Oral History of Anthony (Tony) Michel

Interviewed by:
Marc Weber

Recorded June 5, 2009
Cambridge, MA

CHM Reference number: X5406.2009

Marc Weber: I'm Mark Weber from the Computer History Museum. And today is June 5th, 2009, and I'm here at BBN with Tony Michel networking and ARPANET pioneer. And thank you for agreeing to sit down with me.

Anthony (Tony) Michel: Glad to be here.

Weber: And just really want to start at the beginning. Where were you born, and grow up?

Michel: I grew up in Maryland. I was born in Baltimore, 1944. And I went to school in the Baltimore suburbs. Moved to, near the Philadelphia area to go to high school, Westtown School, and then I came to Cambridge to go to college, and never managed to break away. I always thought I'd move away, but I never did.

Weber: Were you interested in technical things as a child?

Michel: From very early on I was interested in shortwave radio and things like that. I was a Ham radio operator, still am actually not very active. But, yeah, I always had a technical bent, and an interest in gizmos and gadgets.

Weber: And were either of your parents in technical fields?

Michel: They both worked-- my father was a biochemist, and he worked for the government laboratory near Baltimore. My mother was a Biologist, and she worked in the water purification department until she got married. So there was a sort of a chemistry background in the family. And I was interested in chemistry but I-- more interested in electronics. So that's the direction I went.

Weber: And so you started making electronic things when?

Michel: At about the end of elementary school I got interested in building radio receivers. And I built a gadget to convert shortwave signals down to the frequency of the broadcast band, so you could pick up shortwave on your regular AM receiver. And that was the first of many, mostly unsuccessful, but some of the things worked, many radio projects that were-- eventually, as I say, I became a licensed radio amateur and then built transmitters and receivers. I had a lot of fun.

Weber: And so what were you interested in, in school?

Michel: I don't remember being interested in much in school. I sort of ignored school. And I was pretty good at taking tests so I did well in school, but it never-- it wasn't ever the prime focus of what I was doing. Whether I was canoeing, or camping, or building electronic gadgets that was what was in the forefront of my mind, not what was going on in school.

Weber: So you enjoyed the outdoors?

Michel: Yeah I like to do bird watching, and hiking, and camping, and things like that. I did lots of that in my early-- and up until now that's still how I spend my time.

Weber: Which college did you go to?

Michel: I went to MIT here in Cambridge, local trade school.

Weber: What was your major?

Michel: Electrical engineering. And that was real electricity. Now they don't teach the Laplace transforms. Those were the good old days, by George.

Weber: So what year did you come then?

Michel: I started in '62 graduated finally in '69. That was one of the downsides of being not very interested in school is that the grades are not always so good. But I eventually shaped up, graduated. And all of my buddies had come to work here at BBN, so I eventually wound up in a little office just down the hall here at BBN.

Weber: And what got you interested in computers?

Michel: We had -- MIT made it even then in the early '60s. They made it very easy for the undergraduates to get their hands-on gear. There were many rooms, laboratories, you know, filled with hardware, and software, and things that you could play with. You could get part-time jobs. You could come in on weekends and just hack. So I think the accessibility of the-- accessibility of apparatus that was, you know, challenging and complicated enough to be interesting was what did it for me.

Weber: And then you hadn't seen them? I would presume that was your first exposure, right?

Michel: Were there any computers before-- yeah were a few gigantic vacuum tube machines, you know, in banks and insurance companies, but that exposure at MIT was really the beginning for, sure.

Weber: And immediately you...

Michel: Yeah I had a part time job in Building 26 the old wooden temporary building leftover from World War II. So I was in one of those back labs in Building 20, and they just gave us the run of the place. I forget what ostensible job was. I was supposed to wire up circuit cards for the grad students or something like that. But it, you know, it let me see a lot of the different aspects of hardware and evolving software, and it was a good way to get started.

Weber: Did you have summers jobs outside?

Michel: I had a part time job in Building 20, in the research lab of electronics. When I went back to Baltimore for the summer I worked in a radio station. And at some point earlier, sort of at the end of junior

high I guess, I got my FCC radio license that let me sign the transmitter log. So that was always good for a summer job. They always want somebody who's going to work for a dollar an hour and can sign the transmit log. So that's what I did summers. I also had a jazz show. I was an announcer, but that was just a diversion.

Weber: At MIT, or in the summer at Baltimore?

Michel: No, no this was a little commercial radio station, 500 watt station down in-- it's still there I was just down visiting in Baltimore a few weeks ago, and it's changed its call signal, its call letters several times, but they're still up and running and on the air.

Weber: What station was it?

Michel: It was WAQE at the time. Now it's WFBR, which in my era in Baltimore WFBR was a, you know, was one of the big fancy stations. But there must have been churned, because their call sign is on this little podunk station down in the swamp.

Weber: Was music an interest of yours?

Michel: I, at that time, played French horn. And I actually gave brief thought to whether I wanted to be a musician. In retrospect I think I'm glad that I went the way I went. But I still enjoy music. I'm no good at it, but I play a bunch of different instruments. Yep.

Weber: What were some of your extracurricular interests at MIT?

Michel: Well, girls, but more-- much more technical hackery. As I said, I always a part-time job of some sort either in a MIT lab, or I worked for a while at the Fernald School in-- as an electronic kind of a guy in one of the labs that was building teaching machines. So it was always in that-- along that vein. For a while I had a, what we would now call a consulting job. I, you know, I worked weekends for an outfit that I-- one of my lab partners had introduced me to a little outfit that I did electronic design for. So it was usually that kind of thing.

Weber: And so by the time you came here you had been in college for, what, six or seven years?

Michel: Yeah. It took me five plus years to get a Bachelor's. I then came-- I actually went to work briefly for another company for a year immediately following graduation. But I think my pals who had come directly to BBN knew that the ARPANET project was about to start, and so they invited me into coming to BBN. And I was already a practicing engineer. I could build and make work complicated electronic hardware. So I fit right in on some of the early hardware projects. Also I had some catastrophes. I had some projects that didn't work very well. But it was a mix of both.

