Interview of Wesley Chu

Interviewed by:
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James Pelkey: As I may have mentioned to you, when more than one person talks about an event from the past, I get as many different stories of that event as there are people I talk to. Truth isn't always what truth is, it's what people remember it to be, but hopefully I can be as accurate as possible. Thanks again for your time. As I mentioned, I know very little about you other than the fact that I'm led to believe that you have the original patent on statistical multiplexing and that you were at UCLA during a period of time when ARPA was putting the first IMP up here. That's basically all I know. Perhaps you can help me --

Wesley Chu: When I finished my PhD at Stanford in electrical engineering, I was thinking about doing different things, new things. I looked into the area of computers and communication, an interesting area. I wanted to do something with computers, and computer communications had just barely begun in 1966. I worked at Bell Labs for three years and I observed quite a bit of -- there were a lot of complaints about telephones not working well when you hook together. The modem doesn't work well and the line doesn't work well and all that. So we were looking at those things and taking measurements, traffic measurements trying to understand how computers really communicate with computers, how terminals talk to computers.

Pelkey: And this was '67 to '70?

Chu: Between '66 and --in '66 I did a piece of work on distributed databases and after that I was involved with a group of students in computer communications as a member of the team, and they were taking measurements of computer traffic characterizations, trying to understand how the terminal talks to the computer, how a computer talks to a computer --
the traffic statistical point of view -- and we found very alarmingly, we took a lot of measurements, real measurements, like credit card companies, scientific computing, and we found that when terminals talk to the machine, they only use five percent of the time. They are very bursty traffic, and 95% is idle. At that time, communication was very expensive, but components were also very expensive, so we were thinking about how to be able to save bandwidth. So that's what we did, a lot of theoretical studies, trying to find out -- in order to do things differently instead of the time division multiplexing, we wanted to do asynchronous time division multiplexing, or statistical multiplexing, and what kind of problems you would have. So we studied those problems. At that time, buffers and storage were very expensive. We studied what kinds of storage requirements are needed, what kinds of delays are associated with it, purely theoretical study.

Pelkey: Two questions: Was the word "statistical multiplexing" a phrase used then?

Chu: Yes.

Pelkey: That was a commonly used word at that point?

Chu: No, it was not. I think I coined that word.

Pelkey: You coined the word?

Chu: Yes.

Pelkey: So, before you started the study, that wasn't an expression.

Chu: In fact, we first called it asynchronous time division multiplexing. It wasn't synchronous time division multiplexing, it wasn't asynchronous, because --

Pelkey: Synchronous was straight time.

Chu: Synchronous was straight time multiplexing, but with synchronous you have 95% waste, so in asynchronous you don't synchronize with time.

Pelkey: The other question would be: Do you recall what prompted AT&T to do the studies, was timesharing and starting to get terminals, or was there something else prompting them to look into this terminal host traffic --

Chu: No, the traffic measurement -- how Bell Labs works is that it's just a research facility. We just looked at the problems, just a theoretical study, just to see what the problem is, trying to understand the behavior. Nothing was: "Hey, you have to do something like that."

Pelkey: Because at that point in time, timesharing was starting to come into being.

Chu: Timesharing was already going very strong.

Pelkey: It was going strong?

Chu: Yes.

Pelkey: Cause it started in the mid '60s, and clearly the issue of Carterphone in '68 and the pressures that were put on to allow what they called then "foreign devices" to be hooked to the switched network was an issue, at least in the regulatory public sense. I wonder whether those kinds of studies were prompted by this or motivated by this.

Chu: No, I think the Carterphone issue was not the main issue. The issue was really, we felt, that when you sit on a computer, you find out that you spend $5 for communicating cost and $2 for computer costs, ok, that was the issue. The motivation of the study was to see if there was any way to reduce the costs. And nobody told us what to do. We just did the research. We look at the phenomenon to see what you can do, so we did a lot of theoretical studies, studying the behavior of it and things like that. By '69 I left Bell Labs and joined UCLA. There, a lot of people said: "This is an interesting idea, but -- "

Pelkey: The idea being the asynchronous time division multiplexer?

