1973, a memo was written by yours truly in which the term "Ethernet" was coined and in which the basic operations of that network, on coax, not radio, ALOHA network was radio, with the improvements…

Pelkey: In your paper, your PhD thesis...

Metcalfe: …in the PhD thesis that handled the stability problems built in, namely collision detection. There were several mechanisms. Carrier sense and collision detection were added too, and then a back-off algorithm to hook it to basically a control. I had studied some control theory and MIT and this was a control. That is, the more collisions you got, the less aggressive you should be about transmitting. You should calm down. And, in fact, the model I used was, I had read and studied, in fact, the Santa Monica freeway. Whereas, you know that, in Los Angeles and some places around here they have stoplights that let you onto the freeways. It turns out that the throughput characteristics of freeway are similar to that of an ALOHA system, which means that the throughput goes up with offered traffic to a certain point where you have congestion and then the throughput actually goes down with additional traffic, which is why you get traffic jams.

Pelkey: Right.

Metcalfe: The simple phenomenon is that, psychologically, people tend to go slower when they're closer to the cars…

Pelkey: <*inaudible*>

Metcalfe: …so as the cars get closer and closer together and people slow down and the throughput goes down, so they get closer and closer.

Pelkey: That's right, and finally you have...

Metcalfe: So the...

Pelkey: It really degrades.

Metcalfe: So it was a really simple step to take the ALOHA network, and when you sent, and you got a collision, you would just take that as evidence that the network was crowded. So, when you went to retransmit, you'd relax for a while, a random while, try again. If you got another collision you say "Whoa, it’s REALLY—" And you'd randomize and back off a little. So the carrier sense, meaning "Is there anybody on there yet?"

Pelkey: Right.

Metcalfe: Well, the ALOHA system didn't do that.

Pelkey: Oh, they just launched.

Metcalfe: Just launched. So, therefore, a lot of the bandwidth was consumed in collisions that could have been avoided it you just checked. And then—so that was a lot of it was just checking to see if you were going to murder somebody before you jumped in.

Pelkey: Right.

Metcalfe: And collision detection was, while you're transmitting, because of distance separations, it’s possible for two people to check that decide to send and then send and then later discover that there was a collision. So, if while you were sending you monitored your transmission, you could notice if there was a collision, at which point you would stop immediately. That tended to minimize…

Pelkey: Uh, huh.

Metcalfe: …the amount of bandwidth wasted on collided—once they were collided they were damaged irreparably. And the collisions would happen within the first few microseconds, so there's no sense transmitting for a millisecond if you know in the first microseconds you've got a collision.

Pelkey: Right.

Metcalfe: And then the back-off algorithm to—when you had one of these experiences, to back off, kept the throughput curve monotonic, so that it wouldn't…

Pelkey: Fall off to the...

Metcalfe: …fall off and cause a traffic jam. That was it. That was in this memo and elaborated somewhat. May 22nd, which means the 15th birthday of Ethernet is this May.

Pelkey: That's right. In fact, I read in your *Connections Magazine* that that was the case.

Metcalfe: Right, I'm going to try to have a party that evening.

Pelkey: Where did the name Ethernet come from? Was it named Ethernet at that point?

Metcalfe: On that day.

Pelkey: Where did you come up with—I presume you came up with the name.

Metcalfe: Yes. The—well I had been an MIT student and one of the things we studied in physics was Michelson and Morley's experiment to prove there was no ether, or ether wind, and following that experiment, there was no ether so the word ether—the aluminiferous, it was now a free word. And what the ether was, the original ether was, was an omnipresent passive medium for the propagation of electro-magnetic waves...

Pelkey: Right.

Metcalfe: …namely, light. And that word was no longer useful. So what this cable was, that we were going to use, the cable was going to be everywhere, totally passive.

Pelkey: Right.

Metcalfe: That is, no switches, no power, just copper and insulation, passive, everywhere, and what was it going to do? It was going to be a medium for the propagation of electro-magnetic waves, data packets, hence the cable is the ether. It's a copy of the ether, like when you put TV on cable you’re basically—you have a copy of the frequency space and free space, only a copy of it. So it was an ether, and so it was a network using an ether, so it was an Ethernet.

Pelkey: How about—and CSMA/CD [carrier sense multiple access with collision detection], was that coined at the same time?

Metcalfe: No, CSMA/CD was a terminology introduced much later by my then older arch rival, Leonard Kleinrock at the University of California Los Angeles, who did some of this infuriating mathematics. In fact, he and Abramson did a lot of it together. In fact, I remember showing in an airport—in Washington National Airport, I showed Leonard Kleinrock the mathematics in my PhD thesis and he told me it was junk. I don't think he used the word junk, but—"Not very rigorous," that's what he would say, and, ah, pooh-poohed it. And then I wrote my thesis and got my PhD and graduated and published a bunch of papers and then, he kind of liked it after a while. And then HE fit Ethernet into his nomenclature for multiple access systems. So he had termed CSMA and then began analyzing when you had collision detection, so then it became CSMA/CD. So he had a family. ALOHA network was a multiple access, then carrier sense got added, so then he started looking at CSMA networks, and then collision detection got added and then it was CSMA/CD. So he had a whole family of them, to his credit, he analyzed all of them, of which my invention was simply one pitiful degenerate case.

Pelkey: <*laughter*> Now, the process of—you were presented this situation of connecting all these desktop...

Metcalfe: Let me—just before you ask that question—Kleinrock at that time was influential on me in that his mathematics was infuriating to me.

Pelkey: Right.

Metcalfe: He's a genius and a great man, he has published many books, he's a world respected guy and he's—in fact, I'm going to see him very shortly. But, at that time, he was an irritant.

Pelkey: Yes.

Metcalfe: In fact, he's a little bit irritating even today, but he's a great man. I didn't mean to suggest anything...

Pelkey: No. I didn't take it that way, other than just that...

Metcalfe: It was just—I remember vividly as pissing all over my mathematics at National Airport.

Pelkey: I've come to appreciate the fact that people can intellectually, or in the profession, through a thinking process, have as you would say in sociobiology, Wilson's <*inaudible*>, you can be very combative and be very disagreeable, and yet be friends and have a very nice relationship. In fact, the fact that you disagree about your lecture doesn't mean you’re disagreeably as people.

Metcalfe: So the people listed in the—on the ARPA network as the biggies would include, Howard Frank, formerly of Network Analysis Corporation which he sold to Contel I might add...

Pelkey: Right.

Metcalfe: …Leonard Kleinrock and...

TAPE SIDE ENDS

Metcalfe: So in those days at the ARPANET, Bob—Larry Roberts, Dr. Lawrence G. Roberts, was the grand-daddy, and then the three sort of intellectual gurus were Howard Frank, of then Network Analysis Corp., Leonard Kleinrock, the queuing theory wizard from UCLA, and Bob Kahn from BBN, were the three glamour boys, you know, who wrote all the papers and went to all the conferences. I would not say they did all the work, but they were the glamour boys, which should lead to a story about Frank Howard at some point, but he was the guy who did most of it…

Pelkey: Yes.

Metcalfe: …unsung hero of the ARPA network, because of his general makeup, but a real superstar. Anyway, you were about to ask a question.

Pelkey: The process of—you had obviously struggled mentally with this issue of, 1) having seen this article on ALOHA from Abramson and mathematics which was infuriating to you in terms of its assumption/conclusion, that you then did your PhD dissertation in terms of—had thought through lots of the problems of creating what was to become Ethernet...

Metcalfe: Yes. That's right.

Pelkey: …but then you were presented with this situation of this problem of connecting all of these desktop computers together...

Metcalfe: Right.

Pelkey: …which has kind of lent itself to "Wait a minute, I've already kind of solved this problem." Then, boy, all I got to do is go do it, now. Is that, I mean...

Metcalfe: Yes, it followed that way, in that...

Pelkey: So there wasn't really any—it wasn't at that point in time. This is a very difficult problem. You really came to that prepared with having had this—having thought through the solution, you had to go implement it and make it happen now, but that you had a very fixed idea of how to solve the problem of connecting all these PCs to laser printers and being able to get the bandwidth you want.

Metcalfe: Well, the PhD was done not so much in anticipation of the problem, but when the PhD was done, and there's a little overlap here, but in essence, when it was done, then the problem appeared and the solution...

Pelkey: Was obvious.

Metcalfe: …was obvious, but there may have been other ways to do it. In fact, there were other ways to do it. token ring is another way to do it.

Pelkey: Right, yes.

Metcalfe: And the—but there were rings in those days.

Pelkey: Correct.

Metcalfe: In fact, one of the reasons for doing Ethernet the way it was done was that there were already rings being done, and when you're doing science, it doesn't really pay to just duplicate what other people are doing, so one of the things that motivated dong Ethernet the way it was done was to do something different.

Pelkey: At least for the PhD, but, when you made...

Metcalfe: No, no, no. One.

Pelkey: Even at PARC? [Xerox Palo Alto Research Center]

Metcalfe: Yes, even at PARC.

Pelkey: Because you were trying to do science at PARC.

Metcalfe: That was supposed to be science.

Pelkey: Gotcha. That's helpful.

Metcalfe: So one of the inputs on why we did Ethernet is that a guy named Dave Farber at the University of California at Irvine was doing a thing called the Distributed Computing System, of which PARC was a ring. I'm not even sure you'd call it a token ring, but it was a ring.

Pelkey: Right

Metcalfe: And we became friendly archrivals, he doing the ring and I doing the ether. And he had picked this work up at Bell Labs, where it had been done by a guy named Newhall. He had done a thing called the Newhall Loop before that.

Pelkey: At ATT—Bell Labs.

Metcalfe: Yes, I think so.

Pelkey: Do you remember when Newhall did that, at Bell Labs?

Metcalfe: A LONG time ago.

Pelkey: I was told the late 50s, early 60s.

Metcalfe: Something like that.

Pelkey: And it was to connect central offices together or something like that.

Metcalfe: Yes, terminal polling or something. There's an interesting story there about Olof Söderblom and the token ring...

Pelkey: Right, exactly.

Metcalfe: …and having purchased those patents to strengthen his current patent position.

Pelkey: Yes, yes.

Metcalfe: And all the defects of the patent system were evident in that little story.

Pelkey: Oh, absolutely,

Metcalfe: But, anyway, the—so the Ethernet got done. Oh, now, interesting...

Pelkey: This is '70—what time frame, '74/'75?

Metcalfe: '73, '74, '75. It was two years, basically, that Ethernet got done as a science project.

Pelkey: Okay, so you demonstrated it in end of '75 beginning of '76?

Metcalfe: [*Negative*]. Before that.

Pelkey: Before that.

Metcalfe: In '75, we had a hundred-node network operating with a hundred Altos and some Nova 800s in them and, ah—we had this fairly sizable network in operation. A hundred is a BIG number, by the way.

Pelkey: Oh, it IS a big...

Metcalfe: Because there were a hundred people sitting at this network with a laser printer.

Pelkey: At that point there was 3 megabits.

Metcalfe: Yes, 3 megabits per second. But going back a step there, while—when it came time to build the Ethernet for the Alto, I happened to be walking down the hall one day, entrepreneurial scientist that I was...

Pelkey: So you had a hundred nodes, that's a lot.

Metcalfe: In fact, in the paper which got published in July of '76, which was the first public display of it…

Pelkey: Was that your IEEE paper?

Metcalfe: No, it was in the CACM. Communications at the ACM, July of '76. And in the back there was the gratuitous comment that said something like: "Thanks for everybody for the help in building the hundred-node network without which this paper would be just so much speculation."

Pelkey: John Shock is cited in that.

Metcalfe: Probably, yes. He didn't write it, though. He was a graduate student at the time. Which leads me to David Boggs, a guy named David R. Boggs, who also works at the DEC Palo Alto Research Center now. So, I was working on Ethernet, had written this paper, and needed to kind of get the project going; do the logic design, build the boards, write the microcode, etc. And I don't like to work alone. In fact, I believe the ideal operating unit is two people. Three is too many and one isn't enough. Two is perfect. So I went out looking for somebody to work with me, and one day, I saw this guy in moccasins with a pony tail down to his back padding his way through Building 34 at Xerox. And he didn't look busy. He looked like he didn't have enough to do. So, I checked into it and it turned out he was a graduate student from Stanford who was working. I checked with his boss, a guy named David Liddle, whose name should come up again.

Pelkey: Right.

Metcalfe: And I asked about this guy, and this was David Boggs, David R. Boggs, who was a fairly capable but difficult graduate student at Stanford, and he really didn't have enough to do, and David Liddle said "Well, why don't you get him to work on your project with you?" So then David Boggs—so I approached Boggs and propositioned him and we entered into a two-year long project together which culminated in this hundred-node network. So which is, when, in '75.