Weber: Can you describe both?

Michel: I built an interface for the-- one of the original IBM host computers that was tied in at UCLA, tied into the ARPANET. And I built a half-duplex interface, you know, I think it-- you could save, it reduced the

price by 50 percent. In those days the IBM host had a very elaborate thing called a channel and in order to hook anything onto the IBM machine you had to build a channel adapter. And if it had to both send and receive, you needed two of them. So I built only one of them and arranged it to be shared either sending or receiving. Well the network protocols that we had developed switched, and sometimes we would get hung. We would be listening, and they would be listening, and nothing would be working. So I learned about duplex interfaces from that.

Weber: And some of those successes then.

Michel: Well we had a long string of successes with building-- the original packet switch for the ARPANET was done by Honeywell with BBN's supervision and BBN design. But we sort of watched them and said, "Hey this doesn't look so hard." And so BBN, Frank Heart was-- he was the iron hand, you know, he didn't want to get overexposed. And I think he was wise, you know, he got that first network switch up and running. But then he lightened up a little bit and said, "Okay you guys can build the terminal scanners." We wanted to build an interface for the original IMP that you could allow terminals to be tied in directly. So that was-- my project was to build a very elaborate piece of hardware that could support 64 independent teletypes or things-- I can't remember. The VT100, the deck VT100, was one of the kind of terminals that was very popular then.

Weber: That was the terminal IMP or later the Pluribus?

Michel: That was the terminal IMP. That was the TIP. So I did the hardware for the TIP. I then took that hardware and used it in the Pluribus TIP. We made a PTIP, and then we-- that was the era in which we were switching from 50 kilobyte communications links to faster links. And so that was when we built the Pluribus IMP for-- as a multiprocessor. It had enough computer CPU cycles that it could keep up with the faster arrival rate of packets on these fast communication links.

Weber: When you arrived, who was your first manager and your first job?

Michel: The department was quite flat. It was Frank. Frank managed everybody. Now he had-- several of the engineers were older and so they had some nominal responsibility, but really Frank was the boss. We all worked for Frank.

Weber: And so you immediately went to work on the IMP?

Michel: No I-- my very first project was across the-- in the next building over where the host computer guys were. We had two sort of competing divisions. We had the TENEX guys and the IMP guys. Well, the IMP guys, it became clear that while they sharpen it that thing is going to grow. And they went around and rated other departments, and I was one of the fruits of that raid drafted into helping to field the first generation of ARPANET IMPS. And then, well, they seem to work now what are we going to do next? How do we add more services? How do we get more users tied in? Another piece of that business was building the specialized interface that tied the host computers in for-- we built interfaces for most of the what were then the big successful computers of the day, the CDC, and Sperry, and Honeywell and things like that.

Weber: I think for the first IMPS you only built four interfaces for each of the four host, right?

Michel: Well each package switch had the ability to support up to four direct connections, okay. If you had more than that-- I guess some sites did. Some sites had more than that and they would just have two IMPS or three IMPS. In fact early traffic studies of the network for many, many years, there was a huge surge of traffic that happened in about 1970 or '71. It was 10 times greater than any traffic for years on either side. It was Ben Barker testing his DEC PDP10 interface. I can't remember if he was at Harvard or here. But one of the early hardware engineers was just doing local communication through the IMP. It was the easy way to hook computers together was to plug them into the IMP. And a lot of people did that having no interest in other users on the ARPANET. Just they wanted to hook their IBM machine onto their DEC machine. This was the easy way to do it. It was before Ethernet, you know. Each computer was its own genus.

Weber: How long after you arrived here were you requisitioned?

Michel: I was in the TENEX group for nine months or, nine or ten months I guess.

Weber: So when you joined the IMP group what was roughly the date?

Michel: Well I have 10 months after, you know, May 19, 1969, you know, or early '70, early 1970.

Weber: So that just had started?

Michel: Well, in the little IMP room that I showed you across the hall we had two machines. One was the real prototype, and one was the first operating IMP that actually would run, you know, all the interfaces and all the software. Interestingly enough, the very first operating network nodes were in California. We were here and the nodes were all out in California. We had the first instance of working IMPs here but the first network system on remote sites were out in California.

Weber: Yeah UCLA and SRI.

Michel: I forget if it was-- probably right. UCSB Santa Barbara was early in there as well. There was UCLA, Santa Barbara, SRI and then where-- Utah, I think.

Weber: Utah came shortly after.

Michel: So there was a lot of running up and down the West Coast. Mostly the BBN hardware and software was not at fault. We could almost always count on blaming it on the telephone company when something was wrong, but not always. In fact we had a job of calibrating the telephone company guys. The-- I forget the name of the-- the Long Lines. It was AT&T Long Lines was responsible for the communication. And they could not understand that some guy in Cambridge could say, "Oh, you just turned the switch." We had built in link monitoring protocols on our inter-switch links, and we could tell when they turned the carrier off on the modem. So they came to learn that oh they couldn't just turn the switch off and go home, you know. The BBN guy will know. And so that was the beginnings of remote network management.

Weber: Who were the guys you worked most closely with?

Michel: Well there were, what we would know...

Weber: Because you were working...

Michel: I was one of four guys who came in at the same time. Ben Barker, Mike Crowley, Marty Thorpe and I and then we were joined by Joel Levin. So that-- we were all sort of the young kids. All had graduated at more or less-- I was a year or two older then the other guys, but we were all sort of unfettered with prejudices. And we didn't know how things worked so we started from scratch and it was probably a good way to do this kind of a thing. My boss in that era was Severo, Severo Ornstein who is still alive and kicking.

Weber: Oh yeah he's agreed to be interviewed, by the way.

Michel: Good. Well, I give him my felicitations.

Weber: And what was he like to work for?