Chu: Yes, it was a very Playboy type of idea. It's very fancy, because you want to put a label on top of data, and you waste some bandwidth, but the bandwidth can be done, but then you need hardware to decode that, store that, decode that, do a lot of things with that. I began to experiment with that and build some small things. How to build some hardware chips in the laboratory. Trying to build some things and see if it works. We showed that it works, a portion of it, so then I started to do some simple things to see if it works, and it showed in the laboratory that it's working, but that it was awfully -- it needed quite a bit of electronics. At that time I was just trying to validate some of my theoretical results. That was the whole motivation of it. Then, in the time frame of around 1972, the first microprocessor became available from Intel. The four bit microprocessor, the 4004, available. Then immediately I said: "Well, that's the greatest thing that's happening. I can use a microprocessor chip to do it." So I started to build one with microprocessor chips. And then I found out that it doesn't give you enough power. So then the 8008 came out, and we switched --

Pelkey: I remember that, '76?

Chu: '75 or '76. Then we used that, one chip, playing with one chip, but one chip was not enough, because I was very idealized, looking at what was the maximum number of terminals you could have, I used 64 terminals for example

Pelkey: So you weren't going to try to use this minimal function of four terminal or eight terminals?

Chu: No, we were pushing the limit, because I wanted to see --

Pelkey: When you pack them on --

Chu: How you pack the line. And how does it degrade? I was looking at that. But if I were looking at four terminals, one chip is plenty. We'd be playing around with two or three terminals in the laboratory with discrete components, and then with full four, you can handle it with no problem with four, but I wanted to see more, 64. That was the maximum to pack. That was where I was coming from. I was thinking about, if you want so much electronics, you've got to support a lot of terminals to make it worthwhile. That was the motivation. But it turned out in retrospect, actually, most people just use four to 16. Those are the normals.

Pelkey: Right.

Chu: So then I found out that one chip was not even enough; you had to use two chips.

Pelkey: What was the link speed that you were trying to pack?

Chu: 9.6

Pelkey: 9.6? So leased line 9.6 was a constraint that you put on link.

Chu: Well, it could be anything, really --

Pelkey: But that was what you were experimenting with?

Chu: Because 9.6 was the modem that you could buy. That was the reason. You couldn't have any higher than that. The modem would be too costly, and it's just not practical.

Pelkey: You didn't think about using a 1200 baud modem and using your four bit chip?

Chu: No, I was really looking at -- from a marketing point of view, you would design something like that. If I can design at 9.6, the other is a trivial case. From a processing point of view, it requires less power, less processing capability.

Pelkey: So you were thinking the other way around? By having a 1200 and four bit, you can scale it up, versus the concept of having 9.6 and scaling it down.

Chu: I see what you mean. No, I wasn't thinking about that. I was thinking about the super systems. If I can test that out, the other case will be simple, a special case.

Pelkey: It's surprising that you didn't change your constraints to allow you to work within the technology that was available at the time versus -- using 9.6 and having to wait until the 8-bit came out to be able to do your experiments?

Chu: I see what you're getting at. We were thinking about when the four bit came out, I was very happy, I did experiments with two terminals, it worked fine. Two or three terminals are fine.

Pelkey: Ok. And the same algorithms that you used then, used --

Chu: There were two things. Now we knew there were 8-bits coming out. I said: "Well, let's change over to that," so I could do some more, because with two terminals you see very little. With more you can see more of what's happening. How it really fills up.

Pelkey: Four bits was just too minimal a system to really see any phenomena.

Chu: Right, and we even built some traffic generators, because we didn't have that many people typing. We built a traffic generator to emulate all the traffic coming in, to really load the system up. We didn't really use 64 terminals, because the terminal interface card would be so expensive. We just used about

eight of them, but we generated lots of traffic, equivalent to 64 terminals. The reason is that, if you have just two terminals, the traffic is not right either. You have to have enough ports --

Pelkey: Or the statistics don't work.

Chu: Too discrete. We wanted to see what the capacity is? How it can handle this? If it can handle that, the other is much easier. And then we found out one chip is not enough, you have to use two chips. So that also leads to interesting issues in processing, because there are two processors. How do they talk to each other? which I'm currently doing a lot of work in, that area. So then by 1974, '75, --

Pelkey: It must have been '75, '76

Chu: We had a break in understanding of that.

