Robert Elliott Kahn
Oral History
Interviewer: Leonard Kleinrock
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Bob, it's a pleasure to have you we're talking with you meant for their hair to listen. Thank you know what I want to do I want to go over your. Activity at MIT and be an auto industry all this is not so much in the great work you did which you were so much for rent on the environment that allow you to fill with that in mind what will hit the particular activities as well. But that's the information the the conduct of the look. Through one of the can with a very short introduction to your own and our car.
I was born in New York in 1938. Went to school in that area. My dad was a principle at one of the high schools in New York City. My mom was a home maker who had some health problems of the Engage them. We were mainly conscious of it all and growing up in the heart to heart condition. She lived a long life. Both my parents are now passed away. But we h fun then read some of them have a sister. Diana who lives in Clinton though I am. Material backgrounds his two kids both of whom are piste mathematician. As well. One of I guess. No actually one for her son is a P.C. Nathman fissions married. Another teaching US citizen or the daughter. The daughter is a Ph D. in wildlife and physics. And all ask at the moment.
I started my career out after graduating from City College, which you know well having gone there yourself, in January 1950, and I went to the laboratories were there for. Sue months before I was notified that they went to and I said fellowship. And so I took that those had finished the summer work at Bell Labs and went to Princeton University where I got a master's and Ph D. degrees and electrical engineering. Those were the days when they didn't have computer science programs here. To the extent that there was work in computational studies or computers it was all part of the lead for me lately. Became. Many in the Kindle E.C.S. departments sunspot institutions. But that's what it was at the time at work here the age the work. P.C. I got was under actually two advisors one of whom was John Thomas had a number of other well known P.C. students. Probably now. And the Germany be losing joint partly through the now. And he has a birthday. So he's retiring from Princeton release. America's now. But your job when John retirees. He had all of his Ph D. students Helen and. You know attend. Ceremonies. And the intricacies one hand and got to me said you know Bob probably didn't realize it but he's the only Ph D. C. in a rather reluctantly teeth. And I'm thinking How come I don't notice. And I asked him and he sort of explained part of it and they are a fact and leader about it but he said what what what I was working with drawn on problems in modulation. And I was working on how the marginally amplitude and angle of the signal. Solace to minimize bandwidth that is that he started working on. And I solve the problem turns out that the reasonableness is the solution to that is essentially the solution to Schrodinger's way the equation quantum mechanics. An interesting. And a really. A sion to something I never thought would come into play that the early faction principals and both. Electrons are then only been Ph D. program for the four months of the time. He said and hand spends an offense that he resigned at that point towards the lead even though the work that they and then I thought was sufficient to the degree. First spent the next year and a half working with D.D. on a separate set of problem solving the same family and sampling theory basically. We had some very interesting results on multi-channel sampling mean everybody knew what. Shannon's and Niklaus samplings all about that time. But very few people knew were there all of the possible ways to the standard by Kitty. Samples a single with lots of different samplers. Could you. In sacked sample at a much lower rate student perfect reconstruction or with a relationship and that the bandlimited persist not that we showed the essentially Wilson very weak. Conditions. Namely that in a B. When you get ten sun all adults hit. He could take Finn will put it through a lot of differently or filters. Sample mall at one and the rate at hand in samples you can still put it all back together again perfectly match a little bit like. If you know the counties and they're they're related to not exactly the same thing. And some issues about what happened full time job or things. And interlinked. It was a very interesting. Sound so they were actually two parts of the thesis and it was a kind of part of John house and probably be the stable together so I didn't realize that when I got the an honorary degree from Princeton years

later. You know I thought they were in the safest and thinking in monetary degrees to their own graduates and Harold. Carroll's present. And you know. I said to them I thought they made him say he was from forgotten that way. And a real P.H.D.. And now they decided they were going to do it but it was for it. As I later learned from the trustees who needed. Visions for that the social aspects and into that is because I didn't see the in a somewhat. As an engineering contribution as a social question. And that's what Prince intended to hire people in the civil rights movement scientists people who are more cultural revolution into nearing. So I figured at that point five. Was only right at the in the second degree since they've written to these so. He then painted on to see where both the soldier T. ball and I gradually lives I originally thought I might like to go a little school. Home. But after kind of scene was out there and I realize that the smaller schools and then not sporting that the full release. So I ended up sending applications in for the other places and MIT basically really nice letter thing you know. For thank you very much but it's sort of lean and we've already made our selection so the coming year because this was sort of like a month or two asteroids originally started looking. But then by many come up anyway and it was Peter Elias and chair of the foreman. And I guess. The interviews that they went to personally well with the said well we've found a conception in case and Celine lend me to join the faculty and they went up there and started in September nine hundred fifty four. So what was in nature to work you do. Well I started out just finishing up some of the loose sense from the work at Princeton papers on you know sampling with pine dealer and things like that Alpha started in some work on. Rita sort of theory which is. Or. That's an information theory actually. And it's something one can actually work on and some limited context. But most of the problems in rates or simply can't be too hard any people understood that he sent his data below a certain rate that you can get into a channel of polling and the understood that if you took sources. And you coded them in a certain rate that you can reproduce the source and exactly. Question then was Well what happens is you try to send a two channel at a higher rate than channel could handle or you try to code the source. Who left a myth in your lead in so I was able to look at some of those problems and came up with some interesting. Not closed form solution split. Recursive count computations that will play he figured out how to evaluate the store sions or rates. When you want to put constraints on per letters that we see set like it if you only worry about average and source and this is what China chancellery that it didn't say anything that how that proliferates sources play it was an average of all the buttons you sending So we sent this one might have this theory of this one that there are eight. With distortion. But if you want to live constrain with the twenty leaders and can't do more than this and from Canton with an app and do them with the problem was solved and I think it's still a very relevant paper in it's one of the few that there are been written on the subject. That's one of those really. MIT on their source teaching. Course. So wouldn't do it you to be the boy. While I went there in the wind. Is it is that still camera or late September early October of