Michel: He was a good guy. He was not the traditional-- I think he-- part of the reason why the ARPANET worked and didn't become sunk in the mire was because of commercial practice and the way IBM or Honeywell would have done it, was because of-- first of all Frank had a very clear vision for distributing computing network. And the ARPANET program manager, Larry Roberts had, you know, a vision of what he was trying to accomplish, resource sharing between remote sites. So there I was a little younger, not much, but a little younger then those-- each of those guys. And he picked up the vibes and he could work-- he was much older, you know, he was 13 years older than I and 15 years older than the other of his flock. But, you know, he could get people to work. He could get us to work all weekend. You know, he was one of those legendary managers who can really get people to focus on the problem and work. And I enjoyed-- I'm still friends with him. I was just hiking with him a few weeks ago out in Utah. So we've stayed in touch.

Weber: Yeah I know he's an outdoorsman as well.

Michael: Yeah.

Weber: Yeah but he was a nice guy to work for.

Michael: He was a-- yeah, interesting. We shared some interests. He wasn't as interested in gadgetry and hackery as I was, but he was interested in music, and he was very literate, and good guy to be around and to work with. It was more working with him then working for him actually. I think he was quite tedious in his insistence on care and design reviewing. He would look over my shoulder and make me explain, you know, well, why are we building the synchronizer this way and, you know, how is the shift register data going to be sent around. So he did very little of the work, but he knew that-- knew how-- what was going on and it was good influence I think.

Weber: And who else was he managing at that point?

Michel: Well, I guess I don't know the total extent but he was the boss of Ben, I, Marty, Joel, you know, the hardware crew. We had four main engineers. Each of us had our toolbox, and our Tektronix 453 oscilloscope that were given to us as we came to work, you know. And we were supposed to make the ARPANET happen, you know, and I guess, so we did.

Weber: Describe the other guys.

Michel: Well, Ben, Marty and Joel were all from Harvard. Severo had-- I've forgotten who his connection was there, but he had been hired as an adjunct professor at Harvard to teach, you know, a computer science course and he just, who got the A's in this course, okay you, you, and you, you're hired. And maybe he took a few B's, I don't know. But he was a very good connection into the Harvard computer science squad for a couple of years, so.

Weber: Describe the other people.

Michel: Well being an MIT guy I would, you know, be very scornful of Harvard's engineering capability. I would say they were more computer scientists, but, you know, they were all good engineers. Especially Ben was good and thoughtful, and he really understood computer system design, you know, how to-- here's a problem, how do I partition it between specialized hardware, and general off the shelf hardware, and what functions will I do in software, and what functions will I do building specialized hardware. So that was sort of-- Ben, he eventually went on to get his doctorate at Harvard in computer science or whatever they call it. And you could see that even from his early post undergraduate days that that was what he liked to do. Marty had a-- he seemed to have a managerial bent. And he had taken all the courses and done well, but I think he really like organizing and running the project. And he was only with us for a few years. He went back to Harvard B School and got an MBA. And he's still in the area I believe, but has worked as a engineering manager. Joel, Joel Levin, he and I were perhaps the most parallel in abilities and skills. He was a little bit more of a software nerd then I. And Joel has remained as a software engineer all-- for the rest of his career as far as I know. I spoke with him not a year ago out in Arizona with a, you know, software engineering job in Arizona.

Weber: Did you become friends?

Michel: Yeah we sort of did. We would go to parties together and whoever was going out to the Coast would buy a case of Oly [Olympia Beer] and bring it back for parties, you know. And so, yeah, we got along well. And I think it was a case where you could have pernicious rivalries and to me it didn't seem that way. There were some rivalries but, you know, I think it was mostly a collaborative sort of collegial thing. We were building the ARPANET. Even at the time it seemed that we were doing something interesting and unusual, and it was fun to do it.

Weber: Would you just try to describe to people who weren't involved?

Michel: Oh all the time. And most people you'd get sort of a blank expression, you know, "Oh, boy, I don't know." The main-- this was in a era where people were very suspicious of government funded research so they knew we were up to something, and which, to an extent we were. But it was black magic to most people. What surprised me was how long it took for the Internet to arise out of the ARPANET. It really seemed-- "Oh yeah this is great, you know, mail we can do electronic mail now. We

can move files around. Yeah this is the obvious way to do things." But it was much slower for the-- describing it to people was just one of the aspects, you know. And getting them to understand what was going on was another thing entirely.

Weber: I presume nontechnical people, it was just totally amorphous if you tried to tell them about it.

Michel: I tried on many occasions to describe to my mother what I was doing and, you know, she was a scientist but I don't think she ever really got the idea. My dad could, you know, he could track. Yeah he understood. He also was a chemist but that's scientific enough that, you know, he knew how to think about it.

Weber: But when you went to a party and you said you were working on this huge networking or this unknown thing, no one knew what a network was.

Michel: That's right. I didn't try to give computer speeches at parties more than once or twice.

Weber: And what was BBN like in general in those days?

Michel: Well it was transitioning from being an acoustics, the genesis of BBN was in acoustics and architectural acoustics, and there was so a lot of that going on when I came to BBN. And all the hall outside this office, this conference room was filled with all of I-95, the I-95 corridor from Boston to Washington we did the acoustical barrier stuff. I had nothing to do with any of that, but that was the big noise. And us computer guys were some sort of weird little side show in a small part right here in this part of the building. It was much like BBN is today unusually. Toward the end of '60s, and through the '70s and '80s, the commercial focus of the company became dominate. And a number of, you know, people who came into management who really wanted to grow the two billion dollar company, that was the goal at the time. And so the focus, you know, we began having a lot of suits and limos to the airport and stuff like that. And in about the last 10 years the management seems to have been trying to get us back onto our course more like the BBN that I came to work for. And I find, in addition to sitting in almost the same chair that I sat in in 1969, right now I find the atmosphere to be the same now as it was in early days.

Weber: And you mentioned that most people were suspicious of computers at the time, and at the height of counterculture antiwar movement. How did people react when you said you were working for a government contract for the military?

Michel: Well I didn't hang out with the crowd that would have reacted the most violently. Most people were polite. But, you know, you could tell that there was hostility for the government funded research, and especially when the part of the government is part of the DOD, you know. It was ARPA then but they were still becoming DARPA. So that atmosphere turned some people off. A lot of Cantabrigian-- we actually had a march on BBN.