Pelkey: With two: the double 8008s and the simulated 64 terminal environment?

Chu: It did quite well. We even had error control -- blocked them into sub-blocks to save bandwidth. What you want to do is have one label with several characters attached to it, and have from several terminals, form into a packet, and although it wasn't standard yet, we used ISO flag bits and all that. It was a fairly advanced design. We even provided switching.

Pelkey: So you had port contention?

Chu: If I'm input coming in, I could go into -- like 64 terminal comes in --

Pelkey: You didn't have to go to just one host; you could go to multiple hosts.

Chu: You could go to multiple hosts, right, because it says: "I want to go to address 'A', address 'B', address 'E'," which is very easy, really, it's just looking at -- because we have the chip, we can direct that. All these features were already added onto it, so you have addressing to output, what people now call switched statistical multiplexing, we already had all that. And multiplexing, we spent quite a bit of energy on understanding how to design the multiplexing buffer, manage the buffer

Pelkey: Packet sizes, or datagram sizes?

Chu: I had to know all those studies and try to optimize

Pelkey: When did you complete that and have it working? You kept refining it, but that you really had it and said: "Wait, this is it"?

Chu: Yes. Time frame of '74, '75, I think that was it.

Pelkey: But it was after the 8008s?

Chu: Yes. Affordable. Once the 8-bit came out, it was just the right thing.

Pelkey: A couple of questions: One is that you said people thought of it as a Playboy idea, was that an expression that was actually used?

Chu: People said it was very interesting. I was known for doing that, in the community. People liked it, but some people couldn't see the difference. What are you really doing? It
sounds like packet switching, but it's not packet switching. It sounds like multiplexing, but it's not multiplexing. Not, standard multiplexing, so they didn't know what it is. It's somewhere in between, you see. And then the idea of having the label in there is kind of fancy.

Pelkey: But that expression, Playboy idea, you didn't hear that used, that expression.

Chu: No, it was not used in the community. People just sort of -

Pelkey: That's how you characterize their views about what you were doing? They joked about it?

Chu: They joked about, but not really seriously.

Pelkey: But did they use that expression, Playboy idea?

Chu: No. They did feel it had a lot of potential because of the fact that you're only using 5%, and 95% is idle. And I said: "I spend another five percent for overhead." Now 10%. That's still ahead.

Pelkey: I can pack nine times as much.

Chu: Of course, you have to put a lot of electronics in there, lots of electronics, so where I'm coming from, I say: "Alright, true. Is it worthwhile to save five bucks or ten bucks? If you have to spend 50,000 to buy the electronics?" Well I said: "If I can pack a lot, then it will not cost too much."

Pelkey: Prior to '74, '75, as I understand it, Codex had a box that was primarily sold into the IBM environment that did statistical multiplexing.

Chu: I don't think Codex -- We did a lot ahead of Codex. I know Codex people. I think they --

Pelkey: But in '76, Micom introduced, came up with the idea, their recollection was that at that point in time, that Codex was selling these $40,000 that were doing multiplexing.

Chu: No, I don't think so. Codex, those people talked to me, in fact.

Pelkey: Do you recall when they talked to you?

Chu: Oh, they talked to me in the time frame of 1972 or '73, and they were building something using many, many chips.

Pelkey: This is David Forney and John Day?

Chu: Dave Forney. I know him personally.

Pelkey: I meet him next week.

Chu: He talked to me and then he had someone develop something. That was very expensive -- many, many chips to do the multiplexing.

Pelkey: Do you recall him coming to you, calling you up and saying he wanted to come talk to you about it?

Chu: We had breakfast meeting together. I know him personally.

Pelkey: Did you know him before this breakfast meeting?

Chu: Oh, yeah, sure.

Pelkey: How did you know him, from Bell Labs?

Chu: No, I teach a course here and I invite him to give lectures here.

Pelkey: Before '72.

Chu: Oh, yeah, sure, I knew him. He knew that I did work on statistical multiplexing. He knew that. I published my paper in '69, but that was just a theoretical paper.