one nine hundred sixty six and three. Since from going were rather important in my life. Because of the group in life. And in my teens being run by it all he probably nowhere near Jack was in craft. Who wrote a very famous textbook with proven Jacobs called Principles of communications or something like that and. Jack's door was always open and and. We had a very small back of the there but very very competent subtlety in these little world experts. So our culture and I was on the faculty. Was or was to Ackerman Jacobson's on the phone. All the areas entries by Gallagher. Only a few million people. And I was probably the longest. And Jack will often tell me I was probably the most mathematically train which was a compliment but he didn't mean it quickly it sounded because mathematical capability wasn't all that they were looking for. But they were absolutely King forward people who can make a difference in the world. But also their model of looming on the faculty a Mr accomplishment. And in Ireland going to Jack's office. Whenever the spirit moves me. And it was there. And I would say a four out of five times he is this working honest a prince. And he listened to me and case in the look up and found it. And one every five ten to get to the board and we'll be going at it seriously. Solving equations. Back and forth. And one day I just happened to ask him out of curiosity where anything else you know. Why hasn't it sometimes he gets animated and really engage in other times it includes like he's not interested in a least he said that his eyes interested but you know he can't really engage in the stands what to do with solution to the problem. So the polls are really interesting problem. And. What folks have to tell you any answer right now what would you do with it. If the answer is I put it in my drawer and go on to

the next problem is nothing in the interest. And I said Block. How do you know. And he has a solution from how do you know whether you can do anything with it. It's an experience in this sense and he said you know. Make a gratuitous harm if I reveal what I would do is take here. Possibly to Gold trying to sell. Somebody who knows how to make things happen. And then point that he says. You'll be there for it will be better for all. I thought of the ground fine I said low bass who would you recommend. And again Elan three names. One of them once Paul Rosen and Lincoln lamp. Rendition six the conclusion to listen. Actually Paul had been a sin the mine and one of my information theory classes. It's an important well. A second was. Jordan barouche who'll be in and join who's basically one of the founders and. He could've been a named founder. Because he was one of the angel guys. He didn't use instrumental in that company. And third unless somebody in the Philadelphia area. I don't really name to that in the down there was a company like General. Try next or something like this they worked on radar. To the some personally high regard for over there so anyway. It turned out before I got a chance to really explore. Lincoln or B.D.N.F. alone wanted to stay in Austin area. Both of them were up there. Finney and he put a freeze on hiring that here. So the link enough ssion basically off the table so it's pretty clear that subs and follow up on your suggestions. Williamson but in the end so that was the reason I went there but I did go talk to Jordan and. I was very impressed but. In one of these tassel mindset was to fill the room over everything there you know in anyone's sealed in there are always a set of people who are just very fluid. Intellectually. He can discuss any subject in a free wheeling and written for in Jordan was one of those people. And so I agree to go to meeting and member thinking this summer I think I worked it. Maybe NASA if you bring that in Greenbelt Maryland of the summer and Sentinel and St Pete. Happy. The stuff started earlier one year. Simon is going and that was my thought there but it turned out before I got there. Jordan had left to form a company with G.E. called Ned unethical it was providing one of the early timesharing companies to provide timesharing services to the actual hospital. So the suggestion was like go out there I go to work for a phone interview tell kind of another well known name a single cell and that are agreeing to do that and I became centrally with people in series for Jerry sensually came to render that hand the B.B.N. and sign. And the other half was run by Leo Baranik. So Leo ran the physics in acoustics and the line I.T. part and Jerry ran everything. So thin it was like he computers and networks ended up in his part of division as well as work on experimental psychology so he has some really good. Experimental psychologists he feels and from the various It's very little for police. What are we supposed to do to be. The ANY free range of smart country from. You know MIT. You know. Pick some interesting things to work done and my goal was to get some. Practical experience. Do something to make a difference I started or for networking. Why we were they were going to know who was nobody is safe then know that for time communications those the first one they hired at the thing in dilute communications and you know why mention did they said it can't that sounds OK And so I started to work on networking and curious. What drew you to that area source in onse was pure internal. When it was just. I thought it was an interesting subject. That was making you know I started my career at Bell Labs so communications was sort of in my blood. I had been at MIT teaching and was centrally communications information theory. Group. Knew that systems. And I thought that was a natural extension of what I was really into a world that didn't involve computers. One of these computers talk to each other and what I was thinking I was totally unaware that time of any of the other stuff has been going on and in the dark but in the Larry Roberts. I probably knew your name from cooler Republic A I read publications and you were quite a Pulitzer writer. But I didn't know that this Lucille that we're going to amount to anything I just thought it was really interesting. And that's why they chose to Murtha. And in fact they dare. I wanted to be in an angle of writing something all I have to those and to a dozen different reports on various aspects of networking both for control error control flow control. Congestion route and all the things that you now know are associated with working that the features need work and all my own to find you know an elderly only on the soup. Jury all kindly not supervising a that Jerry never really got involved was people under him there and he had some pretty. On capable people and if you remember D.M. borrowed in winter in birds. Subtle and later came in from Lincoln ber performance through Markowitz and to me Jerry. Managed and addition. And he was a very helpful mentor. And Jerry was basic difference trying to understand what it was humiliating and trying to be a helpful advice or hint that he needed no more than I did about the area. Because at first