Weber: Cantabrigians?

Michel: A resident of Cambridge is a Cantabrigian. There was a march on BBN where people started in Harvard Square, and it had mostly petered out by the time they got all the way down Concorde Avenue. But somehow BBN was thought of as being on the wrong side for a lot of the late '60s and early '70s.

Weber: But SRI had a big serious protest.

Michel: Yeah right they had bricks flying I guess. No we never had anything quite that dramatic at BBN. Although in one of-- in the installation of the ARPANET node at Moffett Field in Mountain View I was the installation engineer. And so I-- it took typically a day or two. It took about 30 minutes to get the IMP installed. You had to find a power cord, and then always the plug didn't match so you had to attach the AC to the power, flip it on, and it would just come up and start. And then there'd be a few days of helping whoever the user site was, get his host computer going. So during the evening I would go over to Berkley and dodge the tear gas and, you know, we got enough demonstrations through our installation travel.

Weber: You were hanging out with people that were certainly antiwar then.

Michel: Well there's a good balance of that. Even at BBN there were-- we were by no means a uniform view of things here within the company.

Weber: And you mentioned traveling, when did you first go RAND with the IMP project?

Michel: Well I'm trying to remember which node-- I think Marty had started being the installation guy about six months before I and so he was the expert. And I tagged along after Marty for one or two trips and then I think I did the RAND IMP, and I did a bunch of them after that. One machine, we had to install a TIP. So we had to install a TIP at MITRE in Washington, McLean, Virginia, and I got down there to meet up with the IMP and it couldn't be found. You know, the shippers, "Well, we don't know where it is, you know." Well they were obviously trying to-- well it wasn't obvious but something was wrong. So I went over to the airport and we looked around, finally found the box. The IMPS at those times at that time were shipped in a plywood enclosure. And it had all these strange black marks all over it. Well it was obvious the thing had fallen off a truck, or fallen out of the airplane, or whatever. And inside the machine had been just completely destroyed, if you can imagine taking a old computer of that era and shaking it. So...

Weber: But they were hardened right?

Michel: Well this was one of the cheapo models. The first, I don't know how many, maybe the first 20 were militarized hardened. But that just meant that they had hard metal case. They were still not...

Weber: It didn't protect the insides.

Michel: It didn't protect the insides. So this poor TIP had fallen over. But with my Swiss army knife I had managed to get the thing apart, field stripped, put back together, I got it up and on the Net. It was later condemned, you know. All of the physical mounting, and the rails that the modules slid into, those were all completely destroyed, just bent to shreds. But we did get it going on the Net. And I guess it was scrapped.

Weber: It didn't say TIP on the outside of the box did it?

Michel: I forget. I think it did. It said Terminal Interface Message Processor.

Weber: There's your problem. Someone saw that.

Michel: Tip it over. Yeah.

Weber: But there were a lot of meetings of different people in the ARPANET community in travel. Describe some of the high points of people you met and places you went.

Michel: Yeah, I enjoyed the travel. I liked going to faraway places. And so just the, you know, what would now maybe seem pretty routine, installing hardware for the ARPANET you got to go to various universities and research sites and find out what they're doing. And usually the computer guy also knew what was going on there. So they would explain to us what this synchrotron is for, or what that wind tunnel was good for. And so I particularly enjoyed, you know, rubbing elbows with my peers at the site. Being a hardware guy was-- that was sort of a mark of shame. The good guys were the software protocol guys. And so the guys who got to go to, you know, Hawaii and Norway and places like that, that was the protocol architects. Us hardware guys usually wound up with more modest trips. But working, the same sort of a feeling that existed within the engineers, the software and hardware guys here at BBN, was, you know, it was throughout that whole community particularly the guys at SRI. I can't remember-- SRI ran some of the big service centers. They ran the information, the network information center and things like that.

Weber: Do you remember Jake Feinler?

Michel: I do remember Jake. They also had a huge farm of email machines. So for whatever reason, that was just one of the central points in the network and we spent a lot of time there for some reason. So I enjoyed talking with those guys, and sort of seeing what research was going on all around SRI.

Weber: Because Jake, you know, volunteers for the museum and she's going through all the records of the NEC which we have. Who else do you remember from there? Probably not names.

Michel: You know, I don't know.

Weber: Because I think they had regular meetings.

Michel: Well the ARPANET research community consisted-- I think each of the major projects, the ARPANET was just one piece of a large effort to do distributed computing, and communications, and applications of different sorts. Each one of those things had a so-called principle investigator and the PIs would get together and just do what us hardware guys used like to do at the hardware layer. So I think a lot of what you hear about nowadays are those early PI, Principle Investigator meetings, where they're sort of charting the course of, well, what's not working, you know, where should we apply research funding to do remote file-sharing. Or one of the interesting projects that was built at Moffett Field was the ILIAC, a large multiprocessor computer. And I think the ILIAC didn't tie directly to their IMP. It had some kind of a front-end interface processor. But they were one of our correspondents for quite a while getting-- making the ILIAC connection usable enough so that they could rent out their CPU cycles or, you know, whatever they were doing with them.

Weber: At Moffett Field, this was the Air Force or NASA?

Michel: I guess I don't remember exactly whose space it was but it was a Navy facility. That's where the P3 Orions for the, you know, the submarine patrols in the Pacific were flying in. About every minute there'd be an airplane landing over our heads. For some reason the computer facility was not far from where the runway staging area was.

Weber: Let's pause for a second.