Pelkey: Ok. And at that time it was still called asynchronous time division multiplexing?

Chu: Yeah, and we also called it statistical multiplexing too.

Pelkey: Do you remember when that expression came in, "statistical multiplexing?"

Chu: Around '69, '70, that time frame.

Pelkey: Did you coin that phrase?

Chu: Yeah, I think I'm the first one to use the words statistical multiplexing.

Pelkey: What caused that? Where did that idea come from?
Chu: Because it's random. It's more catchy, and they used that. I didn't call it statistical mul -- well they used it. Codex used it, but the word was around, long before they build it, their system.

Pelkey: So Dave saw your paper probably after '69 --

Chu: Well, he knew about my work. I don't know whether he read my paper or not, but he certainly knew my work. He knew -- I was known for doing --

Pelkey: Did he ever visit you in your lab when you were doing these experiments?

Chu: No, he didn't. He approached me to see if I was interested in going there, to spend a year there, and things like that.

Pelkey: Do you recall when that was?

Chu: '72, perhaps, or something like that time frame, '73.

Pelkey: So you wanted to stay at UCLA?

Chu: No, I was -- I just hadn't thought out what I wanted to do, so I just didn't pick that up. And then he hired somebody, in fact it was his neighbor or something like that, a neighbor's son-in-law or something turned out to be in the electronics field and computers. Then they said: "We're going to come over," and they probably read my paper, and then did something, did something very huge and unnecessarily large, I considered it.

Pelkey: Right, and complicated.

Chu: Very complicated, with so many chips, and could do it in one or two chips. And in fact, in 1974, I was running a conference at Quebec City that he attended, and his salesman was selling that. I said: "I can do this thing with one chip, with the 8008," but then they did -- they had a lot of other functions in there.

Pelkey: What conference was this in Quebec City?

Chu: I was running a data communication conference. In fact, the other day I was just looking at that. I was program chairman for that conference. (Brings out some literature). This is the data communication symposium.

Pelkey: Fred Gleif. I spent time with him on his new company, TeleStream.

Chu: Oh yeah. We're good friends. He knows me. He was the general chair. I was the program chair.

Pelkey: Isn't that something. So they came out and showed -- they were talking about their --

Chu: In '75, just talked about it then.

Pelkey: You're talking about their multiplexer box.

Chu: It's about '72, '73 time frame. Then in about three years they developed them. It's quite different. Quite -- I don't know the detail. It's basically the same concept.

Pelkey: This conference was the Fourth Data Communications Symposium, held the 7th to 9th of October, 1975, in Quebec City, Canada. As I mentioned, Fred Gleif of Bell Northern at that point in time, was the conference chairman, and Professor Chu was -- all the papers were submitted to you for publication.

Chu: Yeah, I was program chair.

Pelkey: So you went on and filed for a patent? When did you file for a patent?

Chu: Oh, I don't recall now. This was filed in '77, the other probably in '76. I have two patents. One filed in '76, one filed in '77.

Pelkey: Do you recall whether Micom had their product out in the marketplace when you filed? Did you ever know any things that they were doing?

Chu: No, I didn't really keep track of what they were doing.

Pelkey: But obviously -- going back to the genesis of this idea, you were doing these experiments and realizing that you were only using 5% of the bandwidth and do you recall specifically where this idea came up of what is statistical multiplexing? Was there anything specific that was the "ah ha!" if we did it this way? Was there a real intellectual problem at that point in time, what to do about this or was it just kind of straight engineering?

Chu: Well, I think it was kind of obvious that you don't want to do synchronous. So if you don't want to do synchronous, then the question is can you really do it? What kind of buffer size do you need? How do you handle overflow? How do you handle what kind of delay it has?

Pelkey: So it was really just a solid engineering solution to a problem. When you realized you didn't want to do synchronous, you wanted to do asynchronous, then it became the engineering problem and understanding the parameters of the problem --

Chu: And how it behaves. But I think it's kind of a revolution in a way, because it was a very different way of doing things.

Pelkey: Yes, and what I'm trying to understand is, given that it was a revolution, was there anything that -- sometimes you have a real mental problem and you're struggling with it, and all of a sudden something happens, and you realize: "That's how I could do it."