Pelkey: [*Affirmative*]

Metcalfe: So therefore the Ethernet paper that got published in the CACM was Metcalfe and Boggs.

Pelkey: Done with him, okay.

Metcalfe: Okay, and you should—all the shit I have taken for having… A lot of people think that David Boggs did Ethernet and I stole it from him.

Pelkey: Is that a fact?

Metcalfe: That they think that. And these are generally people who don't think that articulate people actually do anything ever.

Pelkey: Right, of course.

Metcalfe: This is my analysis of the situation. So I have heard some really strange stories, but anyway, if you'd like, you can call David Boggs and ask him and he'll tell you a story much the same as I...

Pelkey: Where's David?

Metcalfe: At the DEC Palo Alto Research Center. But it is unbelievable. A friend of mine has told me this story that ‘success has many fathers but failure is an orphan.’

Pelkey: Right.

Metcalfe: Well, all the people that I have met who have invented Ethernet or who believe it was stolen from David Boggs or some other pitiful creature somewhere, and I'm happy to share the credit with thousands of people, but, the abuse that I have taken in my life. Anyway, I just wanted to mention David Boggs.

Pelkey: Good.

Metcalfe: With whom...

Pelkey: I was going to bring his name up, because I've had a copy of that paper.

Metcalfe: And if you look at the patent, the patent is Metcalfe, Boggs, Lampson, and Thacker. Lampson was the—who is also now at the DEC Palo Alto Research Center—was the intellectual guru under whom we all had the privilege to work, and Chuck Thacker was the guy who designed the Alto. So when it came time to do the patent and to file it all, I insisted that those four names be put on, not just my name. And the lawyers, in fact, argued with me that I SHOULDN'T put those four—those other three names, but I felt that they had worked enough on it, I wanted their names on there, and I got my wish. But as a result of this, I have now gotten interminable shit from people over the years that actually THEY invented it and I stole it from them somehow. In fact, I insisted that their names be put on. David Boggs did not write a single word of that paper that got published, but I insisted that his name be on the paper because he and I had worked together for two years. But, God, David is the arch example of the introverted, quiet, inarticulate guy, and so—and I'M a loud mouth, so he must have invented it all...

Pelkey: He MUST have done all the work.

Metcalfe: And the fact that my thesis is sort of about this whole thing was written long before this work got done is...

Pelkey: Irrelevant.

Metcalfe: …is irrelevant to most people. Anyway, you should listen. When you hear these stories, you'll hear...

Pelkey: Oh, yes.

Metcalfe: Success has many fathers, and it gets much worse than this. I actually met a guy who—a press guy, and he was talking to me and he asked me about myself and I told him that I was—I had invented Ethernet. He said "Oh really, well I met the inventor of Ethernet last week." You know how cynical press people can be, like I had just lied to him, somehow, he intimated, and I said "Well, really?..."

Pelkey: Who was that?

Metcalfe: "Who could that BE?" And it wasn't David Boggs and it wasn't Butler Lampson and it wasn't Chuck Thacker who were the usual candidates, and should be candidates, it was a guy named Paul Strassmann, who was the Vice President of Xerox when I was at the Palo Alto Research Center and who opposed the Xerox Research Center on a daily basis and who criticized Ethernet from inception, and somehow in an interview he had done with this press guy had said enough to suggest to this man that he had actually—I'm sure he didn't actually say...

Pelkey: Right.

Metcalfe: …but he left this press guy with the impression that he had invented Ethernet, and of course this is 10 years after the fact. Anyway, success has many fathers, and Ethernet certainly has been successful.

Pelkey: When did you go to MIT? As a visiting professor?

Metcalfe: After I left Xerox. Well, I was at MIT undergraduate '64–'69.

Pelkey: Right, but then you went back as a visiting...

Metcalfe: Then I went to Harvard, then I went to Xerox, then I left Xerox in '75, November.

Pelkey: Right.

Metcalfe: No, no, no, no. I have this wrong. I DID leave Xerox in November of '75 but then I went BACK to Xerox in '76 and then worked there until '79. Then I went back to MIT in the first five months of '79.

Pelkey: Oh, okay. So it wasn't until '79 that you went back to MIT as a visiting professor.

Metcalfe: It wasn't actually a visiting professor. I was a consultant to the Laboratory for Computer Science. I mean, I wasn't title...

Pelkey: Did [Michael] Dertouzos—Dertouzos was running it then?

Metcalfe: Yes, Dertouzos was my client, if you will.

Pelkey: Okay. Now, in '76, Vinton Cerf came to Stanford and had an ARPA contract to work on what was to become TCP/IP.

Metcalfe: It must have been sooner than that. There were, I don't know the exact date...

Pelkey: Because he said that you and he interacted while he was there.

Metcalfe: Oh absolutely, but...

Pelkey: Actually, no he did come to Stanford, because he came to Stanford the end of '72

Metcalfe: Yes.

Pelkey: December '72 he came to Stanford.

Metcalfe: We began—well, we had all worked on the ARPANET together, including Vint in particular, and I was at Xerox and spending a lot of time at Stanford and Vint was a professor there…

Pelkey: Right.

Metcalfe: …under the auspices of ARPA and also for IFIP, the International Federation for Information Processing, Working Group 6.4—6.1 it was called.

Pelkey: 6.1, yes.

Metcalfe: We did some protocol work, sort of to follow on the ARPA network. There was a seminar at Stanford that Vint led, at which the ideas that led to TCP were developed, but these were also the ideas that led to XNS [Xerox Network Services].

Pelkey: Right.

Metcalfe: And the—so there was a branch—ARPANET came in, a thing called NCP, which was ARPANET, and out of it came two initial branches: TCP, which is the work that Vint pursued, but we were in more of a rush at Xerox, so we did XNS—we actually, we did a protocol which I devised, called PUP, which stood for PARC Universal Packet, and then PUP became XNS while TCP was becoming—but this was in '74.

Pelkey: Yes.

Metcalfe: And PUP was the protocol that came out of that and it lasted until approximately '76...

Pelkey: Okay.

Metcalfe: …when I—and PUP was widely used and way ahead of TCP internal to Xerox. Huge network I built at Xerox based on PUP while TCP was still being theorized...

Pelkey: Right.

Metcalfe: We were in a rush. That's why it diverted...

Metcalfe: Right.

Metcalfe: …because we had to get something done, while TCP was being standardized. TCP was not made a standard until 1980.

Pelkey: Right.

Metcalfe: So, meanwhile, in 1976, when I returned to Xerox from my seven month departure, I came back and I was given the job of engineering products based on Ethernet and based on PUP, and that's when Ethernet temporarily became the Xerox wire.

Pelkey: [*Affirmative*]

Metcalfe: And PUP became XNS.

Pelkey: Okay

Metcalfe: And then XNS arrived in product form in 1980 as part of the Xerox Star, which is exactly the time that TCP got made standardized by DOD. So that branch—and then the ISO protocols came out of that somewhere.

Pelkey: Right.

Metcalfe: And, there's probably a lot of controversy about that.

Pelkey: Yes, there is.

Metcalfe: Who cares? But, in any case, I think what happened is that TCP got through IFIP Working Group 6.1, got taken back to Europe by some people in France, and became part of ISO, which became OSI.

Pelkey: Right.

Metcalfe: That's what I think happened.

Pelkey: Now, if I understand correctly, as you say, and I'm led to believe by Vint Cerf's example, that you had—one, you were under some time pressures, and secondly you had a relatively controlled environment, you know exactly what machines you were going to hook up to what machines...

Metcalfe: Exactly.

Pelkey: …and he was under the mandate to be able to interface to all kinds of different machines, and particularly there was this concept of radio networks, in addition to wire networks, and so he had a more general—he was working on a more generalized problem than the problem that you were working on.

Metcalfe: Yes, but there is also another substantial difference, which hasn't been mentioned yet, which is: We were working on LANs, and he was working on 50 kilobit per second telephone circuits and that's a substantial difference. And that's why TCP is so slow and XNS is so fast. So, XNS was built to be carried over 3 megabit per second or multi-megabit per second transport facilities and TCP was designed with an intuition about modems and slow stuff. So you run TCP on a LAN and it is slow, in fact, it’s twice as slow, half the speed of XNS at bridge...

Pelkey: Right.

Metcalfe: …because XNS said "Wait a minute, these bits are coming in at 3 megabits per second. We can't afford to grovel through them and look at variable length fields and all that stuff. We'll look—instead of having variable length fields, we'll just have big fields."

Pelkey: Right.

Metcalfe: So they’re big enough—instead of having bytes with little continuation bits and all that other stuff that you do when you're sending stuff very slowly, and you have—where bandwidth is at a premium and you have lots of time to compute about it, you encode it all tightly, which is the way TCP is done, whereas XNS is flat and wide open. So you got the next 16 bits is the type field—BOOM, the next 16 bits is the—BOOM, and—so XNS is faster. So that's the—I believe that was the—that is the principal difference rather than the aforementioned ones.

Pelkey: Actually, I was mentioning—I was over with Dan Lynch earlier today, the TCP/IP purist, and he said XNS is—for LANs it’s much better. And here he's the editor of TCP/IP and he says it’s much faster, it’s much better, he said "Unfortunately, Xerox just wouldn't let the community get at XNS...”

Metcalfe: They started, but they failed.

Pelkey: They failed, whereas, when the DOD forced TCP/IP into Berkeley UNIX, people could go out and buy Berkeley UNIX for $32,000 and get the source code and they got TCP/IP with it, even though it was buggy, they got it, and that's how TCP/IP...

Metcalfe: Well, there's a little detail missed out of there, which has to do with the history of 3Com Corp. and Vint Cerf and getting double-crossed by the US government, which is: In 1980, 3Com Corp. was about to do its first product, very first product, which was to be some protocol software. And Vint Cerf persuaded me; it didn't take much persuading, but persuaded me, that we should implement TCP, because it was going to be a standard.

Metcalfe: Now, at that time XNS was a secret of Xerox Corp., and I had just left Xerox. I couldn't do XNS, even it I wanted to, but TCP was public domain. It was about to be a standard. So 3Com Corp. invested its meager resources, meager meaning our retained earnings, which had been accumulating for only a few months, excess—let's see we were founded in June of '79 and we began this project in the summer of '80, and we had been profitable, so out of our retained earnings, we invested $100,000 or something, to develop TCP for UNIX over Ethernet. A product called U-Net, which we first shipped in December of 1980, and we are now building a business selling the TCP standard, selling the UNIX standard, selling the Ethernet standard, one package, and we succeeded, by the way. We did sell all those things and we made some money and bootstrapped ourselves into a giant that we are today. But the—but much to our disappointment, Vint Cerf, while he was encouraging us to do this and charge money for it, was giving money to Berkeley to do it and give it out for free. So, a few months after we started shipping this product to sell, Berkeley started giving it out for free. Probably a year later, I forget exactly when.

Pelkey: Free in the sense that you had to buy the source license for UNIX in order to get it.

Metcalfe: Yes, but it came free with the UNIX, whereas ours was an add-on product for UNIX. Well, we continued to successfully sell it because we supported it and documented it and did other commercial like things to it, unlike the Berkeley release which was kind of changing all the time and buggy, as you say.

Pelkey: Right. That must have been a strange moment when you realized what was happening. Here, after you have invested your money in...

Metcalfe: Yes, MY money. Not a venture capitalist’s money...

Pelkey: YOUR money.

Metcalfe: …but MY money, and...

Pelkey: That's REAL funny.

Metcalfe: … then my good friend, Vint Cerf, gives HIS money—he didn't give us any money. He didn't say: "We'd like you to do this. Here's a $100,000." He said "You know, you ought to do that," and gives the $100,000 to Berkeley instead. Boy, was I ever pissed.

Pelkey: I can imagine.

Metcalfe: But we—whew, it all worked.

Pelkey: Let me come back to before even 3Com.

Metcalfe: Yes.

Pelkey: You worked on XNS in '76 just to...

Metcalfe: Until '79.

Pelkey: To '79.

Metcalfe: I, personally.

Pelkey: And where did the ideas for that protocol come from?

Metcalfe: XNS is just an update of PUP.

Pelkey: Just an update of PUP.

Metcalfe: And PUP came from those Stanford seminars, which I participated in.

Pelkey: And do you recall who else was at the Stanford seminars?

<long pause>

Metcalfe: Me and Cerf. There must have been some others. I think there were probably five or six people.

Pelkey: Do you remember Judith Estrin from those days?

Metcalfe: No. Might have been. I just don't remember.

Pelkey: She worked for Cerf.

Metcalfe: Yes, but what years? I think she's later.

Pelkey: She might have been later. She probably was later than that, actually.

Metcalfe: But close, close.