started to write these documents. One day. Came to me and he said you know there's a guy at DARPA the one really interested in this things Larry Roberts who we find anyone to spoke to were visibly coming this way media network they sign to project codes to work on. Unless you were bringing in the money yourself in which case you knew was in a sense was some project out of the project code he gave me was for a think that I'm not positive that this but I think it was the first darker contract they never got. And it was called something like natural language communication with computers and A believes that. Danny Barbara little thirty nine. So they were developing some of the media analyst stuff under the air and really doing speech and or standing work. And a lot of people there were more a Irish than. They also had procured an S.D.S. nine forty computer which is one of the early. Timesharing machines. Along with a copy of Genie operating system that Berkeley and can perform like them. And that's what we're saying and it had some natural imitation. So one of the things that they did under their contract than remember the exact timing was that he started it early on or. The second. Revival of that because it was extended a number of times. Was a funding to develop an operating system on the deck. P P ten which came out and sixty seven sixty eight sometime around there. And so there was would be content X. operations of to that was all done in that same group and I think under that same effect. So the idea of working and networking was kind of a natural for that. I think when I started this is very same kind of that contract because I think I can defend why that work will be relevant to the term. Touch. I just didn't know what to tell you didn't did your you know. Point it although they do some will go. Well. I didn't know all their lives. But Jerry. I think. Apparently there. And one day he said what he think he reports and send them to this fellow. And then with Larry Roberts. He's never met Larry. So I faxed him up. Put him in a folder and shipped it to Larry hands and I saw you know that homes that the interior pens the might be interested in some work I've been doing here and some reports and there weren't any and all of that packets and I had night. Them and my head was in the safe and later learn to deal with them ever underway at our villa. Maybe build a network which. In later. Bill color of the net. And I know you were a family. You're involved in the number of the people. I just didn't know that that that sense and then also Larry. In any issues for us and get the answer. So I get a call that X. maybe two weeks later. From Bob Taylor. Nothing Larry. You know it's a simple area comes back from. Taylor who found all very interesting income they had those and he was rather it was a courteous call. But it was short call and he's facing. Lee says things like someone else that's a timeless which I did and that's where I learned the target of actually thinking of actually building a network. OK. That was interesting. It had not gone on a need that I ever be involved in building a real network at that time. Because I thought. Some kind of problems I had been working on my work in graduate school and MIT were all theoretical here with us some this tool house and the end was not theoretical. It was. This is how you actually build a network. And he's the real problems eating her silence get my fingers dirty as us. Turns out and I quite literally have it in the killing as it were so we had a nice chat or that was the last I heard of that I didn't think they'd be a follow up to that except later on this are few shows up in his mail to Joe Markowitz T.N.T. And so when they found it and drill. Instantly comes and brings it to me. And I'm with him to announce an ace. From this really going to do something for me it wasn't. All my stuff. The Lima stuff was in there. Like if you look at the figures like their control figure was right on there now. It took it puts it tasted in the are fake. A lot of the discussion there was based on those memos. But there's one more to listen that. This is a classic DARPA thing in one. Proposals on thinking this is early sixty eight. Since when did some time in summer. I guess that the only thing that happens during a Terry is when I started working on networking and got really interested in some of the problems that I thought would occur for example. The whole area. Deadlocks congestion. Something I was really worried and didn't look into that so little working and being in the time for class programming warrant title no more influence on the ng very involved in the line of the most boring. On the river. And so War I got here and decided that together we need more of the special pirate him as a coder. He would write a simulation ten list to enable me to explore the ideas and computer networking and full. What I wanted was in slavery. I want to be able seen things on the screen for the new print out a day later you get some parts of printing out member weeks. Pressuring was not widespread yet this at this stage during a very unusual situation here. And none of the list. Stuff was display rant at that point. And in the operating system for the line really to run this place isn't the median and build from the whole of a pain to their preamp

on because it was the ten X. a symbol of confusion I think was on the Couldn't be on the Berkeley I can't remember which ones. But enable the entity with real time in generating pages for display and Warren built the display. Complement to be realists and to allow things to be displayed so we actually have graphic displays realtime graphic display saloons also simulation feel worse. TACKETT slowly through the network and you could program things you know we have AK at No seven do the following sequence. You know. Actually program real rallying capability to now over the Dillon and I was using that to the purpose of the exploring the different doesn't work situations that we get into and build out of. Take CONSIDERED from running you know. Our reason for living to whatever it is what we were struggling with. So this or Q. is in house or accusing us sooner or later the simulation Bergen's in house. So what was your in involvement with the sponsor the OR ask you to do to David uniforms all your colleagues will. I was actually not imagining that I would get involved with the this Arpanet project because I was not on A and involved with tons of the see much. Getting your hands dirty if I thought. But here I am and more and I are figuring out the simulation program at that time. And so interesting. Have narrowed a really interesting book called there was a stamp wait she got the whole part of the simulation all wrong in the first version. And I pointed out that are the net effect of which she could verify whether I was right or not so she just to get out of the reality once she thought the simulation program had been written an asteroid going out to U.C.L.A. in the first helping of the Arpanet found these deadlocks. And then came back and wanted to explore it. And Frank was supposed to doing the simulation to see a real men fight usually season that when sadness in relation program had been written before we even had the contract was started to build the Ark of the finding of the can really wrong. So I had been working with Warren on that charge in my time to this contract environment. And for the in fact that people we roll on the snap a simulated simulation programs that actually published in a pink skin conference on. Systems in one hundred fifty nine. Was a formal. Since proceedings. Was probably some in the year before I think. Policemen in the late sixty's or something. But here I am holding this. Aren't you and I was in play doing England. Frankly when this. Dull solar system my office when you're met before either he said and C.N.N. are killed. From DARPA friendly serial kind told you that was all there was Frank heart. Frank also worked for Jerry so frank and I in some sense were peril. Billboards and sent us to our to the salon praying hard and I came over here from Lincoln. You know. Real interest in this Kerry told me you had it so I can say they have got a copy of the given copy of The Phantom you company can't point and. Frank basically on the spot said you know. And like you to tell me Lou want to vote on this. I think he said it's silent scene but I need one of those put it. So that's a funny agri no help to help direct a Volvo because I had already been writing stuff into this. Lessening the already a proposal that's on the net. So I actually wrote the technical part of their proposal. We had the parts of it I didn't know how to write. So for example. There will be parts of the proposal which were description of how we build the hardware. What the interface is a little way to solve and so their awards style. That work for Frank would also come over from Lincoln. Though I would sit down with a very nice and this is how you face us to work. And I describe an evolution he translated for plots and wiring designs and I homo's got it kind of a real time programming. Hardware design course. Right on the spot from the moment and still. OK for the next night and now I can see a ring of hardware so when I would think about the interface I would be thinking. There