END TAPE 1

START TAPE 2

Michel: I'm trying to remember the nature of that controversy. There were two sides to the idea about whether BBN should get tangled up with the users. On the one hand it was important to get people onto the net. What's an easy way to get them on to the net? Well terminals are easy to hook in. On the other hand, now you're responsible for unhappy users. They'll be calling you up and instead of having one user at a site who bothers you, you'll have 64 users if you build a 64-line scanner. So that controversy about whether we wanted to reach out to the end user or work through the local indigenous infrastructure, I forget which of the mighty here at BBN were on which side of that controversy, but anyway it was decided to go ahead and go, I think ARPA kind of leaned on BBN more. We want to get people on, you guys are going to build this terminal interface for us. And so we did and it had all of the features, it was probably Frank who was afraid of so much involvement. He wanted to keep it a cleaner interface to the customer. But anyway, we were prevailed upon to build the hardware and the software for this terminal interface. I don't know if that was in '72, '71. In any case, the rolling out party for the first TIP, we had a big sort of a convention in Washington. It was the coming-out party for the ARPANET, the CCCI or something like that [ICCC], and it was the first of--

Weber: With all the demos, right?

Michel: Each of the PIs, basically each of the other ARPANET research projects came to the base, to the hotel, I've forgotten, one of those old classical Washington hotels, and they had their booth and whatever it was they were doing. They were actually up and online and they were plugged in. We set up an IMP onsite, a TIP actually, so there was terminal access, you could read your mail, there were some nice comfortable chairs where you could sit and log in and get your mail. It kind of set the tone for what the ARPANET project was going to be. It's going to work and we don't want any static demos. We want live demos only, and I think that it was a brainstorm to have done that because it was so different from a lot of other big, high-techery, high-tech conventions and exhibitions and whatever, where whatever it is isn't real. This stuff was real and people could see it was real and I think that was a great thing.

Weber: Show, don't tell.

Michel: Yeah. And there was plenty of telling as well. Most ARPA PIs then and now are good at hand waving and what we now do with PowerPoint, we used to do with chalk, but there was a lot of that going on as well.

Weber: What kind of terminals did you have hooked up to the tip?

Michel: Well I'm trying to remember. It's a little hazy which terminals came when. I think I remember Beehive as one of the ones that, for some reason, there's an outfit in Utah that made a nice little video terminal, keyboard, TV-type screen, just a simple 24 line by 80 characters, but those were one of the interesting terminals, Deck, all flavors of the Deck terminals were popular. The VT100, I still like the feel of a VT100 to this day. It feels right when you type on it.

Weber: Any particular memorable demos there?

Michel: Well that demonstration of real, live interactive computing while you watch and you get to see all the failures if there are any, that was really one of the most memorable demos. We had a pretty memorable demo every time we did an installation. The machines at that time were based on ferrite core memory. So you would load the program and then it would be retained. The main memory of the machine would retain whatever the last contents were when you turned the power off. So we could fit the power on and truly it would start in about 15 seconds. That was just astonishing to people that we're accustomed to oh, when the computer guy shows up it's months of agony and waiting, trying to bring the thing up. The BBN guy would show up, flip the switch, and they were up and running. We're ready guys! So ARPANET continued to grow and it flourished in a number of different ways. It wasn't as if the nuclear core was very palpable early in the late '60s and early '70s, but by the mid-'70's things had gotten so spread out that there were things going on everywhere. I don't know that I'd single out any one particular thing as the capstone.

Weber: For instance, at the Washington thing when people went up and used the terminals, what applications would they be using mostly?

Michel: I'm trying to remember. It seemed to me BBN makes much of electronic mail. I can't remember how our messaging system worked but from the very earliest the ability to send messages back and forth--

Weber: <inaudible> within teams.

Michel: Yeah, so I think mail reading and things like that were some of the big-- I guess one of the aspects of it was that it provided access back to your home computer at work. So even if you weren't part of the interoperable global electronic mail system which was beginning to come into existence, you could get from Washington back to St. Louis or San Francisco or Boston and tie into the machine that you would be hooked up to at that site.

Weber: Yeah, remote access.

Michel: Remote access to your incompatible local assets is what I think may have been a lot of it early on.

Weber: File-sharing was not--

Michel: There were a couple of things. Yeah, file sharing was big but I think one of the really interesting-- there were a couple of efforts to build megabyte stores or gigabyte stores. You know, big giant memory, several million bytes of storage all online at the same time and most of those efforts, as far as I know,

didn't lead anywhere but the ability to save information one place and then distribute and use it, that was the very first application on the ARPANET was moving files around amongst post-computers.

Weber: What were some of the technical challenges on the terminal end project?

Michel: Well I think because the practitioners, I and Ben and Marty and people like that, were young and inexperienced, we weren't scared enough about complexity and design and so the hardware that we built for the terminal access, and even the software that controlled the hardware, was built from scratch and maybe was pretty complicated. So I think just getting working and keeping working that size of custom hardware, you wouldn't find a manager anywhere today who would approve those projects I suspect. Oh, we'll figure it out, the shift registers will come in and etcetera, etcetera. Well, okay, go ahead and do it. I think we got away with design murder. That had consequences later that okay, now there's a lot of elaborate custom design not terribly well-documented hardware out in the field that one of the troubles with the ARPANET was that it worked well enough that people became dependent upon it. It became a critical system in some cases. Somehow we have almost completely designed hardware and software supporting critical missions and that's always a challenge. I think the people who were involved, somehow the atmosphere of the ARPANET project was such that unusually qualified people, you know Ben was just a crackerjack engineer and I don't know how it was we were able to keep him interested for so long. So, you know, smart people can do impossible stuff almost and I think maybe there was some of that going on. That allowed us to get away with some of the inadequately documented hardware, replicated a hundred times around the world. How are you going to keep that going? Well smart people seem to be the answer.

Weber: Who was actually fabricating the boards at that point?

Michel: Boards? Boards? This was all done with wire wrap. It was integrated circuits. It was semiconductors. Not vacuum tubes but individual integrated circuits were plugged into sockets that had little pegs that stuck out the back and then there was a machine that would wrap wire and then wrap it on the other end. It might have been Ray Tomlinson who saw me and Marty and the other guys who were doing all this by hand and he said, "Oh, I can build you a compiler for that." So he built us a really nice system that would automate the process of generating the wire lists and then we would punch a paper tape or somehow convey that, there were various vendors around Boston who would assemble boards for him. He'd say, "I want about like this," and they had all the plug-in boards and stuff and they'd fabricate it for you and wire-wrap like that.