Pelkey: But you kind of participated in some seminars, and then you kind of got, as I hear the stories, you kind of got off and got busy and really started to lose contact with Stanford. Is that a fair statement? You kind of went and did your thing?

Metcalfe: Well, there's an interesting story here, which is that Cerf and Kahn—now Kahn wasn't at these seminars, but Kahn was at ARPA by this time...

Pelkey: Yes, he was at ARPA.

Metcalfe: And he was sponsoring Cerf.

Pelkey: Right.

Metcalfe: And out of these seminars. Oh, so then I focused in implementing and went off and did PUP.

Pelkey: Right.

Metcalfe: Although my association with Stanford, I mean, I was a professor there from '75 to '83, so, it wasn't as if it tapered off, I mean, my—but my involvement in TCP tapered off.

Pelkey: Okay

Metcalfe: Because I was—in fact I remember when it came time for Cerf and Kahn to write the TCP paper, we argued—the three of us argued about whether I should co-author it or not. And, they decided that I wouldn't co-author it. I think they acknowledged me, but they didn't let me co-author it. So it became the Cerf and Kahn paper, and it was in this—we're all pals, now, but it was a source of irritation then, about that. It didn't seem fair, somehow.

Pelkey: Yes.

Metcalfe: You know, history is riddled with these little irritations, some of which go away and some of which don't go away.

Pelkey: Yes, yes.

Metcalfe: Some of which diverge to become vicious things. This one isn't one of those, but this was a—I can remember talking with them about doing this. This was basically to write up what had gone on at this seminar.

Pelkey: And that seminar was in '73, '74?

Metcalfe: Yes, if you'll shut that off. I can…

TAPE PAUSED

Pelkey: We were talking about this course and who else was in this course at Stanford and—maybe a name will come up and if it does, obviously...

Metcalfe: Well, it was working—it was IFIP Working Group 6.1.

Pelkey: Right.

Metcalfe: I believe that was the precipitating group that met at Stanford and was hosted by Vint.

Pelkey: Right.

Metcalfe: And attendees at that included the French and all NAS.

Pelkey: Right.

Metcalfe: The Louis Pouzin and his minions, of which there were five or six, including Hubert Zimmermann and Michele Dionne, most notably, and the BBN folks, but—I don't know. I can't even

remember. I can remember the dingy offices at Stanford where we met but I can't remember who was in the room.

Pelkey: Okay, fine.

Metcalfe: There were probably five or ten people.

Pelkey: So, you were obviously aware of what was happening at ARPA and the TCP/IP effort going on at Stanford and you also had your ideas that led to PUP being created.

Metcalfe: Right.

Pelkey: And as you rightly say, as you were just describing, you built yours for a cable, as opposed to a telephone line.

Metcalfe: Right.

Pelkey: And then PUP became XNS when you came back in '76 to the Xerox Center after a short sabbatical. And then you were at Xerox PARC and worked on XNS until '79 when you then went to be a consultant to the Computer Lab.

Metcalfe: Yes, I short-changed—I was at PARC from '72 to '75, about 3 1/2 years.

Pelkey: Right.

Metcalfe: And then I left briefly and went to work in electronic funds transfer with Citibank, and then came back seven months later and didn't go to PARC anymore and went to Systems Development Division of Xerox, which was in Palo Alto….

Pelkey: Oh, okay.

Metcalfe: …but wasn't Palo Alto Research Center anymore. So the two technologies were—we tried to take everything from PARC and tried to make it into the Xerox Star, which is what we were working on. And so, Ethernet became the Xerox wire, because the marketing people felt that Ethernet wouldn't sell, so we had to change its name, and we speeded it up from 3 megabits to 20 megabits per second and later slowed it down. And then the—to save money. And the PUP became XNS, the Xerox Network System.

Pelkey: Yes

Metcalfe: And a few other changes.

Pelkey: And then you decided—then you went to MIT as a consultant?

Metcalfe: Right, the first five months of '79, upon my departure from Xerox.

Pelkey: And you departed Xerox—anything related to their unwillingness to do anything in terms of commercializing XNS, or just, you had had enough of Xerox and wanted to do something different?

Metcalfe: Yes, I wanted to—personally I was done—I was an engineering manager and I wanted to be more of a business person, and Xerox couldn't, and shouldn't and didn't—I mean I was buried in an engineering organization and there was no way—so I gave Xerox about seven months notice and said I want to at least report to a general manager, because I—actually, the motivator there was, we weren't succeeding.

Pelkey: Right.

Metcalfe: And my analysis, at the time amateurish, was that there were things other than engineering that you needed to do right to succeed, and, apparently, since we were so good at engineering, the problems must be in marketing or manufacturing or something, and so I wanted to find out more about those, because I hated failing and we were—WE, not they, WE were failing, and I was—I had this intuitive feel that if I knew more about the other functions...

Pelkey: The Star wasn't introduced until '80?

Metcalfe: '80, yes '80.

Pelkey: So what was failing in early '79?

Metcalfe: When I came back to Xerox in '76 we were about two and a half years from product shipment and when I LEFT we were about two and a half years from product shipment.

Pelkey: Okay. Now, when you went back to the Computer Lab, if I understand correctly, they were in the throws of making a decision about network. There was Chaos network was going on in the AI lab...

Metcalfe: Whom did you talk to about this?

Pelkey: What?

Metcalfe: Whom did you talk to about this? This is funny. Dertouzos was my boss.

Pelkey: Dertouzos, right.

Metcalfe: And he wanted me to come back and help them think about networks.

Pelkey: Right.

Metcalfe: So I did. I jumped at the chance. $250 a day.

Pelkey: To think about—and they were interested in implementing a network, right? In the Computer Lab? If I understand correctly they going to get this grant of 750s, 11/750s from DEC...

Metcalfe: Which they got.

Pelkey: Which DEC somehow put the requirement, somehow these had to be single user workstations.

Metcalfe: Yes.

Pelkey: And MIT had the responsibility to—they wanted to network these. And they were trying to make the decision as to how to network them.

Metcalfe: Yes.

Pelkey: And you were a consultant to them trying to come up with a scheme of how to network these?

Metcalfe: Yes, and I was more of a change agent. My job wasn't really to do any engineering. It was just to help get the decisions made and we were deciding between the token ring—Dave Farber's DCS ring, from Irvine...

Pelkey: Right.

Metcalfe: …was picked up by MIT, Jerry Saltzer.

Pelkey: Right.

Metcalfe: So, they were working on that. Meanwhile, my friends over in the AI lab had picked up Ethernet and built their own version of it that they called Chaos Net, and I honestly can't sort out what years this was all happening, but I think we were trying to figure out how to network the campus, and I just waded into the middle of that, performed some assassinations and—in fact, there's a guy, I can't mention his name, but Dertouzos asked me to be sure that he left MIT very soon. So I went and GOT somebody to make him a job offer so that he would leave. This guy was screwing things up. Stuff like that I did...

Pelkey: Right.

Metcalfe: …rather than just engineering.

Pelkey: But, at that point it time, it strikes me that that was a relatively important period, in terms of forming ideas about networking.

Metcalfe: Yes, it was.

Pelkey: You had a group—there was a group of people there who I'd like to—if your memory is—who was in that group. That was a relatively—if I'm led to understand, there were some sessions that were very heated debates between rings and Ethernet and fiber optics and, I mean constraints and...

Metcalfe: Yes, Jerry Saltzer, professor Jerry Saltzer, who is still there to this day making trouble, on project Athena, to which, incidentally I have donated a lot of money in gratitude. So, yes, something important must have happened. So we argued...

TAPE SIDE ENDS

Metcalfe: May 7th to 9th the MITRE Corp. sponsored a conference on local computer networks at the Copley Plaza Hotel, in which I was one of many session chairmen. This was the month before 3Com got founded, and the—Saltzer was one of my session participants, and he presented a star ring, he and a guy named Ken Pogran. I believe to this day that if I had grabbed him by the neck and dragged him and threw him in the river that day there would be no IBM token ring today, because Saltzer was consulting for IBM, in those very days. And I was consulting for IBM in those very days, two days actually. And, he won. And IBM chose token ring in early '79, largely for political reasons, but, it was the star ring—it was Saltzer's star ring, the derivative of the ring from Dave Farber's network at Irvine, which was presented that day, May 7 to 9 in Boston—so that May was the end of the five month period—January, February, March, April, May, that I was consulting for MIT. That's when I stopped. It was at the end of May.

Pelkey: Obviously, a number of questions, though. First, you said politics—what kind of politics caused that?

Metcalfe: At IBM?

Pelkey: Yes.

Metcalfe: I've been told now by enough IBM executives, I don't want to mention any names, but I told you about one early tonight, of guys who were on the inside of IBM when I had—I had basically had two consulting shots with IBM that year, '79, and in those five months, one day each, were I in one case went to Franklin Lakes, NJ to talk to the Office Products Division and another day I spent with the Communication Products Group, or whatever it was called then, in Raleigh, where I presented Ethernet to them, with the thought that they would join a consortium I was trying—I was succeeding actually at putting together with DEC, Intel and Xerox, to do Ethernet. And I have now been told by enough of these former IBM’ers that I was—I had basically said many times that one of my great failures in life was that year, when I failed to get IBM on the Ethernet bandwagon, that basically these IBM’ers have told me I shouldn't feel so bad, because it was impossible for IBM to adopt Ethernet because it had been developed by Xerox. And independent of its merits it was just impossible for IBM do adopt it. In fact, that

was the nature of the decision, the politics of the situation, in 1979. It was just not possible for IBM to accept it, so they scurried around and found the token ring and got Jerry Saltzer to help them with it, and that's when they began their token ring assault on Ethernet.

Pelkey: Now, going back to early in the five months, there were a number of other people that were involved in these, kind of, weekly sessions or weekly meetings where you used to get people together and other consultants, or professors, or people interested in this project of wiring—networking the campus, in which you used to debate these issues, about what the network should be and—?

Metcalfe: I'm a little uncertain about this, but I think Dertouzos himself was leading an MIT-wide commission on the network, and I think I participated in that, and that would have been...

TAPE JUMPS

Metcalfe: ….campus, bunches of people, Saltzer, Corbató I think was involved, he was a big old—he's an oldies and big shot there, campus wide—and it was out of that that Project Athena got started, which is why I now have my current affection for Athena. Not that I had much to do with it, but I was sort of there, kibitzing, while that was all getting started. Dertouzos drove it—Dertouzos is a Greek name. Athena is a Greek name. He basically got that started, starting back in '79.

Pelkey: Okay. So, during that period of time when you were a change agent, you would study the issues and primarily work with Dertouzos, in terms of helping him think through the issues...

Metcalfe: And then take on various assignments—I gave some presentations to graduate students, which is fun. I taught and, you know, occasional talks and attended project—we were doing the token ring—we were to the ring, we MIT, were doing the ring with a company called Proteon. A guy named Howard Salwen was commissioned by MIT to actually build token rings.

Metcalfe: The thought was this external company was going to do a very professional job of building these networks according to MIT specs and then they would take responsibility for installing them and running them, and so on. And then for some reason, I can't recall, they chose Proteon—why they didn't choose IBM or DEC or—they chose Howard Salwen of all people to do it. And I remember not being very happy with that situation. On behalf of MIT, I mean, it had nothing to do with Ethernet, as a matter of fact, it had to do with—why in the gods' name would you choose Howard Salwen to do it? Why not DEC? I mean, you want a company who is going to install this campus wide and maintain it, and so on, why not choose AT&T? Why choose Proteon, which was six people, or 12 people, or principally Howard Salwen, and I never actually found the answer to that. But it was...

Pelkey: Actually, I probably know the answer to that.

Metcalfe: Good. Well, don't tell me. I prefer not to know. But, it was a strange—so I was in a constant struggle over that, and by the way…

Pelkey: Dertouzos and Salwen were roommates in college.

Metcalfe: Dertouzos and Salwen? I never knew that. God, after all these years, it's worked out. Anyway, we had a lot of...

Pelkey: I don't know if that's the reason why, but...

Metcalfe: They never delivered the stuff on time or even close to schedule, and it was always buggy, and there was pissing and moaning, and—and I kept lobbying to get the stuff killed, because it was—it was so silly.

Pelkey: Dave Clark was a proponent...

Metcalfe: I hesitate to mention his name because, he and I have agreed not to like each other very much over the years, not that I've ever told him he's an asshole, or vice versa, but I think we think it.

Pelkey: Right, yes.

Metcalfe: I certainly think he's an asshole. <*laughter*>

Pelkey: I suspect it’s reciprocal, though I haven't asked him that question.

Metcalfe: And he is—well he's on the board of Proteon now, so therefore he's another competitor and I have to dislike him now.

Pelkey: Don't let yourself off that easily.

Metcalfe: Actually, I though he was an asshole before I knew that he was on Proteon's board. But, he...