we put a lot of this. Me at that little details. And the rest of their was all a lot of folks who had to deal with the dealing with Honeywell the output the sheen. It's all in Holly rising that. Handle that interaction for Frank. So they are number of people involved in space and description of how the system isn't working I wrote mainly a little help from team all in on you know what kind of software support you need he wrote those sections for the things that's what it wasn't published being in reports only two hundred fifty three I think also some of the sixty three was a technical portal to pull in the door. In essence. So that people who win on the deadline was the sometime in late one nine hundred fifty eight to Dollywood by DARPA. And we heard back sometime in late sixty eight where conceivably even beginnings of the night that. Begin in war time tracking dogs and holy smokes. That's really neat and threw it into the starting of early early Fifty nine hundred thirty three something like that so that the sister Szell started in heaven nine months a little read a fringe number one. To this little school in Los Angeles police Elaine's. So that's that was the start of it all and the thing it happened at that point there was really interesting was once a contract had been else. Jerry said

to me. He got stuck turning to this account number. You know any thirty church. The letter the recount. So you know when Betty. In the group. Respectively with Frank Horace Nash and so talk about how the team was for that eventually. In the Cage. What the management style. You were experienced in a true. Indian and be given out about government is not about being married. So and was always with Frank considered P.R.I. this point. I think Frank was on there was no V.I. He wasn't T.I. that blows. Largely a management role in the Frank. I don't know how deep Frank him regarding into the details of the technology. Very distended in the conclusions. Something would happen to fall in the next. Sushi's he was this guy. And he trusted. Really only a handful of people in this group to Europe this year and also the hardware frankly taken in the last fold it Bill Crowther who he later hired from Lincoln Labs to some over and take charge of the software poured the wall in the for keeping Bill Crowther had Will been working with Frank we think we did we can. I can't say for sure but I think I was the case. I mean these were people he knew very well since his paper is painfully told the crowd were told something about software that's what Frank would believe in a vital and some of the ego we have C.N.N.'s And so I had no credibility with him as an authority. I was just C.E.O.'s more mathematicians and then my face. So this is the issue. How much he believed this possible your story. Work to be done to people below him. And how much he held back in decision. Frank actually made only a handful of solutions in my. One of the things he kept to himself was all the interactions with Doris. He essentially told everybody in the group. I want to have any conversations or bonuses always on those that was around. Which work for everybody the grief that medievals. Larry Roberts will call me tonight. Every day at least every week. Some time for her owner and he often had the strange. Conversation to go remember Olsen details and actually what it was but you know Larry. Call me to kind of toss an idea and forth when you think that there is in this and sweet. We figure out something still in the face something like OK Thanks very much and huge number sales of India. But Larry but all these take your input and figure out what to do. It's such a loser place we will be talked into any call it involves the movie any call Frankenthal. Frankly one of the little to lag recipient fees. Larry thanks to them in the program manager and Larry was a very effective program manager knew one of the reasons that I've always been very careful never to say anything new that Larry. Sequence. I I always believed Larry Flynt done this if he stayed Lincoln they had another P. and C. sort of. You know he he gave up his practicing career. To make this all happen. And I think their morals and did everybody else. And I appreciate your neighbor this. So you know you know I was hands on a lot of the stuff myself I realize Larry could have done that if he had been in fifteen times. But I can learn a little Larry. That can see there and so on it helps and from from others as well so. Larry within call for instances when I want to happen and frankly call a meeting. We went in by me. And then the scuffs. What to do there that and then later that same what they have cited in the bring to the station so I was not one of the insights. In that group. So maybe you can dance. Within the group that he didn't work closely with or he passed on that generalized task. Here is into sight how to accomplish it. Or was it tightly controlled. It was like Starbucks. You know Company times have I got Have I seen in writing. You know where the secretary of defense told our clinical still the organs. You know you're always on like that dark you'll figure out what is the infant was kneeling at the director's lessons often. You know this program managers where the researchers who told are the once it is all what they think they should do that somehow we turned into a program to get offended up. Fundings the same things. Was True their way. Happened in that group was mainly driven by three people whose. I was in myself. Sir when Dr Other need because I was sort of work a technique thing. Compacts playing on the gene and. Frank. I think in the end brothers would have had Bill and Verity architecting but I was actually doing. But you know what would happen in the fossil was really up to deal with him or he did. And frankly descended never happen hardwoods it's a very good friend who defended. And he had a few things that he took on and fun. For insults. You know like everything in a Sunday. He controls everything there. He called management social who was going to be allowed to do what he can kill so many to his credit he needed the freedom to worry not all the architect insults. He was not really involved in any of the technical solutions and then we can we try to get into them on his own. He often had to consult with the girl and bill for forty didn't solve the content in those details alone of finally one example understand what issue. I was pushing very hard. When writing the proposal to slaying that issue and to put me in some way. Innocence until Frank Frank rejected a completely instructed not to go in even

some day written on. There's like a Texan prison which a written. Wouldn't go in and doesn't go in because he says to his are in the support package a late oxygen molecules in the air since we don't need a separate system. Just to make sure all the US can models onshore the next corner room for thinking not going to happen now will says that was as we'll. So he took certain positions like that if you recall when out there Walden Island L.C.C. lay some time in late one nine hundred fifty nine after the first impulse. We have small network. And the first set of tests that we did after just checking the Sigma seventy in connection sniffly work was to make sure that from the sun is where their lives were either true or false and something like that up in the first war packets. Remember going there. You know Frank was told that he has been living sponsible until Bill Prather way through the simulation Now you sit and wait on him for a while that three months later he did a simulation. Clue that. He said like vastly that happened and I remember important in his office wondering you know how come you didn't know that that and well. We discover that some new Massy those in the in the police. Anyway. Nice to see still reading the whole architecture. System to deal done. Life's not everything but the point that tells you that some need to rewrite the laws of told once it's in the field in order to kill them once that happened I ended up going back to what I had hoped to be doing for is one of the part of the story also a witches when I was talking Franken writing a full full and still the. The N.P.T. and structured