Weber: Because the hardware done for early on, it was the computer companies that made the host that did some of that, right?

Michel: Well even the first amps were done by Honeywell out of their shop. I think it was up in New Hampshire. Maybe Nashua. Honeywell, they had bought the CCC, the Computer C Company, I forget what the initials stood for, but they were absorbed into Honeywell so Honeywell had a well-proven line of little modular carts but the BBN stuff, we didn't want to use their design, their partitioning of hardware. We didn't want to use their modules, we wanted to get all the way down to the individual chips and so we did that. That was an example of where a more prudent management might have said, "Well, we're going to use those Honeywell parts anyway and you'll make them work somehow." But we were allowed to start from scratch, build from the individual parts up. Same with the software. The original packet switch came with a suite of software, an editor and a Fortran compiler. I think Bernie Cosell actually ran Fortran

on the IMP at one point but we took all the Honeywell software and threw it out and said, “Oh, we can do better than this!” and wrote from scratch the assembler and the editors and then after we had written an assembler and the editors then we got to build the software the way we like and we could run it on our own homemade PDP10 timesharing system. In fact, a lot of the early software came through the DEC PDP1. We had one of the early serial number PDP1 computers and everyone was familiar with that and we had a nice timesharing system built for it. We understood how to do reliable backup and restore and so that was just the logical facility to do all the software development and so that’s where it was.

Weber: So the Pluribus came along when? What year?

Michel: Well again, I guess that would be ’73 and 4 was the early days of the Pluribus. As I’d said earlier it became clear that communications circuits, there were a bunch of things going on in deregulation. AT&T’s vice-like grip on the Long Line monopoly was breaking up. So not just ARPA but other federal research agencies that we dealt with and could see oh, we want much faster networks. This networking stuff was just what we want but we want to go much faster than you can go. So we needed more powerful hardware for the packet switches and that’s what was the motivation for building Pluribus.

Weber: Describe the project to <inaudible>.

Michel: It started out with the usual suspects of Ben and Tony and Marty and Joel and there were a few other new kids. Mike Kraley had come in at that time and then there were the software guys. Bob Bressler and Will Crowther, Bernie Cosell and there were 10 or 12 of the engineers who were involved so we portioned the job out in different ways. There was just a little bit of the beginning of having an operating system and an application in the Pluribus. There was a set of libraries but I don’t think we called them libraries, what we would now call libraries, sort of organized pieces of software that different applications could call on and so you didn’t have to manage all of your own hardware devices and you didn’t have to do all of your own memory allocation and so forth. So that kind of modular software and modular hardware, the idea was well we’ll take units which are one standard rack wide and, I don’t know, six or eight inches high and software modules, I think 16 slots would fit across that and now my job was to build the processor or memory switching system, the thing that we call the bus couplers. I also designed a cool hardware scheduler for tasks, a thing called the Pseudo Interrupt Device. I think Marty designed a real time clock. One of the ideas in a multiprocessor is how do we ensure that if a processor has nothing better to do, how can we make sure it does the most important thing if when it comes free from whatever it was doing last, so this combination of a clock and an interrupt, like a hardware scheduling device where two of the pieces of hardware that we had. Then we used the standard. The hardware was based on a line of minicomputers from Lockheed. They had a small operation in was it Carson? Anyway, one of the LA industrial suburbs. So we bought their minicomputer line and then we built all of our own special modules to go in with that and it had standard Lockheed CPU and standard Lockheed memory. All the rest of it we got to design the hardware to work the way we want and likewise for the software. We took delivery of their Fortran compiler and their assembler and we ceremonially took them out and threw them in the dumpster and said, “Okay, we’re going to do all this from scratch,” which we did and that was, again it was astonishing how fast that project came together. I mean, at least by modern projects that I work on. I think we had first smoke in six or eight months. I think it was because we had a relatively small team and relatively collegial. You know, people were friends and the hardware guys understood enough about software that they could see what was going on and the software guys were tolerant of the peccadilloes of the hardware guys and so we could evolve the design. We had the software up and running quite well and horrible flaws, at least in my part of the hardware. The memory mapping system. I had to redesign that several times and the cable driver, cable terminations and things had trouble that

had to be dealt with. But we had enough working stuff that the software could run well enough to show the PM [program manager] from ARPA, “Hey, you know, this looks like it’s going to work.”

Weber: The multiprocessing aspect was--

Michel: Well what is multiprocessing? Multiprocessing in that case meant we wanted to be able to have up to say, 16 or 32, some pretty large number of central processing units, CPUs, with no specialization. Each hardware processor could run any strip and any piece of the algorithm. So we chopped up the algorithm into what we called strips, sequences of instructions, about a millisecond. It would run for about a millisecond. And then we hoped that by statistics, there in all if you had 32 of them you’d usually have one coming free in 1,000 over 32, you know, 1 over 32 milliseconds. Every 30 microseconds a processor would come available and so you could count on having very rapid redirection of “What are we doing? What’s the most important thing to do now?” with this symmetrical and uniform design of the processor allocation. Same for the memory. The memory we could have one, two, or four major banks of memory and it was all just general purpose. Any piece of that memory could be used for data or software or code. We had some of the code housed in what we call local memory on what we would now call a cache. Closely associated with a central processor we had 4 or 8K of local memory. So the hot inner loops would run in that local memory and then all the shared data structures and the packet buffers and all that stuff, because you don’t know which interface a packet was going out on, it comes in and you don’t want to put that off, squirrel that off in some specialized location so all the data and global variables were out on the common memory. And that seemed to be a good way to build a system. It did mean that the switch was very complicated. You had to build a switch that in essentially one memory transaction time find what part of the shared memory should this request be directed to and then do the transaction, return the data all in one memory cycle. So that imposed some constraints on the design of that memory-switching system. But it worked pretty well and that design lived on for a long time. It never made a big hit in the ARPANET as it turned out. I forget what upheavals there were but they were either none of them or a few of them installed in the ARPANET. They were used in other networks.