Pelkey: So, during that period of time there wasn't—that was a fervent period with broadband, baseband, and—you know—the different types of—that process in the engineering community that was becoming an issue. Wasn't it token ring versus Ethernet? Saltzer's issues and yours and...

Metcalfe: Well, the trouble didn't start until May of '80.

Pelkey: Okay.

Metcalfe: In earnest, because it was in May of '80 that DEC, Intel, and Xerox announced that they were going to collaborate on the making of an industry standard based on Ethernet.

Pelkey: And when did that process start?

Metcalfe: That started in February of '79.

Pelkey: I presume you were instrumental in starting it?

Metcalfe: Absolutely. I was consulting for DEC for the same time I was consulting for MIT. And so while consulting with MIT—for Gordon Bell, who was then head of engineering, and Sam Fuller, who is now head of research, and Bill Johnson, who is now head of distributed systems at DEC. Those were my three clients, if you will. And we were working on DEC's ten-year long-range plan, and I was sort of a facilitator, specializing in connectivity. Now, I believe it was in that year in which I had the privilege of watching DEC decide on the strategies that have led to its recent successes.

Pelkey: It must have been fascinating.

Metcalfe: Fascinating, and I had...

Pelkey: Now, I—I'm confused. Here, Xerox wouldn't promote you because all you were was this little techie, and all of a sudden you've got the consulting assignments with Gordon Bell, and Johnson, and DEC, and IBM, and so on, being a change agent in major corporate issues, and yet you couldn't become more than a techie at Xerox, it sounds kind of strange.

Metcalfe: Well, I'm not quite expressing it quite right...

Pelkey: I'm exaggerating the point to make a point, it just…

Metcalfe: Is the phrase about prophets not being appreciated in their own land, or something—something like that. No, but you know, I'd go into Xerox Headquarters, and met the president of Xerox the week I left Xerox, where for the previous eight years I had never been to corporate headquarters and would never, would NEVER have been able to meet the president. So, I mean being...

Pelkey: Was that [*unintelligible name, Pres. of Xerox*]

Metcalfe: No—ah—yes—wait. <*long pause*> I forget.

Pelkey: Well, anyway. Memorable meeting!

Metcalfe: I forget. I honestly forget. God. I met Kearns enough time times since then that it all runs together and...

Pelkey: So February '79 you were consulting...

Metcalfe: Oh! On this connectivity strategy for DEC—and Gordon Bell was my client, principally, and I discovered Gordon Bell is a—was or is—a referee for the communications of the ACM. In fact, he was the referee for the section to which the Ethernet paper had been submitted in 1974. And that paper got reviewed for a couple of years and finally published in '76. So here I am at DEC, and I find that Gordon has all these people working on building a local area network. And what they all have are copies of...

Pelkey: …of your paper.

Metcalfe: …of my paper. But dated 1974! Which is not nice.

Pelkey: It is not nice.

Metcalfe: But, it was a complimentary thing, so I haven't made much of it.

Pelkey: Right, right.

Metcalfe: He liked it so much that he had said to his people: "Well go do something like this, but be careful not to do the SAME thing because Xerox has it patented." So, you got to do something like this, but you can't run afoul of Xerox's patent. So their busily trying to do Ethernet, only NOT do Ethernet, if you see what I mean.

Pelkey: I see what you mean.

Metcalfe: So, in a meeting with Gordon, and I can't remember who said what or when, we decided that this was silly. Why don't we just call up Xerox and say: "Well let's do it," because Xerox was interested in—no Xerox was one of DEC's largest customers at that time, buying PDP11s for their systems. And DEC was interested in using Xerox laser printers for its systems, so we said "Why don't we just work together on this?" So I wrote a letter, in fact, I have a copy of that too—for Gordon Bell to the right people at Xerox, and I chose the three of them, proposing that DEC and Xerox work together on doing an industry standard Ethernet. And I got involved in anti-trust and all that stuff because I had to solve those problems.

Metcalfe: And, so I wrote this letter and I gave it to Gordon and then he changed it a little and he sent it, adding a few silliness’s on that, and he sent it to Xerox, to David Liddle, George Pagent, Jim Campbell, saying: "Gosh, I'm Gordon Bell. I'm at DEC, and Bob Metcalfe suggested that maybe you would be interested in letting us just do Ethernet so that we could have industry standard compatible products, and our products will be used together and—" and Xerox said "Gee, that might be a good idea." And so—but it was very hard for those two companies to meet because anti-trust was a big deal then. So, I was running back and forth then. As a principal, I was a consultant, because my contract for DEC forbade me doing any Xerox Ethernet consulting with them. I didn't want to run into legal problems, so in my contract it said: "Not allowed to consult on Ethernet." So, for all these things, I'm working as an unpaid principal, trying to get these two guys to...

Metcalfe: “You should really talk to him, because he's got the latest—you should really talk to him...” Running back and forth. I had an apartment in Palo Alto and I had an apartment in Boston and I was spending a week on each coast. And finally got a bilateral meeting to happen, between Gordon and

David Liddle. And then in the midst of this—while they were "shwarming" it up—and this is in February, March, April, May, June of '79, I went to the US National Bureau of Standards, because I was doing some work on standardization for the National Bureau of Standards, another consulting contract. And I got told the day before my visit, a guy had been through from Intel, a guy name John Blesh [?], who I have never seen since, but... I think his name is John Blesh, had been there and he said he had some 25 megahertz chip technology that they were looking for applications for. And did they—they, NBS, have any ideas? And as soon as I heard this I had an idea. I said "Why don't we just build an Ethernet with it?"

Metcalfe: So I called up John Blesh at Intel and said "I'd like to come by." And I went and visited him at Intel. Only I never met him. Instead I was introduced to a guy named Phil Kaufman, who it turns out reported at the time to Andy Grove. And I showed up there and, incidentally, I was—I showed up there were 40 people or 35 people in the room. And they wanted—and I was going to tell them a little about Ethernet and what they ought to do with it. So they arrange—now I used to get paid $5,000 for something like this. But I did it for free that day because they caught me. It would have been embarrassing for me to leave. So I pitched them on how they ought to develop a custom chip for Ethernet. And the reason they ought to do it is that if DEC and Xerox were going to do this, they're going to need chips, and you guys can make the chips for their standard.

Metcalfe: So then I went to DEC and said "See, you're going to need chips and Intel has this 25 megahertz technology. They can do this." And I went to... and that started in June. And Phil Kaufman can tell you about all the lunches that we had together. And then finally in the fall of that year, the fall of '79, I went to Boxborough, MA. And we sat—the evening before the big meeting that I was not allowed to attend, and here was a DEC guy with his attorney, and a Xerox guy with his attorney, and an Intel guy with his attorney, and they had the first tri-lateral meeting at the Boxborough Hilton, or something, Boxborough Sheraton, I guess. They allowed me to come to the dinner, because I had set this all up, but they wouldn't let me come to the meeting the next day, because I was a principal, and they had enough trouble, these three big companies.

Metcalfe: Which leads to a very interesting story as to how we got those together, because all three of those companies refused to meet, because all their lawyers wouldn't let them. So, I talked to Gordon, I said "Gordon, what's the problem?" He said "Well, we have anti-trust problems. I can't meet with these guys." I said "Well, what are your anti-trust problems?" He said "Well, I don't know, lawyers—da da da... " and I talked to Dave Liddle, he had the same problems. I talked to Kaufman: they had the same problems. So then I called up my former college roommate, Howard Charney, who is a Division Manager or 3Com now. Howard, before that, he was an attorney. He had just finished suing IBM on behalf of Memorex for two or three years. Anti-trust expert. So I called up Howard on the phone, one phone call, and said "Howard, would you please tell me all the ways you can screw up anti-trust wise? And what are all the ways that there are of eliminating those problems?" And he gave me five buzzwords—and five remedies. So I called up Gordon, and said "Gordon, here's what you got to tell your attorneys. There's five ways you can get in trouble. A, B, C, D, and E. And all you got to do is these three things and you can have the meeting." And I called up David Liddle and I gave him the same story and I called up Phil Kaufman and I had the story, and the meeting happened.

Pelkey: That is great.

Metcalfe: Just like that: a lawyer on top of everything else. I said "Look, there's only five ways to... " and then I talked as if I knew what I was talking about.

Metcalfe: Right.

Metcalfe: I said "Look, Gordon, I've checked with the experts. There's only three ways you can go—you, know, run afoul of Sherman. You can do—you can have a meeting to fix prices. You can have a meeting to…da, da, da, da. All you have to do is have a meeting whose purpose is expansion of markets, making of standards to be publicly disclosed. To have ….” and so on.

Pelkey: Right.

Metcalfe: And he said "Oh, is that all?" And he turned to his attorney and he said all these buzzwords that I told him and the attorney said "Well, yes, that's right." And so they allowed the meeting to happen. So the first meeting could only happen if they all agreed, "a benicio," that it was for the purpose of making an open industry standard, in which case all their problems were solved. I mean, they weren't allowed to talk about prices or any of that shit.

Metcalfe: Right.

Pelkey: So, from the very first bi-lateral meetings to the tri-lateral meeting it was built in that the result of this effort was going to be an open industry standard, which led to IEEE-802.3, which led to—the token ring being the standard. Because if DEC, Intel, and Xerox had not tried to make Ethernet a standard, IBM had never before submitted its stuff for standardization.

Pelkey: Never.

Metcalfe: They were forced, forced to bring token ring to the IEEE. They had no choice.

Pelkey: Now, this process of taking it to committee, however, versus just taking it to market—taking it to a committee to make it the 802.3, delayed that process of getting it to market two years.

Metcalfe: Well, excuse me, it took two years longer—DEC, Intel, and Xerox then had a year of meetings. They met all of '79, in increasing amount, and then half of '80, hammering out a standard. Then they submitted it to the IEEE, and then another two years, three years went by before the standard was actually made, and the standard was epsilon from what they had worked on. It's not clear that that was totally wasted, because Intel had to build the chips, and DEC had to, so there was some overlap there.

Metcalfe: Were you involved at all in—I presume you were in the '79, '80 work, in terms of these meetings and working out the details?

Metcalfe: [*Affirmative*]

Pelkey: And there was a team of people of the three organizations that worked on the project as well.

Metcalfe: [*Affirmative*]

Pelkey: Do you remember a guy from DEC called Patrick Curtain?

Metcalfe: No.

Pelkey: Were there anybody from any of those teams that strike—you remember particularly well as having contributed?

Metcalfe: Well there was Dave Liddle, of course, and Bob Prentiss from Xerox, and others. And then Phil Kaufman and Rob Ryan—and a few more from Intel. Then there was—especially when the IEEE got started, Gary Robinson and Dave Potter, who went to Interlan...

Pelkey: Okay. That's right. Potter, yes.

Metcalfe: …who was quite instrumental.

Pelkey: Gordon is going to sit down with me in March.

Metcalfe: Gordon?

Pelkey: Gordon Bell.

Metcalfe: Well, his great moment was in that February, when he either generated or saw the wisdom, and I'll never know, you should ask him, of saying: "Gee, why are we trying to build an Ethernet but NOT build an Ethernet? Why don't we just call Xerox and offer to do this deal?" And you might ask him where that idea came from. I don't know. But it was in a meeting he and I had, and we were just sitting like this. And that's when I agreed to draft this letter for him.

Pelkey: He approached you and said "Why don't we just—can we get Xerox to go along with us?" or...

Metcalfe: No. I don't know how it got proposed. I just know there was a meeting he and I had out of which I got the job to draft the letter to send to Xerox. And I honestly don't remember whether I said "Hey, Gordon, this would be a great idea." Or whether Gordon said "This is a great idea," but out of that meeting came that assignment for me to write this letter. I have a copy of the letter, so I know that that happened. And then he took the letter and he rewrote it. I have a copy of that one too, and he sent it off to the three people I recommended, and the deal got started.

Pelkey: So, in May of '80, it got announced to the world.

Metcalfe: Right. What got announced was—we, will in September of '80, we will publish the specs for the standard. And then I began working on my business plan.

Pelkey: Now, at that point in time you said "Wait a minute. If they are going to make this a standard, other people are going to need it, and, this smells of opportunity."

Metcalfe: Right. So the business plan timing was—the business plan was done on September 30th, which is the day the specs were done. The business plan was contingent on the specs being good, and of sufficient specificity that one could begin developing products, which we then started doing.

Pelkey: And, you had mentioned before that you—before you took on this, kind of TCP project out of your own retained earnings. You had retained earnings that you invested in this project. Where did the early revenue profitability—first of all, before you get there, as we saw upstairs. It originally wasn't going to be 3Com. It was going to be…

Metcalfe: Yes, now that was written when I was still at Xerox, a Xerox employee in '78.

Pelkey: Oh, okay.