Chu: Obviously you struggle through quite a bit, can you do that or not, because you worry about it. So we just did analysis and -- it's not "Oh, we can do it this way," and quickly we did that with some kind of a mental exercise, thinking about it -- just realize it and see if you can -- if performance-wise it makes sense, in terms of delay and things like that.

Pelkey: You mentioned that you had come in contact with Dave Forney and that you and he had talked in the early '70s, and that you're friends. Are there other individuals within the data communications industry who you have come in contact with and have either gone off and created companies or who have been professors and have trained people? Or people who were students of yours who have gone off and had successful careers and done innovative things in creating or starting companies?

Chu: Well there's quite a few people who call me and talk about these sort of things -- at least half a dozen. They want to create a company. They want to do this and that. Certain times, at first not really, because in 1971, '72, I really felt it was not ready because I didn't understand how to do it. That's why several small companies fell apart, started and fell apart, because they really didn't understand how to do it, they just say: "That's it. Let's do it." It's not an engineering solution by itself; there is some science to it. There is quite a bit of science to it, in the sense of how you efficiently do it and how to do it. That's what I did quite a bit of research on. At first, I did it purely for research -- never thought about this as a product and patents. I never thought about it that way. I just wanted to understand how it works. That was the starting point on that. Then in -- the companies started in 1979, no sorry 1969.

Pelkey: Do you recall the names?

Chu: I don't want to mention those names. They have shows. Fall joint computer conference and spring joint computer conferences. Their product's another box, but it doesn't work.

Pelkey: But there were companies during that period of time that got started trying to do statistical multiplexing, they just didn't pull it off.

Chu: Yeah, right. Can't pull it off, for several reasons. One is without a microprocessor it's very expensive to build; second, they don't even understand how to do the multiplexing efficiently. But that's what entrepreneurs are all about. They feel: "We can do it," and usually what happens is the money runs out before they can push the product out, because they don't understand how to do that.

Pelkey: And some of those people came to you and said they wanted you to be involved in their activities, but you always declined.

Chu: No, they didn't really want me involved. They didn't do it like that. They already have their own company anyway. They feel they can do it, but they're interested in what I have done.

Pelkey: Were you aware of General Datacom and Infotron and Paradigm and Racal-Milgo during those days? Did you ever have any contact with them?

Chu: No, they were mostly modem companies, and they built Stat Mux.

Pelkey: Timeplex?

Chu: I know somebody at Timeplex in New Jersey. I know some people who read my patent and they built something. He was working for Western Union then. Not Western Union, Western?

Pelkey: Electric?

Chu: No; a subsidiary to Western Union building equipment, also in New Jersey, they read my patent and they built this multiplexer, and then Western Union decided not to use it. Western Union read my thing, and western Union didn't want it, so this guy later on, when I ran into this fellow a few years later, he was very much interested. And then some other company, oh yeah, in fact they sold -- Western Union -

Pelkey: They sold some of their stuff to -

Chu: Halcyon. And Halcyon called me in. So you know the story?

Pelkey: I know some of the story.

Chu: He called me in and wanted to talk -- I showed them the patent and they interpreted some of the management scheme all wrong. I don't know whether wrong or right. Halcyon couldn't interpret what was going on. So I told them: "Really, this is what's happening," and so I spent a day there. I don't know what happened to them. Do they have a product?

Pelkey: I don't know. I'm chasing it down, but I don't know.

Chu: And then some people left Western Union, I don't know the name, a subsidiary right next to them, they build equipment for Western Union, they walked to Timeplex, just to have this technology, because they were involved in developing -- and I think that's what happened at Timeplex.

Pelkey: Now, Timeplex, as I recall, at least in a commercial sense, was credited with creating what was called a port supervisor: that is, you have an RS-232 port, and go in and get some statistics and know what was happening.

Chu: This stuff, from my point of view, is trivial. Monitoring, that's trivia, that's nothing. I think it's useful, but it's not challenging from a technique point of view.

Pelkey: So you came to UCLA in '69, and '69 was also the year when UCLA, over in the Computer Science group, got the IMP for ARPA. Did you have contact with that group at that point in time?