in different buildings. And there was a building. Addition for which owns this house. Most of the good Cheerio can render rectally. He ran multiple groups and you're in one of those groups of cells. Frank's groups another building. Lives in the building with it for all of his framed print edition. And so when. When Jerry told me of the star chart into the other code the way B.T.N. were handing it Frank's to Mission pieces he was the one. Controlled funding on it if I was going to be allowed to charge he had it agree that he would agree with us and over his building in one me right there in the group. For whatever reason and. So the culture of be in and was such that people didn't make those kind of moves from here today or. Nobody read this years and still. But I picked myself up one day insists moved over he says is that from your office. So I picked up everything went into the office. And that's where say for the whole Terry time that we read in the argument. Until one day. Have to be an airy thing wrapped up in a certain Now I thought we were going to work with fixed all the problems we had done all the development. And that I guess the biggest problem I had when I was there was writing. Susan documents holding the inner forty eight hundred twenty two schools in space station see their connection a post in which I wrote an ironic. Basically all I myself. Which trolls. Some The other guys not Bill Crowther interesting too and was really unhappy. He was not involved in such a fine what then is it look like. But now. He was the. Asked to implement things too busy doing everything else they have signed into and needed him till he kills a gentleman here proving Mike we feel who didn't only innovate he needed that argument. So we need to get it out couldn't wait another two or three months until they figure out. So we just send it out. And so that's what Bill Bennett That was my. That was my way is influencing what when what happened in the architecture of those two mechanisms for some simple while it was a very tense situation I was not part of the inner poor but I was probably falls going on and I had a better chance in order than Frank saw how much interaction was in the Besides involving con interaction with you know much interaction. I think we are the only one I know well Lou was teaching needing to target we call people and so I can't say I know every single phone call Frank. And Larry had together. And don't think they talked earlier next LARRY night probably talked a week in minimum three maybe next five or six times as much as they did and I never instigated a single call. Thing and I was instructed not to be all came from Larry. You know the thing. Namely the naming were very private called Frank Olson and I recall the flaky post or think you privately. Nobody else in the frame. Wanted to go down at the end of issue with any force contractor. Interaction. Clearly feeling would have told them were there all the groups were you aware of outside the DOING IT occasion but a contract is floating point is. I was instructed to be the only one. You know contact anybody outside. Except maybe Frank. Although I think he did have Scully right into the Indian feast Honeywell so that it was space. Nice and early Basically I had the task of reacting in responding to near the scene with no second in writing that. For forty eight hundred twenty two was part of that responsibility. I had all the interaction pulling T.N.T.. Phone lines and clear how they work. You know remember all the time was trying to negotiating isn't built real for most incident. To learning to use a built real tree moments which a little trivial or

Cecil can learn in the seat of the killer lives a second. They actually have a three or four mono until evidence. You know perfectly capable of being used and ran a hundred eight killed in seconds. These are on the the forty killed her it's group channels so running it to bits for hers was no problem for mold in those days. But they chose not to release them from Haiti or the less. The cause of the. One is still more group chance on using more efficiently. So you never feel good that I had all the meetings they were ninety five Broadway with eighteen T.. Trying to sort of sort out some of these issues I wonder all the detail specs. Community Hills banks this and you don't need to know the history of three months really proof. News this is this interface. You need to even know the other interface. I was on that managed to convince. Larry to buy me up to kill the line between the P.N. and U.C.L.A.. And I ran for probably weeks if not months. Tests on that line. Only put a special program. On these Elaine. Machines for this in that part of the network. Thing measuring packet. And I still know all the statistics it's fascinating since it's turned out this you know. On a long line life time of day. Variations and I knew almost no errors during the day. The way up until now has purposely calibrated so wanted to be sure of that the air control mechanisms in the Clinton Place can work with his firm which Turner. And then we ran the same and the same programs. After we had the first three No didn't work and put the same program at U.C.L.A.'s are in Santa Barbara. Which was the first three known to the ARPANET this. And I was measuring time delays and the like will it turned out that the time delay between them in the whales connected. Santa Barbara and Sri were connected. Soon were recently. Connected the two later I were connected at the time the way between the sea lay in sri three milliseconds. The time delay between U.C.L.A. and Santa Barbara was one and a half Melissa. But interestingly the time delay between. Santa Barbara and so I lose four and a half. Literally some of this in this. Which was what got me to conclude body around me in them to their language to back in the family. Measuring the form of the lines. So you know we stand there like a then surely measurements like morning and went into this the scene U.C.L.A.. Or so many years. Because he never went out into the care unit. Something others. Pino answer. One of the morning before six in the morning. And no arisen or hear the barman put here to so we go there is no there isn't all that during the day. To your silly. We doing all this well this is interesting to me to question your experience in my teen communication to calling every control to suggest that you from behind a large part of siding with Harry controls everything to action scheme was on the architecture for you to want to put in the old territory. It was taken coding beseeched only one of those four been D.C.'s feelings in the name also the sense of something I put in knoll. It was mandated by Norman you must do this for the only entity following through you find that since and then with and then second question. Given the added to the thumbs down to single packet switching. He were never going to eighteen nineteen to say cease give us this use your technology to help. Through the network which may be competitive. You sense any political issues or an I.E.D. shoes. Will you know Larry having some of those sessions two thirds pushing you also should ask him that I won't actually question. Someone didn't wasn't so much. A teen team and comes down and turns in this is only an idea. I think it was more. This is just a timely for them. That is you look at the world their own theory nine hundred seventy two three four stars. I'm sorry. In the fourth. Sixty six sixty seven sixty eight their whole fine print. Time sharing was non out there and being way. The number of companies that have time sure sometimes even by the early seventy's probably less than a hundred and believe the proper through the proper rendering. What the is was the same working with some science and certain subject in the. We're doing enough we can just jump in and get in there is no reason to spend the time in initiative or them from whatever and then we feeling so they basically said listen the happiness of a gentle I think you money in you know thing that happens. You know. Eighty eighty actually filed for the first time packet switching to planning to maintain the six or seven. You know when that happened they also filed for the personal attack and speech. Which is all after the work he and Jane Leeves on each speech therapy also to tackle and. Their argument is all those who choose to dance of. Some want to be somebody else can dictate to us what we can do in the future so they're actually proceedings and they didn't really get into the tank then look into this. Until the least seventy's when they decide to jump in the times. For the program called the C.S. the truth in communications of them. And they put thousands of people in this one of their places. The one the only thing where you were eventually fails to company so we build the ark in their lives. You know handful of people. They thought but plenty of two thousand the much