Metcalfe: I was about to—I had given notice and everything, and I was beginning to think—and—but then there was the five months of '79 that I spent consulting…

Pelkey: Right. You were just operating as an individual operative, not as a corporation.

Metcalfe: Right.

Pelkey: When did 3Com—where did the name 3Com come from and where did...

Metcalfe: We were incorporated June 4th of 1979. It was just me. The name came out of a day, I spent a day in Boston in my apartment dreaming up this name. Then I called Howard Charney and said, Howard, please do a name search. And 3Com was founded because I thought that Ethernet was going to be a standard. Because that was June of the year and that whole conversation with DEC and Xerox had begun in February of that year, so I began to see the light that it was going to happen. But then the business plan to raise venture capital wasn't until much later. That wasn't till September of '80.

Pelkey: So you—so June of '79 is when 3Com started. So when you were working on the project in the end of '79 and early '80, you were working as 3Com, when you were receiving consulting fees and so on?

Metcalfe: Yes, well, the…

Pelkey: And you were also largely a principal of this, I gather.

Metcalfe: Yes. The incorporation of 3Com is a—I mean I was consulting before the incorporation and I was consulting after the incorporation, so it wasn't a major—the main event was when we—so I went from DEC, which is the Fortune 500 company, to General Electric, which is a Fortune 10 company, to

Exxon which is a Fortune 1 company, in terms of our funding plan. So we—so DEC funded us as a consultant. Then we started with GE, which is probably the deal that made the company, because the—I was able to expand then from one person to ten people, by doing consulting with GE, and basically we were designing a personal computer for General Electric in '79, and then that project didn't go anywhere because the consumer market fell apart and GE said they wouldn't be investing.

Pelkey: Why, given that you had all this interest in networking, whey did you take on the project of doing it—doing a personal computer?

Metcalfe: Ah, it was related in that this personal computer would be doing home networking. You remember the SRX10 home networks? Well the idea was: GE—you see we actually brought the idea to GE. We're in the networking business. One of the things you can do is network homes. If home networking is going to go anywhere, there's only one company that could do it…

Pelkey: GE?

Metcalfe: GE. So I was going to—let's go do it with GE. So we went to GE and said "You should do home networking." They said "Well, alright. Sure. Let's work on it for a while." And eventually we got into designing a personal computer related to it. And the personal computer thing got shelved, but we kept working on the home thing called HomeNet, which is still alive at GE today. In fact it’s a product—in fact it’s a standard of the EIA—it came out of work that we did. But they paid us about $300,000 or $400,000 over that time. It allowed me to bring Howard—get Howard to stop being an attorney, start being a mechanical engineer.

Pelkey: Hardware engineer.

Metcalfe: But then—here's a key thought. Then we went from GE to Exxon. Exxon, in a deal that, I don't know how I did it, but we got Exxon to agree to pay us to develop our first three products. We gave them fully paid up non-exclusive licenses and they allowed us to retain ownership of the technology. That was worth $750,000 or so. So when it came time to raise venture capital, instead of selling half the company for $1.1 million, we only sold a third of the company for $1.1 million. It was sort of—I told them it was second round financing. And they said "No it isn't, it’s first round." And I said "No, no it’s second round." "No, no it’s …" "Well, alright…" and so on.

Pelkey: And, what group at Exxon did you negotiate that with?

Metcalfe: Summit Systems, which is now defunct. It was part of Exxon Enterprises.

Pelkey: The office automation group.

Metcalfe: Yes. And all the venture capitalists said "No, that—this technology doesn't matter because Exxon, you see, has a fully paid up non-exclusive license. They could just put you out of business." And I said "You don't understand. They're not going to do anything with this technology. I mean, the chances that their going to compete with us in this technology are pretty small." And by the way the contract was written that they could only use this technology in connection with an Exxon system. And so, they're going to sell Exxon—at worst, their going to sell Exxon systems and we're going to sell all the others." They said

"Ah, no, no, no. You're first round." And I said "No, no. We're second round, and we own all this technology." "No, no, you're first round." Negotiate. Negotiate. Hateful negotiations and so on. But—I mean, almost a month after we delivered these three products, the UNIX networking product, the Ethernet transceiver, and the Ethernet adaptor for the Unibus, which would have been during '81. Well, the software was done and first shipped in '80, the Ethernet transceiver on March 4th, 1981, and the Unibus controller later in '81, was all paid for by Exxon, delivered to Exxon and shortly thereafter Summit Systems was closed down and Exxon Enterprises vanished.

Pelkey: And when did you start to go for venture capital?

Metcalfe: Began in September of '80. Closed the deal in February of '81.

Pelkey: And getting venture capital at that time wasn't particularly easy, was it?

Metcalfe: Not for us, it wasn't. No, I think it was beginning to get better. It wasn't quite easy, but it got a lot easier right thereafter, but during that period it was somewhat difficult. *<inaudible>* my stubbornness and stupidity, but we eventually succeeded.

Pelkey: And the lead was Melchor?

Metcalfe: Melchor.

Pelkey: Melchor?

Metcalfe: Melchor and Kramlich—it could have been Kramlich's deal, but I fucked that up. So it was Melchor for $150,000 and Kramlich for $300,000, and Mayfield for $300,000.

Pelkey: One last question on the name of 3Com. Was there any significance in the name 3Com?

Metcalfe: Yes. Computer, communication, compatibility. Com, com, com: 3Com. Compatibility meaning standards, computer communication being what we were doing, so it was based on a standard idea, and not just Ethernet but, protocol standards like TCP and UNIX and so on.

Pelkey: Now, when you launched your products in '81, there were a number of other companies that launched their network products in '81.

Metcalfe: Well there were three companies founded in June or July of '79. And those were 3Com, Ungermann-Bass, and Sytek. Those three companies almost were one company, but the principals couldn't stand each other, so they became three companies.

Pelkey: So there was collaboration in that period of time between the three of you?

Metcalfe: Absolutely. In fact I helped Charlie and Ralph with their initial business plan, and—at Ralph's house in Los Altos on University Avenue, as I recall. And Mike Pliner and Jack Goldsmith at Sytek and I were almost partners.

Pelkey: Had you known those individuals before?

Metcalfe: I knew Charlie Bass briefly from the University of Hawaii…

TAPE SIDE ENDS

Metcalfe: ...Exxon, because it was a different part of Exxon. Not Zilog, but Summit that was funding us. That put us in an adversary position with Zilog.

Pelkey: Right.

Metcalfe: Oddly. I'm not sure how I met Pliner, but it was right around then. I didn't know him from before.

Pelkey: And you couldn't get along with each other, in terms of putting one business together because you couldn't agree on the technology? Or…

Metcalfe: No. We couldn't agree on…

Pelkey: Who's going to run the company? Or you couldn't agree on anything?

Metcalfe: No. In the case of Ralph and Charlie, and I'll say this as crudely as I can, I couldn't see why I, who had been working in local area networks for years and years and years and years, was going to get one half, or one third, or one tenth the amount of stock that Ralph and Charlie were going to get, who were newcomers to the business. Now, I mean, my thoughts on that have matured greatly since then, but at the time I just couldn't figure it out. "I just don't understand. I know about this stuff and you guys don't know shit. Why are you, Ralph, going to get all this and I'm just going to get little this?" And what I was underestimating was—I mean, if Ralph was everything he said he was, then he was entitled to all of that

Pelkey: Right.

Metcalfe: But…

Pelkey: Circumstances have proved differently.

Metcalfe: Who knows? It just didn't work out. Plus I beat him at racquetball, and I don't that that ever sat well with him.

Pelkey: He never forgave you for that.

Metcalfe: Right.

Pelkey: So, all three of you went your own ways.

Metcalfe: In the same month. I mean, I think we were—I know we were June, I think Ralph and Charlie were June, and I think Sytek was July, but they were all basically the same month of the same year. And—you know, it’s a wonder what the world would be like had we done it together. I don't know.

Pelkey: Had done it together and had been successful doing it together, I mean, just not to have done it together and kind of torn each other up and gotten nowhere, but having been successful together.

Metcalfe: Yes, because, for example, I did know more than Ralph and Charlie about local area networks, but Ralph and Charlie knew a hell of a lot more about how to start a company.

Pelkey: Right.

Metcalfe: And, you know they were off and running, and, boom, they suddenly became big while we were still bootstrapping.

Pelkey: Yes.

Metcalfe: And so then—and Sytek did the same thing. They went into consulting in a big way and got very big fast, and suddenly we were the most knowledgeable people, in my opinion, but way behind in size. Slow and steady wins the race.

Pelkey: But, in retrospect, I mean, at the end of '81, you had raised money—in, what, February of '81?

Metcalfe: The deal closed February 27, 1981.

Pelkey: The rest of '81—you sold some product and so on, it wasn't a particularly successful year…

Metcalfe: No.

Pelkey: '82, I suspect by…

Metcalfe: We almost got sunk in '82.

Pelkey: You almost got sunk in '82, and then the PC came along.

Metcalfe: Right.

Pelkey: And, in my recollection is that the PC was really—you had the only real connectivity solution for the PC at that point.

Metcalfe: Well, among those three companies.

Pelkey: Among those three companies. There was Nestar and Corvus who had products, but I mean you won that battle.

Metcalfe: Yes, well, you see, we never—the thing that Mike and Ralph got wrong is that they took networks, or in Ralph's case Ethernet, and used it for a different purpose.

Pelkey: Right. Terminal to terminal.

Metcalfe: Which was the evident market, but it wasn't the purpose for LANs, and we stubbornly—I stubbornly stuck with the idea that, "No, no, no. Connecting terminals to CPUs is a relatively low grade application of my technology." It was intended to connect PCs together. Our problem was, that there weren't any PCs, or rather the PCs that existed were Apple IIs, which cost $1500 and Ethernet in those days cost…

Pelkey: $1500.

Metcalfe: No, no. It cost $5000. There were no chips. We were building it all out of TTL [transistor-transistor logic] and the boards were this big and, actually, that's an exaggeration, $4300 or something.

Pelkey: Yes.

Metcalfe: And then—so we focused all of our energies into getting it to be cheap and getting it to be for PCs, and then the IBM PC came along, and thank God it had the option slots. You could plug them in, but they stuck out the back, unlike the Apple II.

Pelkey: Right.

Metcalfe: And that's when we had this brilliant idea of putting it on a card and sticking it in, and we had to modify Ethernet considerably to do that.

Pelkey: In terms of taking functionality out of it?

Metcalfe: No. We used different cable, a thin cable. Instead of using an outboard transceiver we put the transceiver on the adaptor, which allowed us to go, basically, I guess by then we had gotten Ethernet down to a Multibus card with and external transceiver, which would run you $1500, or something like that. And then we took the next step down with the on-board transceiver with the C-chip, $950. So we had come down a factor of four…

Pelkey: Right.

Metcalfe: …from inception. And, the IBM PC took off and we—it took us with it.

Pelkey: That must have—those must have been some hairy days there, right before the PC took off, in terms of—I mean, there was still commitment on your part, since the market was going to come your way, but the market wasn't there yet. There wasn't the platform…

Metcalfe: No. Right. Well in '82, our battle was with Interlan.

Pelkey: For the UNIX—for the Unibus

Metcalfe: UNIX and the Unibus market. And then we started on the PC and we—and Multibus, and then we dropped our Unibus, dropped our Qbus, and dropped our Multibus products, and just did all PCs. Whereas Interlan stuck with it and that's how we passed them. We just hooked onto the PC wave while they were still chasing—the trouble with the DEC world was DEC HAD products.

Pelkey: Right.

Metcalfe: And furthermore there were all these operating systems: UNIX and VMS and you had to have the software expertise or you'd get eaten alive by all the—plus DEC was now finally catching up and having products, so it looked to us like a plug compatible DEC world, with a lot of disjoint software technology…

Pelkey: Right.

Metcalfe: So we went after the PC and it worked. And the reason we clobbered Corvus and Nestar—a combination of reasons—they were the big guys.

Pelkey: Right. They were big.

Metcalfe: Corvus was huge.

Pelkey: Corvus came out with a workstation, that 68000 UNIX workstation.

Metcalfe: They—but that—that was just the coup de grace. Nestar decided to go direct. That was their fatal problem, one of their two fatal problems.

Pelkey: Direct to whom?

Metcalfe: Sell direct to end users, networks. So they started opening sales offices and hiring people. But PCs were exploding through dealers. And all the visibility was through dealers, so we said "No. We're going through dealers." And Harry Saul used to lecture me, and he said "Networks are too complicated to sell through dealers." I said "Well, we're going to give it a try, Harry." <*laughter*> Like this. He couldn't hire people fast enough.

Pelkey: Right.