Chu: We were in the same department and Kleinrock was heading the group, and Jon Postel and Vint Cerf and all those people were working on that. Vint Cerf wasn't working on that until later stages, but I was working on, interested in that stuff.

Pelkey: You were interested?

Chu: I was interested in what they were doing --

Pelkey: But you weren't involved.

Chu: I was not much involved, until a later stage I was involved. I was involved in packet cell life experimentation, packet radio experimentation. That was in like 1978 or something like that, 1977 time frame.

Pelkey: So the ideas that were being developed on ARPA –

Chu: Had nothing to do with it.

Pelkey: Had nothing to do with it?

Chu: This was entirely separate. In fact, when I presented my paper, Larry Roberts was kind of, he had a different interpretation. It's different things, but they're similar.

Pelkey: Yes, they are.

Chu: Different, but similar. He is thinking about a network, I'm thinking about links. So it's different. But of course you can use that link to build a network. Build a tree network type of thing. That's what I envision, but it's a different type of a network, compared with a distributed network. But on the other hand, they complement each other. With a network, you have many paths. It's very similar to that.

Pelkey: After '76, '77, after you had filed your patents, did your activities have any additional impact in terms of the data communications industry?

Chu: Well, I think once I filed -- the patent's real idea is to let people know what's going on. It's good for the developer, rather than for the inventor. The inventor, all he can get is some royalty.

Pelkey: But in terms of your impact on the communications industry, you mentioned now that your interested in parallel processing and then you went on to packet radio and satellite stuff, but in terms of local area networking or T1, did your activities take you into any of those areas?

Chu: No, I wasn't involved too much in local area network. I did some theoretical studies on optical fiber network, like what kind of megahertz, what kind of protocol you need. I did some experimentation work; lead a group that did some experimental work on packet cell life. That was under Bob Kahn at that time. He provided the funds to do that. Vinton Cerf later on. It's interesting he was a student here and later on he involved the group and gave us money to do the experimentation. That was really just for understanding, for research and things like that.

Pelkey: Let me go back to the Bell Labs days, if I might. My understanding is that a lot of Bell Labs people were raided by the data communications industry, particularly the modem guys in the early days because the applied mathematics of understanding circuit design really came out of Bell Labs. Then when the operational amplifier came about then modems became commercially viable, if you will, and they went in and they'd steal the engineering know how out of Bell Labs. Is that your understanding of the history, that Bell Labs, the people in there, were in fact raided by the commercial sector for talent?

Chu: I don't think that's -- I wouldn't say raided. I think they did a lot of fundamental work, and they published their work, and a lot of people benefited from it. I don't think they really -- most Bell Lab people, unless they started their own company or something, they would not just join another company and be a circuit designer. I don't think that's what they are doing. I think what they do is they usually try to understand things, and then publish their papers, and it's good for AT&T, Western Electric, but also goods for the community at large.

Pelkey: There was some work done on local area networking, I'm told in the late '50s, early '60s at Bell Labs

Chu: That's right. In fact at that time, this is the fellow, [Wayne] Farmer and [Ed] Newhall.

Pelkey: Do you know anything about --

Chu: I know them very well. We were colleagues then.

Pelkey: Do you know where they are now?

Chu: I think, Toronto. Ed Newhall has his own company in Toronto.

Pelkey: Do you know the name of that company?

Chu: I don't know.

Pelkey: Do you know how I could track him down to talk to him?

Chu: I think if you go to the Toronto area, Waterloo, everybody knows him. He did some of the early work on loop networks.

Pelkey: Yes, what became token ring --

Chu: I don't know whether token -- probably is -- he built a network at Bell Labs.

Pelkey: So I'm told.

Chu: In 1969.

Pelkey: In 1969 he built it?

Chu: Yeah, but not Ethernet. Ethernet is -- started out with Aloha. Norm Abramson. And Norm Abramson was motivated by my paper on statistical multiplexing.

Pelkey: Oh was he really?