many jobs in this project. The story goes. You're right he was wrong product time heavyweight worn out. Occasions will. For free. So they don't think the fear calling that A.T.T. I think it's fair to say that since serious people here. Probably understandable the ruling and the scientists and one business opportunity and gracefully. I think any of this until Nov don't darken or who are to gracefully to phone to get involved with what they saw in the sense alone and not be involved in what they funded provided the innocent. They go through with your brain right there was plenty way traffic has been dangerous. So when the opportunity something was a business opportunity. You know Larry actually tried to pretty hard to privatizing even a small contract to keep data Paul there and company to write only answer was new of the organ and then slowly. Think humans. One of the government bunnies. Say gee a basement when he can give the organ in a way in to use needed to terminations when the killing fourteen the deal D.. So they ended up to the final analysis. Transferring responsibility to the C.S.A. I was very involved in that transfer point. That's essentially what happened. Let's talk about it later. The only question will give you new media just with the October seventy two don't talk to us about what in Washington politicians. This was before. AIDS on the door going on and also any to explain. We're on wasn't in the in this in turn. Last quarter in this conversation and still working for Frank Sartor group. All during that time and reported in theory so I was kind of a fish out of water in a group because everybody in Frank's group wanted Frank to meet. I reported to Jerry Springer spots. So I was sent to suspect their way to win in the sense. And more human Frank was one easy for me. I had a great respect for him. In terms of his ability to take a complicated project and make it happen. Something I never condition myself be involved with and can and cannot learn. First and only from him but from the people in the involved here. Painting something like that happens. So that his credit but he's very hard for me to work with because this I was not born in circles. Nothing there. I said recommend it for purple. Something he really certain faces hand you know one day I have decided that I have enough. And I really need to move back to where it was before. And then bomber was perfectly happy to back to that indigenous and he can my tennis and regularity and he was nineteen in context. All during that period since I remember walking in the French office when the insane I'm going to move back to the city of listen. He pleaded with Nina and. When was this. This would have been some time in their April for me. One hundred seventy one and the other thing I would say is. Larry Roberts. Very well we are told the circumstances. In this position he knew that the restrictions he also near load is working very hard in the face of six problems that exist in the sense that in the two ways and Frank shared them with a very very well prize. And to the point. I told Larry King on a really nice get out of there by Nathan Norman. This is probably in pro-war name seventy one and then up into my world. Just all these are so I have not been thinking of that. So I told him I think about it he wasn't on the table. Never took it off. But I ended up the side. Back into the ONLY piano. And so I walked in the French office one day and I says I'm going to leave and I said Frank what the problem is our styles are different. And we like doing things the way through says he and he gotten the audition children and in finally way. Says are actually nice and of the things that work and so one day I just picked myself up to fly home there in first place. And in the film back bedroom. Samosas Thornton is the next song but it was roughly next year a foreigner remember any Barbara showing up the next day the back of this year he didn't know whether the news or night. Nor did Frank but so there are less and now Now as mentioned any solutions are pouring out of her soul into the sentiment find a way to do what happened here is sort of I go back to my team plays out in your mind. They are no longer a possibility or little I fall these have thought I would go back to waiting. I had been. I guess I was so committed seen the ARPANET pork. And I was so invested in building in a new leaf I left at that point. Probably would call it Clinton and the SO when they got it right and I'm sending use trying to figure out how he found my view. Frank might say. You know what to me feel. You know from Texas. Put things in that field that I don't think you would in the case. And still lose small and was played in the chairs and for him and he selected you know you know I don't want to keep use was in limbo in perpetuity. MIT MIT smaller share in the form of a certain point you know. You can fly back. You know him with. And I split the snow will reconsider is that fully concur to me that. That was on the problem. Never never problem and want to thank you mighty as me on several occasions after that to come and never once might do to those wanting me to go back into the little L.C.S. doing it didn't work. Might actually be a proposal to beis you know right here for his certain scene or I have for the

serpent. And I think the only reason that he wanted to do that with he wanted to get back in there and we have some money in the bank to fill it is very clear. When it's going to give the thing well and our board discuss it and suddenly he finally said I think the coin. So we did in fact that the whole set of a scene or I was an interesting story in its own right. You know a gotten letters from. We were actually thinking of setting a scene or I as a whole in the last stand for an MIT in Carney. The letters from excited Corning the from Paul drain MIT and from John Kennedy. Stanford basically agreeing to this. But they all said. You know if you do with that way based on what seen right is doing. He's there. It would be very horrid feeling. Things on the national scene for us to play into it if we're also the owners and place. A conflict of interest for what has to be not only the three of us weekly cheapening body else and well. So they're willing to do this but we strongly would recommend if you can do it on your own. You better off for everybody. I didn't like and you just saw and I picked myself and a pen. Back there and actually Frank. You know showed up in my Office two thousand. As a home of the state. We do next year in the face of this that it would swear me to that sleepless. So that was when I decided to flee and the demonstration in the open. Service. My any of the times and what to do because nothing worked quite here. We had the network work. To move back and from U.C.L.A. to somewhere else. But you know you try to get MIT to work with Stanford the machine. Didn't work the protocols for your support and in the queue. You know. You often talk yourself at some of your lectures about this you know. First communication of the Arpanet with such and such when in fact they were no protocols. Nor Brady Center. Can speak to the surface and. We are trying to figure out how to get into the machines I was an involved in that personally. This with Steve Proctor and insurgency. Core and bunch of other. Funny some people in C.T. and that person was hiding in these machines or the operating systems can actually time. You know. The tunnel loopback which was like it will be it's a