Metcalfe: And we suddenly had thousands of sales people. The other problem Nestar had was Nestar was older than we were, and they had products for Apple IIs. And they felt compelled to keep having products for Apple IIs.

Pelkey: Yes.

Metcalfe: The same thing happened to Corvus. So they're trying to do Apple IIs AND the IBM PC and we were just doing the IBM PC. So we decided, no Apple IIs, no Commodore PETs. Those are too low end for us. We're IBM PCs and above, and we focused on it and they—so they got, both Nestar and Corvus got hung up on the Apple II, which was too low end. And we had to walk away from a lot of business where the customer said "Well, I would buy your network if you could take my Apple IIs." And I'd say: "Ah, shit. We just can't do Apple IIs. You’re right. Go buy from Nestar and Corvus and go on." And we found that there was a year in there where people thought they really wanted to have IBM PCs and Apple IIs, and then after the end of that year, "phtt," no deal. Different people.

Pelkey: So, I remember that year, '83.

Metcalfe: Yes. And the other thing that killed Corvus was they couldn't—they didn't invest properly in supporting the customer, so their products didn't work.

Pelkey: Right.

Metcalfe: I mean, ultimately they just—so our dealer channel—selling to the dealer channel was made extra hard for us by Corvus, because Corvus had systematically gone in and demonstrated for all the dealers that they couldn't sell networks. And we had to go in and say: "Well, actually, you CAN sell networks, it’s just that you can't sell Corvus networks…

Pelkey: So they set themselves up to be beaten out of the channel.

Metcalfe: Well, they gave us the dealer channel, but it was worse. They poisoned the dealer channel, so not only did we have to get them out, we had to…

Pelkey: Overcome the poison.

Metcalfe: Exactly.

Pelkey: But how did you—what caused you to be successful in doing that? Just the—the demand to the channel that they had to satisfy? Or…

Metcalfe: I think it was Bill Krause. He more than I ever did appreciated that aspect of the business and had a very convincing story to tell them.

Pelkey: When did you bring Bill aboard?

Metcalfe: March 16, 1981. Shortly after the venture capital arrived.

Pelkey: And had you known Bill before?

Metcalfe: About a month before, I was introduced to him by Mayfield: Wally Davis.

Pelkey: Did you—did raise more venture capital?

Metcalfe: A year later.

Pelkey: '82? Middle of '82?

Metcalfe: Roughly. We raised a couple million then. That's when Don Valentine joined us.

Pelkey: This was when—this is when things were looking a little—a little…

Metcalfe: They started bleak then.

Pelkey: ...uncertain? After that second round—third round?

Metcalfe: I can't remember exactly. I think—things hit a low in June of '82…

Pelkey: Yes.

Metcalfe: …when I became head of sales and marketing. See, Bill came in. We had the classic CEO struggle. And—God, just—went backwards. Bill came in and made a lot of mistakes, but I was CEO. So then he got to be CEO, because of the mistakes that he made.

Pelkey: <laughter>

Metcalfe: I mean, he hired bad guys, and they fucked up, and we started not doing anything, so they said "We need a CEO." And I kept saying: "Well, wait a minute. They're mistakes HE made." And they'd say "Yes, but you were CEO." So HE got to be CEO, and then I…

AUDIO MISSING [11:25-12:53]

Pelkey: Right.

Metcalfe: So that all worked. So, the combination of an entree and personal selling skills worked. But then at a million a month, I came in to the board and said "We now need…

Pelkey: A manager.

Metcalfe: ...a head of sales and marketing, because it’s not personal selling anymore. You can't get above a million a month on personal selling. Now we got to know about sales contracts and rep deals and da,da,da,da,da including sales managers and all that other stuff. And I had recruited sales managers but I could see they were already the wrong ones. I mean, I had an eastern region guy and I had a central region—and we—it was time to get a manger, so that's when we got—went out and got Chuck Kempton, who had been western regional manager for Wang, and he became our head of sales and marketing for another couple years. He took us from one to five million a month. And then we got John Monlin, roughly speaking, and he has taken us to 20 million.

Pelkey: Now, business—when did business—Computerland and Businessland’s report to you?

Metcalfe: Well, Businessland, not Computerland.

Pelkey: Businessland.

Metcalfe: Yes. They were…

Pelkey: You closed them.

Metcalfe: Businessland certainly, yes. They were—they were a new company. And I knew Enzo Torresi from Olivetti, because I had done some consulting for Olivetti. And they opened in January of '83, approximately, which is three weeks after we had our IBM PC product, I mean like, we had it in—we first

shipped it on September 29, 1982, which was an IBM PC card, and they opened in January of '83, so they became our lead…

Pelkey: And you were sales and marketing?

Metcalfe: Until July of '83.

Pelkey: Until July of '83.

Metcalfe: June of—that works. June of '82. No, no, it was two years.

Pelkey: So in '84—you were in that role until '84?

Metcalfe: No, no, no, no. I was—I was in the role, actually, I was in the role from the day Bill became president, which was M arch 16th of 1981. And then we…

Pelkey: So you were chairman and—you were CEO and marketing/sales and he was president?

Metcalfe: I was also head of engineering.

Pelkey: What was he?

Metcalfe: He was president, I was head of—initially. He was president, I was head of engineering, and we had a marketing guy who I fired a few months later. And then we didn't have a sales and marketing guy and we couldn't figure out why we didn't have any orders, so we—I started—we all started getting orders. And then the first part of '82, we had these two, Mike Halaberka [?] and Larry Hartke [?], who had done a lot for the company. They didn't leave, by the way, they just took these other positions, and Mike Halaberka [?] later became vice-president of sales again, and then left the company. But, they were in the first part of '82 when we went like this.

Pelkey: Yes.

Metcalfe: And then—so two years, minus that little period in there, I was responsible for sales and marketing.

Pelkey: Well then—I want to ask you a couple of questions, and then I—you've been kind with your time tonight. One was, when you were the facilitator of that scenario book you'd been showing me upstairs, ah that—I guess it was really Bob Kahn's concept of having this public demonstration of ARPANET, I'm led to believe that was really a seminal moment, in terms of demonstrating that it worked, and that there was such as thing as a network. Is that your recollection as well, that that was a very important event?

Metcalfe: Very important, and I don't know if it was Bob Kahn's idea, but in any case it was—I don't remember if it was Bob Kahn's idea.

Metcalfe: I don't know—I don't—a number of people have told me that. He's perceived as—his having been the driving force behind that…

Metcalfe: It’s possible, I just don't know. I have never thought of it that way.

Pelkey: But in your recollection, in terms of important events of this—that was really an important event.

Metcalfe: Promotional. And the big—as the—as one of the more talkative graduate students I was, aside from doing that book, I was an employee of Xerox when we did this. And I did it as—I spent two weeks at SRI putting that book together, and then I went to Washington to work on the show. And they gave me the job of escorting 10 AT&T vice-presidents around the floor to see all the demos and do all of that—and could—see, I could do all the demos because I had written the book. So I was demo’ing the system, and for the only time in that whole show, the IMP crashed. But this was a very enlightening moment for me because when I looked up, you know, graduate student doing demo, they were happy that it crashed. They made no point of hiding their joy. Because this confirmed for them that circuit switching was better and more reliable than packet switching, which was flaky and never—would never work. And I watched them smile. And I had been working on this for two or three years, and it really pissed me off.

Pelkey: Oh, it must have been an awful moment.

Metcalfe: They were smiling at each other.

Pelkey: You just wanted to go over and punch them out.

Metcalfe: I'm thinking to myself: "Oh, I get it."

Pelkey: Yes. Enemy.

Metcalfe: The only time. The whole week, or however long it was, I forget, it went down for about ten seconds, 20 seconds. It finally came back up again. We reestablished connection and never went down again, but that—I looked up and they were smiling at each other. They were having a good time and I was going through hell, as everyone does when they're giving a demo.

Pelkey: Oh, yes.

Metcalfe: These guys were not people—people persons—a people person would never…

Pelkey: Right.

Metcalfe: ...do that in front of the—I mean, he might privately go "Heh heh heh heh."

Pelkey: Right. No, yes.

Metcalfe: Not, in front of ME. And I'm—I'm—I was self-aware enough to say "They're doing this to ME."

Pelkey: Right.

Metcalfe: "They owe me more than this."

Pelkey: Yes.

Metcalfe: Now, that's when I…

Pelkey: Well they can, I mean they could key the whole—that was a very—I mean, there's obviously a big…

Metcalfe: So you've heard of broadband versus baseband. This was packet switching versus circuit switching.

Pelkey: Right.

Metcalfe: So, by the time broadband versus baseband happened…

Pelkey: It’s analog versus digital.

Metcalfe: Yes. Well, even before—well—yes. It was even still analog versus digital.

Pelkey: I mean, in terms of…

Metcalfe: It later became circuit versus packet, and then…

Pelkey: Right. It wasn't—at your level it was circuit versus packet at that point in time, it wasn't for the people who were <*inaudible*>—it was analog/digital.

Metcalfe: Yes. And broadband/baseband, which recurred ten years later.

Pelkey: Right.

Metcalfe: It was old hat to me, because I recognized it as the same argument. It was analog…

Pelkey: But they—they had no idea what you were talking about. That was Greek, to them? Question is: This issue of, again coming back to <*inaudible*>—I'm struggling with this, the modem guys really didn't participate in multiplexing, which I describe as these kind of links where you really didn't need protocols, you need standards, in terms of modems, which was the struggle with ATT and that telephone wire and so forth. And none of those guys, who were in the data communications business, ever got into the local area networking business. They have now, because they've bought into it. Interlan and DCA bought Fox and—I mean, there's going to be more of that—and the local area networking guys never got into T1, which has been the—in terms of data communications…

Metcalfe: We're into T1. But not in the same way.

Pelkey: Not in the same way. Why do you think it is that those guys who were—those companies that—modems and multiplexers and guys didn't see the LAN business. Why did they never come and be competitors? Why did they never develop the technology?

Metcalfe: Well, it’s—it has to do with the life cycles of all companies. They became locked in—I mean, they began to have products and a mindset and a culture attuned to connecting terminals to hosts, and so they didn't anticipate the need.

ADJUST TAPE RECORDER

Metcalfe: Well there used—you know when—I can remember when 150 baud—150 bits per second was big time, that was the 2741 terminal. And then I remember 300 bits per second was zippy. And then I remember 1200 bits per second and I remember something somebody said about 1200 bits per second, which is: "That's as fast as you'll ever need, because you can't read faster than 1200 bits per second." And I can actually remember that being a plausible argument, because I would watch a 1200 bit per second modem and the stuff would go RIGHT OFF THE SCREEN faster than I could read it.

Pelkey: Right.

Metcalfe: You'd never want to go faster than 1200 bits per second. 9600 bit per second was—you know that was just overkill. So I can imagine that that whole industry got trapped in that kind of…

Pelkey: Did that mentality come out of the kind of timesharing mentality in that computers really wouldn't get around and be everywhere and...

Metcalfe: It was pre—it was pre-personal computing.

Pelkey: Right.

Metcalfe: You see, LANs are based on personal computers.

Pelkey: And it was minicomputers, too. I mean, there were minicomputers too then, but they weren't—they were laboratory settings or they were research settings—they weren't business settings, they weren't…

Metcalfe: No I think modems were made by minicomputers. Because prior to minicomputers you—the way you interacted with a host was through a punch card. And it was with interactive timesharing that you developed dumb terminals.

Pelkey: Right. Timesharing caused them to...

Metcalfe: So minicomputers led the modems in my—in mass marketing.

Pelkey: It turns out—it turns out that that's not exactly correct, but—in terms of making it a market thing that happened. Modem networks—IBM had a lot of modem networks. Actually, there's a great story...

Metcalfe: What <*inaudible*> are you talking...

Pelkey: Oh, they started in the late '50s. In fact, there's a great story...

Metcalfe: But doing what?

Pelkey: The PARS network. The TWA reservation system was a modem network. IBM mainframes.

Metcalfe: What year was that? PARS?

Pelkey: Early '60s.

Metcalfe: So that's timesharing.

Pelkey: Okay.

Metcalfe: Timesharing started around then. DEC machines in the '60s—middle '60s.

Pelkey: Modems—modems was almost all IBM until the late '60s when timesharing came in and you started to get, other than—you started to get the Xerox machine, and you started to get the SDS machine, and Honeywell's—I mean, there's some other things out there...

Metcalfe: I think of modems and multiplexers as being things that connect terminals to hosts.

Pelkey: Absolutely.

Metcalfe: And that came to me—in my mind that came with minicomputers. Prior to that mainframes were—mainframes learned how to do that later but initially mainframes were batch processing, punch card things. In any case, that's how it is in my head.

Pelkey: Yes. I understand. And that's...

Metcalfe: And PCs brought LANs.