Weber: Like what sort of-- oh, okay. But another network. But also beyond that working, that was used--

Michel: Yeah. I can’t remember too many of the other applications but the idea of having a problem which is inherently sort of multithreaded, evidently the Nuclear Test Ban Treaty was just about ready for signature and we didn’t want to sign. The U.S. wasn’t going to sign unless we had a verification. You know, trust to verify. So that was on the project that I had was to build a version of the Pluribus that could contain the beam-forming element for a big seismic array. I don’t know where the sensors of the array were but the beam former was down in Alexandria, Virginia, and we used the Pluribus in that case because it could spin up a processor on each-- there were each potential-- this may be a detection, let’s look at that. So one would go off and run on that, and well this might be one and so another processor would go off and run there. It was a generally usable machine. The software defeated almost everybody. I never had any trouble how to make code work on the Pluribus because I was a hardware guy and I used to think about what’s happening in the inner loop. We began hiring what was then, what came to become computer science of experts and they thought about stacks and things that were just very unnatural and multiple things happening simultaneously and so some people, I don’t know if they had complete nervous breakdowns but there were some people that found it completely unsatisfactory that their Pluribus software and us hardware guys. I don’t see what the trouble is you know?

Weber: But that seems to plague multiprocessor things in many instances.

Michel: I think it's true to this day. How do you find the multiple threads? What's really independent from what else and then assign that and how do you produce a resource to run the thread and then get it, to run it and then return the answer or whatever. Yeah, that remains, we're getting a new round of that with trying to move algorithms into the graphic processing units, GPUs. [Nvidia has made some of their internals visible now. So it's just like the Pluribus.

Weber: How long did the Pluribus project last?

Michel: Well as I say the design phase was probably two-and-a-half years but then several different government agencies picked it up and deployed hundreds of them all around the world. So that turned from a development research project into a sustaining project that went on for 10 or 15 years.

Weber: But your involvement with it was?

Michel: My involvement lasted up until about 1979. I forget again how this worked out but somehow we and Citibank, Citibank was buying Honeywell mainframes and they wanted to do communications. Honeywell said, "Well go talk to the guys at BBN." One thing led to another. Well that effort didn't go anywhere but we decided to build a-- that was just at the time in the late '70s when national banking was made legal. It was possible for Citibank to have branches in Texas and California. So I had a project to take the Pluribus and install it in these six or eight major mini-hubs that Citibank was building. So that was an entirely different, well I shouldn't say entirely different, it was a very different environment, of a business environment, but the problem was one of tying resources in Houston to the giant brain in New York and letting them share data and information processing, file storage and CPU cycles basically.

Weber: And the whole security requirements that were no big deal after working for military--

Michel: The banks at that time had a different approach. First of all everybody was a vice president. Officers of a corporation don't make mistakes. They do crime. In order to motivate people to be good we'll make them all be officers. Now you could be either a guy who understood the application or who understood the computing system. The people that I associated with were the computer experts. They knew about how many VAX 11/70s we were going to put on the 13th floor down at 111 Wall Street and what those machines were for, my colleagues didn't really understand the details of how the business of letter of credit or whatever were but that security wall between applications and infrastructure was very strong in the bank and it's similar to what the military security is involved with.

Weber: So what did you do after that?

Michel: Well I then took the network technology to Italy. We had had a small consulting contract with Olivetti and in 1980 became clear, well we let that BBN set up a small engineering office near Milan outside Torino actually in Ivrea. So I went over there to set up a small engineering office. We took my wife and we threw all of our possessions into a huge plywood box and took our eight-month-old son and put him onto the airplane seat and moved to Italy. My job there was to establish a small group within the Olivetti communications, the part of Olivetti that ran the check-clearing and bankbook printing and a bunch of things that were all part and parcel of their bank support business. So that was post-Pluribus but by this time the basic IMP program, it was still the ARPANET IMP program and all the subroutines had the same names basically but we had ported that basic Honeywell architecture onto a machine of

BBN's design that we called the Multiprocessor Building Block or something like Multi-programmable Building Block, the MBB processor. So here we had a BBN piece of hardware that could run the Honeywell order code which oddly enough wasn't copyrighted or patented or anything and who would steal your order code? Well we found we could run that instruction set much more efficiently and so we used that family of ARPANET software in building banking networks all around Europe. So I did that through late 1980 until '82 and at that point our son was becoming Italian. Also my wife had promised her work she would come back some day. I would've been happy to stay there. Italy is better than Disneyland. It's a great place. But we wanted our kid to be an American and my wife to not lose her job so we came back in '82.

Weber: What's her job? What does she do?

Michel: She's a professor at Mass General in the Institute for Health Professions.

Weber: My wife actually comes from the Valle d'Aosta--

Michel: Oh, okay.

Weber: --which is just about 40 minutes--

Michel: Well more the fool is she. That's the best place anywhere. That's where we lived. It was at the mouth of the Valle d'Aosta where it opens out into the Po Valley.

Weber: Yeah, she's from the town of Aosta.

Michel: Okay. Well that's a beautiful area and the town of Aosta is quite charming.

Weber: Yeah, it's great, and Olivetti was active in those years.

Michel: Yeah. Italians are really smart engineers. You could just go out on the street and hire, you know, the secretaries all knew how to do assembly welding.
They were technical people out there. So that was the culture in which Olivetti had grown and flourished. I don't think he was very translatable to silicon but when it was a steel era they had a wonderful sound and we enjoyed it.

Weber: So you enjoyed working with the Italians.

Michel: Oh I did. Yeah. The <inaudible> I don't know what Romans are like or Calabrians but I know that these northerners, Longobards and Savoyards are sharp cookies and we had a great time.

Weber: But the banks that were connected around Europe, what were they using to communicate with each other?

Michel: The banks didn't communicate with each other. Don't be silly.

Weber: No, this was for internal.