new warning you know it's easy to navigate they will do nothing without it you can do an answer thinking oh this will make this happen and let's hope. Let's have a target. Get this me tricks and who can talk to whom these what kinds of things done with blue balls having a few Nelson. The deadline to Salinas demonstration campus or to not raise any can purchase when I had several ideas on how to do there. And I think Larry and I talked about that but she was terribly nice happy with the end of the timeframe I was suggesting would think you would then you. He struck some of the deal with the guys who were saying at the very first conference call the I.C.C.C. comfort zone computer. Which was consuming the ballroom the Washington Hilton. In total of nine hundred seventy two. Said to me. I think this is unveiling the. But I want you to condemn all there to lose. That was the decision they made her. So since we didn't focus on that gives you more time I was trying to push up a little faster. Settle all the folks around the country to get their stuff in the inner workings of them. That's what their words are paying for it and Iran and Iran and how the mission for being in and then she has been working on Frank was actually working with these guys were helping the police. Installation. And I think he was serious and me. That whole curious than bailing out of this group and he want to be there with with me. We in the sense we doing the demo think it was Linda they are one of the people. Frank is hired to help to commercialise frankly still very much. Another commercial I think the openness acknowledging. And I had been promoting be an end management to think about doing it to him was no one taking the D.N.A. to place where research place we don't we don't build networks improvise things like that you know they have until some first centuries rooms for that there was no no look think this morning and leave Calvert to some use in the Pentagon at the time and legal. Real interested in playing for. I don't know the personality conflicts in my view insistent but. Currently he felt he couldn't make this happen and been going to come to Frank it could have been but the system itself. All the media in every finally once and I just don't know. But he ended up deciding. Leave their fifteen April news of the short period of time. And he left for me some people packing communication thing. Which was the first company to file a two fourteen terrifying the A C C crew attack and services. Thing to missing their businesses solutions to one of the local control of the company and of not having enough money in the the sale but during that whole period. Steve Levy. Took he was like yes when the piece an instigator of any actual evidence to can later became president he took components to convince the event to do something and so the form a wholly owned subsidiary called Telenet. And Steve Levy actually prefer the present all that. And it was running a P N N A Times. Larry still adorable and Steve wanted me to go with telnet and become the certainty technology officer.

It really wasn't my would be my psyche to do that I was thinking maybe now is the right time to go back and mighty and I talked to Larry some that doubt that. I don't think needed talking to Larry so that kind of getting Larry involved. Dallaire. That's when the involved. Toll and sneaking back and mighty Real really do operate on Darva. That's one accepted that are all true. Probably made hundreds of the to. So I work and see lonely for the next several months to get talent up and running I opened it and then one was also an issue in the dental sentiments are still many folk tunes we'll see now. Since a lot there were two people. I don't remember when they really were hunting I knew. Stu. I don't know where they were the over who said some consulting firm of the phone over Knoller films. His lawyer. But the levy and then the contact in the NE can turn into the hopper from somewhere. Part one of the names could come from the crew and in the villain without incident in a public servant known Nicholson flair a phantom from the hand we approached to the naked real interested. And they joined in the helps to lose touch with the F.E.C. filings and all while the structural something that can he tell and then up and running. So anyway. I am the one when the general in the Hiltons that back to that more details of those ended up going to normal. And that was in elites of temper or killed for in the we are told or November. One hundred seventy two I happen to think. Essentially something like a total eclipse and so certainly in Boston time the plane went to Boston to learn their lesson that condense I'm actually seeing my first day on the drive into our buildings sleepy November. So the Something like to get in the box story just a moment. You know this issue here. It was the issue of keeping the peace talks to see him privately in the in the new issue it was funny you can you tell us about that we are you familiar with what happened and why when I got adorable. Part of the reason I went there was to get in something other than Then Larry will tell you in just propulsive hundred million dollar program on the in a century. This infernal never worthless truth competing on the station. Till it builds a really interesting legal challenge and the boat coming on the program. Those reasons. And so I think yes and programs. Later canceled like owners. But actually thinking of leaving going back to MIT. At that point in time. The awful storm takes. Larry. Convince me to stay on getting more involved in everything for a deep reasons. I said I learned. But the one thing I did not want to get involved in the organization. Because of all the conflicts and friction they just didn't want to throw myself back into their circumstances. During the whole time as a target. I was never actually formally responsible. In the open for as a as a programmer. No I was involved in the back channel so please explain to actually the D.C. important than terms and ended up agreeing to do that and that's where he got involved in building from the newer technologies. Banchory satellite. Larry and story past satellite work. Two years for me in the protocols that was still plenty of actually build at that point. Suzanne to beat anyone to be in your mind. What we're motivations or do over what we're hoping to accomplish. OK. Oh gosh I was trying to answer your question although for where a story going to find it like a small hole that question on the stack trying to tell you that I was not responsible for the opening for going anytime. One of the Dark Side of people rate. You know. On the stove and when the Arkansas opinion that and. So I was aware of some of the sessions about software. But in the last discussions I was principal to the dark. Think it might and water who was running the program at the time or another or several people who are thought. All right. Well. I was kind of squeezed in at B.B.N. and all I have very strong support from Dan Bob Irwin birth level and. My real interest in that working or not really able to flourish there. And at least not in my division. And the options were either go back there likely and risen to teaching career which I assume could have happened at that point. Or Larry Roberts had made it clear he was still interested in having me come to door open the set up a program an automated then you factoring orderly say had proposed to the Congress and it was a very large program one hundred million dollar here program as I recall. But it. It never came to be. I went to DARPA. That's what I was going to get into it has a real appeal to me because distributed computing networking distributed FOF where all the things. And manufacturing per se which was something I thought. Really important to the future of the country. But after I got there it turned out the Congress and canceled the program so that was thought to be. And Larry persuaded me to stay on and continue to work on networking and I finally decided I would give it a shot I was already there. So that's what they did and. Well. While I was there I got into. Really working on a number of interesting networking projects Larry it started some work on Packard satellite. Years before he wrote a series of notes. That was the Aloha stuff at Hawaii. But there was no effort. Afoot to really build a