Pelkey: That's largely how it is in my head, too, and I'm being disabused of that in the early days. In the '70s...

Metcalfe: Yes, but not numerically. I mean, yes—so there was a modem in 1823 but there only two of them 1858 and then there were nine billion of them after minicomputers came, so in a numerical sense, I think interactive computing made modems in large numbers, because that's when—because terminals didn't exist until you had timesharing, and timesharing didn't exist really until you had minicomputers.

Pelkey: Right.

Metcalfe: I mean, numerically speaking. DEC made timesharing.

Pelkey: Yes.

Metcalfe: Roughly speaking.

Pelkey: Roughly speaking.

Metcalfe: More the minicomputer—I mean numerically, they made it happen.

Pelkey: Right.

Metcalfe: I was alive then, and I remember the way you use an IBM machine is you sit down in front of an O-29 punch, and you punch.

Pelkey: Yes.

Metcalfe: And the way you use a minicomputer is you sit in front of a teletype and you type. And if you want the teletype to be far away from the—if you want the punch card machine to be far away from the mainframe you put it far away and you mail your cards.

Pelkey: Right.

Metcalfe: You want to put the terminal far away you put a modem, in fact acoustically coupled modems and then later attached—anyway, that's how it is in my head.

Pelkey: I know.

Metcalfe: LANs made PCs. And the reason that the terminal people didn't get it is they didn't know about PCs. They were resisting PCs. They were connecting terminals. And for terminals you don't need LANs, except Ralph Ungermann proved, and others like him proved, you could use LANs to connect terminals to hosts but you didn't NEED LANs for that. And I always used to argue that's why that business was so vulnerable, is because PBXs could carry terminal traffic pretty well. So you're really kind of at the periphery of what LANs were good at and you were climbing uphill. Now I turned out to be wrong. Bridge and Ungermann did build substantial businesses base on that. Both of those companies were topping out. I mean that technology is—you use terminals incremental to carrying computer traffic on a LAN, you don't use the LAN for terminal switching, in my—except they built a hundred million dollar companies out of it, so, I couldn't be entirely right. But—so that's why they missed it. Because they were thinking terminals, they weren't thinking PCs. They were thinking this notion, not exactly, but—God, it goes across the screen so fast. Why would you ever want to go fast? You know, and the purpose of LANs is to go fast.

Pelkey: Some of the—some of the—I haven't completed all of my interviews—it turns out that many of those companies really wanted to be in LANs—their view retrospectively. Their problem was that they only had so many R&D dollars, and that they were constrained to protecting their own niches.

Metcalfe: They have an installed base.

Pelkey: Installed base and product—and at the end of the day, they only had so many dollars. Like Micom. Micom early on knew it wanted to be—knew they had to be in the LAN business, they just didn't have the resources to be in the LAN business. And it hurt them not to be in the LAN business, in terms of, they knew they should...

Metcalfe: DataPBXs...

Pelkey: …but when they—absolutely. The dataPBX market told them that they need to be in the LAN business, because the customer base was telling them that. Yet when they prioritized their development tasks, LAN never made it on their lists.

Metcalfe: Plus, every time they put it on their list, they put it on their list in a stupid way. Every time I would see somebody—occasionally we'd get scared to death that some big powerful company was going to get into LANs and they would do something absurd with LANs, and I wish I could think of an example off hand, but I'm sure Micom was one of the people who said "Well, we're going to use LANs, but we're not going to use Ethernet or token ring. Oh, no! We're going to build our own LAN. It'll be neat, and it's going to use nine wires and it’s going to go 80 feet, because who would ever want to go more than 80 feet. And it doesn't have to run 10 megabits per second. Hell, we'll get a lot—" You know, a bunch of kind of compromising decisions that just missed—is missing the essence of...where this is happening now, I think, is with the Telcos. Telcos have invented the thing called the central office LAN. Central office LAN

is resisting—I mean, there is no reason that, if you’re going to send data from that desk to that table that it should go back to the central office. That's crazy. But they're trying to do it. And it’s this new fangled concept to send—ISDN is what this is. ISDN is an attempt...

Pelkey: It’s a precursor.

Metcalfe: …to bring all these services back to the central office so they can continue to expand their revenue base. Only, it’s not going to work because it doesn't make any sense to take all the data back to the central office.

Pelkey: I tend to agree with you.

Metcalfe: And telephone companies are becoming a real estate play. I mean they OWN the central offices, now, what can we do with these central offices?

Pelkey: Yes.

Metcalfe: Let's bring digital in here and let's make central office LANs and let's put computing here like Net 1000, Bell Data Network, ACS, the success and failures of AT&T to enter the service business, all stem from this mentality of wanting to bring all of it back to the central office to make use of all that real estate they own. But it’s—I mean it’s bucking the trend.

Pelkey: I'd love to have that conversation with you, because it’s a conversation that—it’s a bit tangential to this. I want to get back to something. Do you find it ironic that ARPA found its home in local area networking and it started off to be wide area networking?

Metcalfe: I didn't know that ARPA had found its home in local area networks.

Pelkey: Well, in terms of its—it seems to mean that, its real impact, in terms of a market impact and so on, is TCP/IP and—and networking and local area networking. It strikes me that the ideas that got developed out of that period in time—that there's an ARPANET out there and...

Metcalfe: That's true, the company—the company that has made TCP is Sun, and they've done it on Ethernet using UNIX. I think if it were not for Sun that TCP would be nowhere. We knew it. We were in the TCP business by the way, as I told you. Ironically, we left the TCP business AND the UNIX business in the same moment.

Pelkey: Right. When you went to PC...

Metcalfe: To enter the DOS world with XNS.

Pelkey: Right. But it seems to me that the intellectual heritage of having started early on the resources sharing and wide area networking phenomena, that where it's found its fulfillment is in local area networking.

Metcalfe: Well, as a matter of fact, when the ARPANET was built, and got running in the '70s—'70, 1, 2, 3, 4, most of the traffic carried by the ARPA network was, so called, incestuous traffic, meaning traffic which never left the IMP from which it originated, namely, it was local area networks.

Pelkey: Is that true?

Metcalfe: So you have this IMP. Yes, true. You have the IMP, and you have four hosts in that site connected to the IMP. And then you have the IMP connected to the world.

Pelkey: Right.

Metcalfe: Most of the traffic never left that IMP. It would go into the IMP out of one machine and go either back to the same machine or to another machine on the same campus. So, actually, the ARPANET got used for local area network from inception.

Pelkey: Now isn't that—that's the first I've heard that.

Metcalfe: Incestuous. We called it incestuous traffic and we used to plot—we used to measure. There used to be reports on incestuous traffic versus...

Pelkey: Real traffic.

Metcalfe: Yes, traffic that counted...

TAPE ENDS

Pelkey: The question I was about to ask was the issue of email—that email was never part of the original specification either.

Metcalfe: Right.

Pelkey: Why did email take off? Why was that not anticipated? Why was it so successful, in your opinion?

Metcalfe: Well, the same is true of LANs—the number one use of our LANs at 3Com is mail. And the fact is that mail is the nut—electronic mail is going to be, and probably always has been the number one application of communicating computers. And why wasn't it anticipated? Well I guess—I don't know.

Pelkey: You had a lot—I mean a lot of you—you were all computer-philes back then, you were all true believers, and…

Metcalfe: Well, mail—I started using mail in 1969 on Multix. So, you'd have users of a single computer sending mail to each other. Actually, early in '69. But anyway, roughly.

Pelkey: Well '69—I mean '69 is when BBN started doing the IMP.

Metcalfe: Though it didn't work, yet, I mean the ARPANET didn't work yet.

Pelkey: But there was a specification for what the functionality on top of it was going to be.

Metcalfe: Yes, but there was no electronic mail beyond—I mean, the electronic mail that I'm describing was extremely degenerate and was used for sending messages...

Pelkey: But there was a rudimentary concept...

Metcalfe: Yes, there was, but, it would have taken a genius to...

Pelkey: …have projected that.

Metcalfe: Yes, I think so. But it was a surprise, and it was—and ARPA for a long time fought the conclusion. They wanted it not to be true, that electronic mail was the number one application of this. For some—for a long time they considered that not defensible, or respectable, and it’s extremely respectable and defensible. It is—you're connecting people together—sharing information with my research scientists—da, da, da, da. So as exotic as process migration and resource sharing, which either have...you know, which have hard dollar justifications—this was a soft dollar thing.

Pelkey: It kind of started off with this resource sharing in mind and just wanted that to be true and they—don't confuse me with the facts. This is what we're doing. Semiconductor technology—UART was important. Ethernet controller chips were important. Obviously microprocessors, memory, but in terms of—semiconductors, other than controller chips and the UART, haven't been really important, I mean, in terms of specific communication chips, have they? Can you think of a communications chip?

Metcalfe: Wait. Semiconductors are what made personal computers possible, and personal computers are what make LANs necessary, so, semiconductors are at the heart of all of this.

Pelkey: Understand, I agree with that statement, but in terms of semiconductor breakthroughs that were communication chips—where the semiconductor industry created communications chips, the only ones that I can think of are controller—Ethernet controller...

Metcalfe: LAN chips...

Pelkey: …and UART. Can you think of any others?

Metcalfe: CRC chips. Cyclic Redundancy Checks on chips. A major factor in the ARPANET was, we put—not WE, BBN built in 16- or 32-bit checksums for reliable communication, and there was a big deal, except now it’s just a chip.

Pelkey: Who creates that chip.

Metcalfe: Everybody.

Pelkey: Everybody. Okay.

Metcalfe: It’s part of SDLC chips, UARTs have it built in, but there used to be CRC chips before there were—anyway, there used to be a major problem transmitting data reliably, and now it’s…

Pelkey: You don't think about it.

Metcalfe: …no problem.

Pelkey: And now it’s built into UART or...

Metcalfe: Encryption chips, data security.

Pelkey: Right.

Metcalfe: For transmission and storage.

Pelkey: So there's not a lot of <*inaudible*>—I mean, clearly it wouldn't be possible to put memory and microprocessors and, I mean all the other ROMS and all this—I mean, in terms of com chips themselves...

Metcalfe: Well, there's modem chips. I don't understand the question. I think almost everything that you do in communication has been chipped. Modems chips, encryption chips, CRC chips, data link chips, transceiver chips, encoder/decoder chips.

Pelkey: Were those created specifically for the data communications industry, or they happened to be used by data communications?

Metcalfe: No, specifically for—you know, I'm sure of it.

Pelkey: Patents for—other than Söderblom, are you aware of any patent that played and important role in this industry?

Metcalfe: Well, the Ethernet patents, of which there are four...

Pelkey: That wasn't a blocking patent—a patent that gave—a blocking patent versus a patent that—not intellectual breakthrough but a patent that somebody used to an advantage. I don't particularly—Ethernet wasn't used that way.

Metcalfe: No. In fact, it was public domained in order to make it a standard.

Pelkey: Right.

Metcalfe: So you mean patent in the...

Pelkey: Protective sense. There are patents, I mean, there were some <*inaudible*> patents, but they were licensed out. They didn't stop anybody from doing anything. Any—back—looking back over this period of time, other—are there any major events that you think, where a group of people got together and where something was shaped or discussion took place or ideas came forth that we haven't touched on in this conversation?

<*long pause*>

Metcalfe: There's the PBX people. The ISDN thing. AppleTalk, Apple's whole role in all this.

Pelkey: That to me sounds—I'm <*inaudible*> peripheral. It impacts it but scope is an issue.

Metcalfe: Well, just the major impact of Apple is that Apple was the first computer manufacturer to build the LAN into their PCs—build it in.

Pelkey: Right.

Metcalfe: And it’s already become—AppleTalk is already the second largest installed based of LANs, second to Ethernet, way ahead of token ring by a long shot, for the simple reason it’s built in.

Pelkey: Right.

Metcalfe: It gets used a lot, for connecting LaserWriters to Macs. The role of BBN. Paul Baran.

Pelkey: Do you think that, when the Mansfield Amendment changing ARPA to DARPA—do you have a reaction about that?

Metcalfe: You mean direct military relevance? No.

Pelkey: Do you think it’s kind—do you think it cuts down on a lot of the science that's done in this country?

Metcalfe: Well that's the big—I'm on the Computer Science and Technology Board of the National Research Council, and one of the things we spend a lot of time doing is the—justify the expenditure of money on science, because DARPA is no longer—computer science—because DARPA is no longer doing it, and I'm not sure—I myself, I don't get any of that money, so I'm not as hungry for it as some of the professors are, but the—I'm not sure what's happening there is bad. I'm not sure about it, and the—but I guess on the surface of it I do know that DARPA, ARPA's funded most of the good computer science research in the United States for a long time. And it—this theory the case is, they're not doing that anymore. They're now funding applications and the National Science Foundation hasn't picked up the slack, so there must be a shortage of funding for computer science. That's how the argument goes. But, see, I'm the wrong person to ask, because I'm—I was brought up at ARPA. I mean, ARPA paid me for years...