Michel: Each bank--

Weber: I don't mean with each other but with the <inaudible>

Michel: Yeah each bank had its own private network. It had its own private custom design business procedure. Again I didn't learn much about the business process but at least the Olivetti business was very much built around all these electromechanical devices, things that could flip checks over and turn pages and do all that kind of stuff. So there were sensors that had to make sure the checks were right and read the checks in, read the data off, send it down to Milan, send how much money back out. So all of these specialized hardware-software interfaces were tied together over the network and again there was a substantial, you know, this was the '80s, there were substantial computer centers and things like that but not much interoperation between the Banca Commerciale and Banco del Lavoro or what have you.

Weber: What sort of networking was involved?

Michel: Well the protocol suite was based on X25. That was sort of a product of the late 1970s and it's not great but it's a functioning, you know, very usable interface for tying a computer into a packet switch. So we took our ARPANET IMP and preserved all of the internal datagram-based packet-switching system and then built a simple piece of hardware that could do the serial link protocol and then basically a software process that could appear to be an X25 switch on the outside. But it was just through ARPANET. ARPANET protocols inside and that was a heady advantage of being very scalable. Our systems could be built pretty simply in quite large size and easily adapt to different-- to crummy, noisy lines, low-speed lines for a variety of reasons, some of the other commercial X25 switches were much more critical and not very adaptable. Ours was flexible. So we built networks in South Africa and Israel and all over Italy. I had a lot of fun on that project.

Weber: So IMPs really went everywhere and they were running <inaudible>--

Michel: It was the ARPANET IMP. Nobody realized that the Japan Airlines reservation system was running over the ARPANET IMP protocols but it was.

Weber: That I haven't heard.

Michel: Yeah. Well, I'm telling you, all of the young engineers that you see here were not born at the time that all these subroutines were named and the subroutines are still working. They're still in there. Well most of the ARPANET, most vestiges of the ARPANET software are now gone but they lasted a long time under these very guises.

Weber: We've got a few more minutes. What are the high points between then and now?

Michel: Well remember I said I had worked in radio stations and had been a radio ham and so I had all along been hoping to somehow get-- can't we use this kind of packet-switching over radio channels so

that I can have a packet-switch on the bus and read my mail as I drive down Concord Avenue? That idea sort of came up very early in the '70s. We haven't got it going yet but we're getting close. We've had a couple of projects which are sort of derivative of those early packet radio experiments. It's a whole different set of speeches that no doubt you'll look into.

Weber: No, I've interviewed a lot of people about that.

Michel: Well I and the people that I've worked with were for many years on the outside of that. DARPA was very interested, I guess ARPA and then later DARPA put a lot of energy into researching that area and us guys in the part of the packet-switching world that I was involved with were not tightly coupled to that but in recent years we have gotten several big contracts to develop what we call mobile networking software where a lot of these same ideas of automatic topology, discovery neighbor management, finding who's nearby and who can I hear and who can I send traffic to and how do I avoid sending too much to an overloaded part of the network, all of that kind of stuff, and a lot of the original ideas that we developed in the ARPANET have been brought to bear on that, in particular some of the ideas about managing this. How can I know where the hotspots are and where the trouble spots are in a network where the nodes are moving around and the leaks are not very reliable? So some of those early things that we developed in thinking about ARPANET algorithms have continued to be useful even in current stuff that we're doing now on super high-speed gigabit radio links, joining IP routers and things like that.

Weber: In the '90s, what were you doing <inaudible>

Michel: Well one of my not very successful crusades at BBN has been to try to recycle the military research into commercial business. The '90s were a period, a very retrograde period. We got several large, very influential, at least within our world they were big contracts for us that developed tactical military radio and tactical network systems. So I was drawn into that. I'm interested in working with the users and that set of people had a lot of interesting problems. So the ARPANET technology comes to real production military systems was one of the threads of the '90s and going into 2000. After 1999 it became clear oh, this stuff isn't researched, this really can sort of work. Maybe the way we've tried so far isn't optimum but this is good enough for what we're trying to do and so the hardening, you could think of the '90s as being ARPANET technology makes its first few tottering steps and 2000 and beyond it's hardened and built into real production systems for operational use and that seems to be what's happening.

Weber: And after you came back from Italy in the '80s, what were you working on?

Michel: Well that was the time that you and I talked about earlier where it became clear that the ARPANET technology could be used for both government and military government application. So as soon as I stepped off the boat, well I must've been in an airplane, but as soon as I arrived back from Italy I started working on the so-called Defense Data Network, and that was the job of taking ARPANET IMPs and installing them on military sites and just throw them down anywhere, let's see if the logistics guys can learn about networks. Let's see if the weather guys could do their job better. Trying to bring the technology into different user communities and then that quickly shook down and the weather guys turned out, oh they could really use networking, it really helped them a lot and likewise the logistics, shipping palettes from Bremerhaven to New Jersey [Tony meant "from New Jersey to Bremerhaven" as in reinforcing NATO in Europe – Reforger]. I guess that you'd go the other way, but anyway so now the problem is okay, we can see how this can be used operationally, we don't want all of our packets going

through UCLA's computer room. That's not how we want, so that was where the motivation came for splitting the military version of the technology away from the research and the ARPANET and the MILNET men had to be divided. That project took a lot of the '80s, and at the same time as the ARPANET was hiving-off the MILNET, so was Citibank and Japan Airlines and all those people building commercial versions of all this. So it's kind of hot, making the technology, getting the technology out of the lab and into the real world.

Weber: Up by the '80s you're starting also to get Cisco and other people producing--

Michel: Well Cisco came along with a much-simplified protocol stack. One of our claims was well our stuff is real efficient and it handles congestion, and Cisco said well <inaudible> T1 rates for half your price and they were right and we were wrong. Keep it simple, stupid.

Weber: We're almost out of this tape. Anything else you would like to--

Michel: I've enjoyed it. I've enjoyed working on this project. Thank you, <inaudible>.

Weber: No thank you very much. It's really interesting.

Michel: Good. Glad to help.

END OF THE INTERVIEW