Chu: Sure, if you go back to his paper, he credited me for it, and then he wanted to do things -- you see I'm doing it on a line, he wanted to do it on radio. Don't get me wrong, he has his contribution, but where it was motivated from -- he wanted to do it on a radio. So he did it on the radio. Aloha, their radio channel is very poor, so he did Aloha around that.

Pelkey: Did you know him back then?

Chu: Oh, sure.

Pelkey: Do you know where he is now?

Chu: I think he is still at the University of Hawaii.

Pelkey: One of the comments I have heard about the Aloha work was that they made assumptions about all this traffic that kind of forced outcomes, in terms of what the design was going to be. Am I making myself clear?

Chu: No.

Pelkey: He was aware of your paper, and he was aware of your work.

Chu: Oh he referenced to my work

Pelkey: In his work? And did he talk to you before or during the period of time he was building the Aloha network?

Chu: No, we're friends and colleagues. It's sort of he knows my work and he -- his work is very different from mine, don't get me wrong. He is not following my work, but he is influenced by my work. He did very different work, but the idea is still the same, do it asynchronously. Then Bob Metcalfe took his idea, put it onto a line again, back to a line, you see.

Pelkey: Well, it was never on a line, right? Cause yours was kind of a communications channel, as opposed to a coaxial cable.

Chu: His thing -- the whole thing, an engineer would never think about that. He's a physicist. So he broadcasts on the channel.

Pelkey: So he didn't care what the media was, it was just a channel.

Chu: And I'm not starting from a pure -- my background was computers and mathematics and that kind of stuff. That's why, if you talk about classical communication engineer, they probably wouldn't do it the way I was thinking about it. This is the whole thing. You come in cold. You say: "Well, let's do this." It helps.

Pelkey: That does help, doesn't it?

Chu: You have a fresh look.

Pelkey: And that fresh look from your perspective that you brought to it came from --

Chu: My computer background.

Pelkey: From the computer background as opposed to the analog background.

Chu: Well, from transmission.

Pelkey: From a transmission background. And that whole process of people getting trained in computer techniques and digital techniques, that only really started happening in --

Chu: Well, computer background, this is kind of a --

Pelkey: Early to mid '60s is when you start to get people coming out of the universities such as yourself, who had been trained in computer sciences.

Chu: So we know what a computer can do, what logic can do. And in communication, it usually involved very little logic; the logic is not that extensive. And they were working on analog, and digital is quite different. You see, the same thing -- Bob's contribution is that he felt that he could broadcast on a cable, which was the whole thing. Then he
had other things too, to add to it to make it better.

Pelkey: But that issue of, particularly out at Bell Labs and the early modem guys, they were really analog engineers. They were transmission engineers. The statistical multiplexer was really the first product in the data communications arena that was really digital based. You could use microprocessors in modems, but it was incidental. In the case of statistical multiplexers, it was the first time that digital techniques became the heart of the architecture of the product, versus a tool to cost reduce it or do it faster or something like that. Would that be a fair statement?

Chu: No, I think that Bell Labs at that time, Bell System had digital and analog both. In fact, John Pearce did a study showing that digital could do better than analog. So in Bell Systems, they had two systems, analog systems and digital systems, coexistence. They both are developing. Eventually digital will be better than analog. Of course it also had a lot to do with digital technology nowadays. But way before then, digital technology could be very expensive. Already a lot of studies had shown that digital was a good way to go.

Pelkey: Back in those early days in the data communications industry, do you recall that the Carterphone was something that was understood and perceived as being important? Or was it a non-issue that has only taken importance in retrospect.

Chu: Carterphone was really a political issue. It's kind of a regulatory issue. It had nothing to do with anything else.

Pelkey: But the concept now that foreign devices could be hooked up?

Chu: That's right, which was very important. But the whole idea of foreign device hookup was just that AT&T at that time didn't like the idea. There was no science in there. No science. As long as you did not disturb the signal on the line, it should be ok, but clearly it was a big step from AT&T's point of view. You invaded their whole system.

Pelkey: Do you recall in the community of engineers or data communication people that there was a realization that Carterphone, by allowing you to put foreign devices, that that was a real opportunity? Or was it because Carterphone happened to deal with a radio network down in Texas that no one really knew about it?