Pelkey: But you don't seem to be strongly biased and say—you didn't jump and say: "Yes, that's a problem." You're on the fence, where I would have expected you to have said "Yes, that's a problem."

Metcalfe: Yes, but I tend to—I tend to reserve judgments like that until I've figured it out, and I think I was selected for this board because the people expected me to immediately jump and join them in this conclusion. I'm waiting to see if it’s really true or not.

Pelkey: But during this period of time, and in this communications industry, we did two things. One is that thing, dump ARPA. ARPA/DARPA. The second one is Bell Labs mission statement, that, Bell Labs being a major source of science in this country that, I think, over a period of time is going to change.

Metcalfe: I think it could be argued that Bell Labs has been a waste of a lot of money over the years.

Pelkey: Yes.

Metcalfe: I mean, a lot of good things that came from it, but look at all the money that got spent and all the PhDs that got consumed by it, so you—I don't know the answer to this, but you could argue that what's happening now, it’s better now. Instead of wasting ALL that money—you could even argue that the same is true of—you could argue, once again, I haven't studied this and I haven't concluded, but I'm asking myself whether it was really wise to spend one or two or three million dollars a year at MIT, or whether the money would have been better spent in lumps of a hundred thousand, across the United States. I don't know the answer to that. My predisposition is that it was better to spend it in big lumps, the way they did at CMU and Stanford and MIT and Illinois...

Pelkey: This being ARPA.

Metcalfe: This being ARPA. Now, Bell Labs is huge. It has always been huge and has been very bad at exploiting its own inventions, like the transistor, for example, so it’s not clear to me that Bell Labs was a good way of organizing science or—I don't know the answer, but...

Pelkey: I'm always struck with this concept that, to do science, you have to have some continuity. It can't be year-to-year decision making.

Metcalfe: Right.

Pelkey: And therefore, this big brother—this fraternity of MIT and Stanford and CMU and ARPA—it was incestuous, in terms of getting funding, and you always got funding, and you just swapped people back and forth between ARPA and the universities, particularly between MIT and ARPA, that it—it kind of—everybody knew that there was going to be money there, and might have allowed people to get a little more aggressive, in terms of doing things that they might not have done if they knew they had to justify it every year.

Metcalfe: In other words, as cruel as that sounds for the poor schmucks that attend Louisiana State University, it may be the only way to get good science done.

Pelkey: Yes.

Metcalfe: And I think that's a plausible...

Pelkey: The question is science management, which is an issue you’re begging relative to Bell Labs…

Metcalfe: Right.

Pelkey: …of how do you manage good science? And there's a question there in terms of whether Larry Roberts, in terms of—there's a real dichotomy of view about Larry Roberts relative to—did he get so vested into ARPANET that he gave undo weight to it? And then the positive was that it got accomplished, and so on and so forth. The negative of it was that maybe an awful lot of other good programs that could have—should have been receiving attention from someone in his position at that point in time, didn't get funded, didn't get supported because, in fact, he—if it was related to ARPANET it was okay. If it wasn't related to ARPANET, it might have gotten crowded out in terms of funding, bandwidth and so on. Sponsorship's important at a certain level. One can't be too heavy a sponsor when you're managing.

Metcalfe: Which is how I feel a little bit about superconducting supercolliders and the incredible amounts of money that have been spent on physics, with hardly any returns except a list of fun sounding particles. Can you imaging if they had spend a small fraction of those billions that they dumped every year into fusion on computer science, it would be—the amount of money spent on computer science is a tiny fraction of that spend on all that earth moving they did around SLAC.

Pelkey: Oh, yes.

Metcalfe: So, boy, if you're going to ask that question about Larry Roberts, why don't we ask it about the National Science Foundation and why the physicists get all this dough for hardly any return.

Pelkey: Yes.

Metcalfe: Honestly.

Pelkey: Well—you know—again, this is—I thought that, maybe on another occasion you and I could get together and chat about some of this—I, as an example, think right now that the United States needs a policy relative to space and—so there's this trade-off. There's trade-offs between long-term type of investments and more immediate short-term investments, and there's clearly the issue of how you take—where half of the R&D funding in this country is done in the government sector and how you take it out of the government and you get into the commercial sector. And, it’s critical that we, as a country, figure some of these things out.

Metcalfe: Right. These are huge, complicated, as I have found from this board I'm on, almost impossible to have these discussions, because they're so complicated.

Pelkey: I agree with that.

Metcalfe: Just so complicated. Unbelievably so. So at a certain point you have to become intellectually dishonest to make any progress whatsoever. You have to say: "God, yes. I think we're not spending enough on computer science." "Prove it." "I just know." Because you can't really prove that, it’s just too complicated.

Pelkey: I don't know if you had any chance to read any of the documents I sent you, but—one of the premises that I had in writing this, and I haven't read the last chapter because I want to see how things come out, was that I think organizations in the information age are going to, if you will, show a change from this kind of rational paradigm to biological paradigm, and that within organizations that, where you have computers—where everybody has one and they can talk to anybody else inside an organization, that the organizations are going to be less concerned with planning and control, which has been the sciences of management up until now, and are going to be much more concerned with what I call learning and evolution, in that you're going to start to—behavior is going to start to happen within organizations which we can't predict right now, when people in fact can communicate to anybody within an organization, and that this idea that, if we just collect enough information from outside the organization and model it we can make better decision about what we should be doing. That, that's going to fade away in terms of being important to organizations. You still collect data in terms of invoices and customer numbers and all this kind of stuff, but what's going to be more important is that, people in an organization—something's going to happen, someone's going to react to it and then they're going to communicate that to other people in the organization through these communication networks. And organizations are going to give meaning to how organizations are perturbed from the outside. The meaning isn't given to the organizations as a consequence of what happened outside. Reality isn't outside the organization, just like reality in cognitive science terms isn't outside us. We create reality by engaging each other and so on.

Pelkey: And—meaning as it rises from this conversation doesn't exist a priori or outside this conversation, and that, what's going to happen is that the organizations are going to get much flatter. Middle management is going to disappear from organizations. And that, we don't know what's going to

happen, just like as I'm finding, curiously enough, that there was no anticipation of this email phenomena, and yet it became the dominant raison d’être for ARPANET and it, in fact, is a very important contribution of this, this whole concept of email. And whole parts of the engineering and science community, if you took email away from them right now and all their email networks, they'd go crazy, I mean, it'd be like throwing them back into the dark ages.

Metcalfe: [*Affirmative*]

Pelkey: I think the same thing is going to happen with organizations. You’re going to get computer conferencing. You move beyond email, and you move beyond bulletin boards, but you go into sophisticated computer conferencing and things like that, and that—that's—when we talk about information in a company, we talk about the information age, it’s those kinds of things that are going to characterize how business is done differently than business is done these days, where we're more worried about energy, that is moving things around, and collecting more things about things, and one of those things that we collect is information. Anyway—that's a vision that I have of what the future is going to be like when everybody is connected up to everybody else.

Metcalfe: And you see that in the way electronic mail infects an organization. The thing I like watching is the way you design something, you put it in an organization. It then changes the organization, which means you have to design something else, and it’s not just one iteration, it’s like ten iterations. So, for example, my favorite example of this is that the 3 megabit per second Ethernet, after it had been installed for five years, and was mature as hell, and the people had their personal computers by the hundreds on these networks for five years, lo and behold the network was utilized approximately 28% of the time, which could be used to prove one of two things. It’s usually used to prove that 3 megabits per second was a good number. It was enough. But it doesn't prove that at all. What it proves is that the people designed systems…

Pelkey: To use that bandwidth.

Metcalfe: …to use that bandwidth effectively. And every time they designed a system that tried to use too much of it, it wouldn't work, so they stopped doing it. And so—so that 3 megabits was an invisible constraint on everything that got done. So now—which is why we chose 10, 10 megabits per second in 1979 for Ethernet, which was overkill. It's even overkill today. But it’s not the limiting factor today, and won't be for another 10 years, I think. So the—what we tried to do there was not to match the requirement, because we couldn't tell what the requirement was. I mean, OmniNet was running at one megabit per second.

Pelkey: The issue is not to make any constraint.

Metcalfe: Well, what we chose to do was to go to the cost/performance curve. Which is to say, here is cost as a function of speed.

Pelkey: Right, yes.

Metcalfe: Phtt! And we can't tell what the requirement is, and we all know you marketing guys like to know what the requirement is so you can meet it. Well, frankly, the requirement is—toady's requirement is way down here, but we can go up to here with only modest incremental cost before really hitting the knee,

so we're going to pin the needle. So we pinned it at 10, and it’s working as far as I can tell. The networks are underutilized, but every time somebody thinks of something new to do, there's bandwidth for it and it’s growing and growing and growing.

Pelkey: Yes. I think it’s a fact...

Metcalfe: Anyway, it's this iteration thing that you were talking—excuse me, to complete the thought—so that it’s like, the way everything is built, and there are all these constraints, and they keep iterating. Every time you relax one you run into another one. And then you have to relax that one and you run into another one. So in organizations we're adding mail and other means, and they affect the company. Well like this thing that's going on at Bridge and 3Com now. We're questioning mail.

Pelkey: Right.

Metcalfe: What we're really questioning is, we built the mail system, now everyone's using it in a different way than was anticipated, so now we have to build another mail system.

Pelkey: Exactly right.

Metcalfe: As opposed to backing up, which is what some of the Neanderthals want to do. "Let's go back to memos." How the fuck can a memo be better?

Pelkey: Right. What I see as different set of issues, and I agree with that, your comment—I think the issue is that you have to facilitate—the behavior of people in an organization to effectively accomplish a mission in the organization is what has to be facilitated, and that when you have this behavior that's coming up over email, the question—the issue is finding the way that that behavior can be channeled to effect the organizational purpose. Not to say that it’s bad behavior or it’s good behavior, it’s that that's the behavior that's arising. Now how do you channel that behavior to where you want to go? And, I think some of that behavior is trying to find—and email is this issue; that email shouldn't be status conscious and it shouldn't be time conscious and it shouldn't have all these other kinds of domains to pile on top of it. Now the question is how to manage the information flow so that in fact the organization accomplishes its mission. Not to cut down on it. It’s different. We don't know how to manage that difference.

Metcalfe: Right, we don't.

Pelkey: So what we do is that we take the paradigm of memos, or we're going to put another one in because it’s not doing what we want it do. It’s just like email—we kept—ARPA guys kept denying email is just really resource sharing. It’s not email. They denied that. And I think organizations such as the experiences you're going through, and I think that if we go through other organizations, we're going to find the exact same thing. It’s going to be denied, and it’s totally new kind of behavior which we don't understand. That's what information economics is about, and that's why the stuff that Kenneth Arrow writes about and decision support and the decision trees all miss the mark in terms of where information is. I also hold the view that, much like Eskimos have 13 or 14 words for ice, or the Hindu meditators have 56 words for consciousness, isn't it interesting that we have only one word, "information." But when you think about information, you can always identify data. Well you can argue that there's really different words there. But what about—a concept versus a heuristic versus an idea versus, you know, an algorithm. Those are all kinds of information, but we kind of—we've lumped an awful lot into this one word

that we kind of say everybody understands what it is, and I think we have a definitional problem. We—because we haven't—we don't know how to deal with this world...

Metcalfe: Yes, but that relates to your earlier question about the modem people and how did they get trapped? One of the things is there used to be a list: voice, video, data.

Pelkey: Right.

Metcalfe: Like, there's one kind of thing called voice and there's another thing kind of video and another thing kind of data, except data has about fifty kinds: two of which are voice and video. But we made this list and all those modem people are: "We carry data!" Well, I'm sorry friend, you carry terminal traffic, which is degenerate 1958-style data. We, on the other hand, carry high class data. We carry data that has floating point numbers in it and bit-maps and that's not the kind of stuff you guys can carry. Ever try to carry a bit-map at 300 baud, I mean it just doesn't work. But, no, they got locked into this word trap that you were just—they didn't have a hundred words for snow or ice or water.

Pelkey: That's right. And the people had that point done—just like the early days of LAN, when the arguments were broadband and baseband and—remember all—and media types and topology, star—remember all the articles out on Star, Ring and...

Metcalfe: I wrote half of them, of course I do.

Pelkey: I mean—and now those arguments—those discussions—we don't even talk about that anymore.

Metcalfe: Largely because we're tired of it, not that those issues are all resolved, we're just tired of talking about them. Plus it’s our job to make sure they don't matter.

Pelkey: That's right, they don't matter. Thank you very much for your time. I greatly appreciate it.

INTERVIEW ENDS