Chu: It was really, from a scientific point of view, it was not an issue of interest. It's more business aspects. It's a very significant impact from a business point of view, but
from a scientific point of view, most scientists didn't care about it either way, but certainly it had a tremendous impact in the communications industry.

Pelkey: A value judgment on your part: I believe that with the break up of AT&T, that Bell Labs had been, and will increasingly be, reduced in its ability to be able to fund science.

Chu: Agreed.

Pelkey: At the same time, the Mansfield Amendment came in, when they changed ARPA to DARPA, and focused it onto defense related projects as opposed to, in the early '60s ARPA funded 60% of the computer research that was going on in the country, that when you no longer had ARPA that was funding basic research, that we, in the data communications industry, have seen two major sources of science in this country negatively impacted, which in my view has long term negative implications in terms of technology being created in this country. Do you agree with that?

Chu: I didn't follow it.

Pelkey: Bell Labs is going to be reduced.

Chu: That I agree with.

Pelkey: And when ARPA went to DARPA, and they couldn't fund research as much as they had to fund projects that were defense related, that it reduced the science investment.

Chu: I guess that's true. But hopefully, they want the National Science Foundation to take over that.

Pelkey: Which hasn't, very much.

Chu: Not -- well, it's different kind of support. National Science Foundation support is a little different from ARPA support. ARPA liked to run big projects and the National Science Foundation, although they'll have big projects, but it's different. Most likely, most cases, smaller projects. The most important thing really, I don't care whether DARPA or ARPA, as long as the government provides more funding for research. I don't care where it's coming from. Scientific research should be supported, and basic research should be supported by an agency that handles basic research, and the Department of Defense, they have a different type of research support, so I think the way they decided that makes sense, the logical structure makes sense, but I think that perhaps the money --

Pelkey: Hasn't been forthcoming.

Chu: The money either hasn't been forthcoming, or coming to areas not very well focused, perhaps. Like at ARPA they want to do a project. They did this. They spent a lot of money developing it, including basic research, doing that. So it is more project oriented. Basic research is usually not very project oriented. It's sort of, understanding certain things, so they might have had a lot of things then, but not well focused in a sense. So maybe DARPA is good for telecommunications, for certain aspects, because of networking and all that, but maybe National Science Foundation is good for some other things. It is true that they didn't want to do things directly related with industry, because that's not basic research. It's industrial research, and they didn't want to support that.

Pelkey: Are there any other comments, or are there other areas in data communications that we haven't touched on that -- here's an example. In those days when Kleinrock and Cerf and Kahn were here, could you characterize that, as you saw them from the outside, in terms of the excitement and the energy level, how would you characterize that? Was that group thought of as a special group within the department?

Chu: I attended some of the meetings and all that. It was a very active group. A lot of research was done.

Pelkey: Was it an exciting period?

Chu: Oh, yeah, very exciting. UCLA used to be known as the best, maybe still has the best telecommunicating group in the world, because we have network people, computer communication people, myself and my students, and we also collaborate in understanding what they're doing and things like that. We were THE school, for many years.

Pelkey: Some of that resulted as a consequence of the IMP being put here and being part of the Arpanet and your coming here

Chu: It all just happens. It wasn't planned at all. It just happened.

Pelkey: So those guys used to have presentations every once in a while to the rest of the faculty as to what they were doing?

Chu: I think usually there were research groups that discussed things, and you have reports.

Pelkey: Were there instances in which things were going crazy?

Chu: I think I shouldn't speak for them. You should probably talk to Len Kleinrock and he could tell you more about his activity.

Pelkey: And where do I find him now?

Chu: He's here.

Pelkey: He is here? Good, I'll have to look him up. He's a professor here?

Chu: Yes.

Pelkey: I do intend to talk to him about it. I was looking for your perspective from a distance.

Chu: You should talk to him about that, because that's really his domain. I think it was a very exciting time, and I had a lot of fun developing it and understanding it.

Pelkey: Any other comments you might care to make or that you thing might be helpful?

Chu: No, I think you have asked a lot of questions. I hope I have answered some of them.

Pelkey: You have, and you've been very kind. I greatly appreciate your time.

END OF THE INTERVIEW