satellite. Thing so I haven't figured out how we actually get a satellite network up and running. We were no domestic satellites. So I made the decision to do it on Intel theft for which involves working all the kerosene arrangements working with the post office. And that's an interesting story in its own right. I won't go into it right now and then the PAC and radio net. Which again Larry. Had had about you know. Handle terminals. But there was no program in place so we actually put that program in place as well. So that's where they started to work fine. Once I decided to stay. It's. It's a little fuzzy in my mind as to whether we actually had like troops or instruction on that. I knew enough about DARPA by that point in time to roughly knew how they work because we had been working with them. You know for a number of years by then my man I had access to the files so I could see what it actually and sort of all became intuitively obvious to me. It was a. There was a side of me that actually. Unlike many researchers who want to do research you know like the bureaucratic side of things. It was a side of me that actually enjoyed the bureaucratic side of things. You know. Take an idea and document it and put it in in writing and explain exactly why you're doing this and so forth. I wouldn't want to spend. You know even thirty percent of my time doing it but I was pretty perfectly happy to spend. You know ten or twenty percent of my time on that. So it became almost second nature to me upon. Didn't work like that. You know was like OK. Figure out what we should do here figure out what we should do there was more. When I showed up a conceptual a matter of formulating a program. You know what would it consist of what things needed to happen. And what would the architecture look like who might be possible performers. There were no actions to be taken. Right right away. And there in fact were essentially no actions taken right away of four of the recall. Well I know the community pretty well. And at that time DARPA was operating in its former Moses nine hundred eighty three or four there was pass something called the competition in contracting Act better known as the secrecy I ca and at that point it became a more formal process for dealing with the wrist with the community or proposers than the way you dealt with proposals but before that pretty much everything that was done out of the P.T.O. office and DARPA was done with selected source. As opposed to peer reviewed or proposal read. Submission kinds of things in the. The more structured way. So you could work with the people in the community so let's say I wanted somebody to work on a good theory for multi hop radio networks. I'd look and see who in the country. Have the ability to do that they might a pop up. Maybe there'd be a few others and if they were there probably a students. If I tried to get somebody in the information theory world working today. Probably isn't was not a well enough for a problem for them. So they would like something that was more formed for them and so it pretty much could figure out who the. You know if it wasn't one person may was a half dozen people and you talk to them you know I would you approach it might actually solicit moldable proposals you'd let them write their proposal any way they want sleigh up their ideas and then you could sort of say well there are two good ones are the ones that seen so little of the other guys do something else later. And we will find a way to fund these two proposals that would be identical. Because he would want to have a fund to identical things unless it was some reason for doing two identical things. And that's basically how things work with lot of interaction. We often help people. Rewrite their proposals to put it in a form that would be more acceptable internally order shape and form things under the Sikh proposal is a proposal. You can interact. It was no really good dialogue and feedback method other than as specified in the our affiliates or the B.A.'s of that point. Well. I often like to think in terms of multi-year plans. If you talk to Danny Conal probably tell you in the early days when he was dealing with being a DARPA. I like a five year plan for here's what was going to happen radio satellite. I mean. And he probably even has the. The diagrams they drew with five your timeline. As a little. But I knew that if we could make the satellite net happen in the radio net happen the ARPANET was out there. We need in a way to interconnect them. And the. That was the genesis of the Internet. Program. It was packed radio net. Didn't have any substantial computing that you could carry around with yourself of that time. Big time for existence were on the up in it and the back and satellite networks intended to link. European researchers with the US and so we need a way to get the computers one way or another on both sides of the Atlantic. That's that's how the. The the formulation of the problem. Showed up in DARPA. But actually started working on that earlier I mean if you look at Bob Metcalf thesis at Harvard which was published sometime in one thousand seventy three. Or maybe seventy two before he went to park. He will find a reference in the back to a paper that

I wrote a B.B.N. it was called communication principles for operating systems. This is a paper that seems to have vanished in to the antiquity of files in boxes similar. I don't know if I even have a copy anymore. And I've got lots of archive boxes. Maybe I'll go through one day. But see that paper was all about the concerns that I had a bad N.C.P. as being a viable protocol to use going forward. And if you think about how the N.C.P. protocol was developed by some of the people that you know well. Steve Crocker and and others. I think the treated with this my perception. And they may disagree with this but I think they treated the ARPANET as kind of a peripheral The biased of their computer. So it was like a line printer and if you put something out either got done right or it didn't if your line printer wasn't working it's going to shut it off or if the recent button and started over again. And if your packets weren't making it through the ARPANET was something wrong with your peripheral. The Vice and so just start over again and. As a communications guy I knew that that was not. That's not the way I would have started the private. And I wasn't working on the computer protocol fight. Because I didn't know enough about operating systems at that time. And in fact that was the reason I finally been served to come and work with me has been a been involved in all that. And he didn't know more about operating systems and I did even though I was in an operating system group at B.B. and then. Before that that was developed in the Atlantic stuff. And I knew a little bit about it. I mean I knew what an operating system was I knew the compound if I could describe one for you but I was not one who is building operating systems. So the memo that they had written was essentially describing how a protocol really ought to work. And I was my argument was in auto work as part of the operating system. And there ought to behave according to communication protocols of his Something the didn't get there. Well maybe send it again. Or maybe have a coating. Or whatever and so it was arguing from that point of view we need a more communication oriented approach to dealing with networks. From the protocol point of view. So that I guess that motivated Bob to reference and I don't recall how we reference it is the says but I know it was a reference so when I got to North I had that notion in my hip pocket. And as I started to think about what the internet would be. I said OK let's assume we do this communication stuff. In the in the host machines. And a roughly what it's going to have to do. But these different networks and have different properties. Different packet sizes different controls different error. Responses different interfaces. Lots of things would be different and therefore we need a way to sort of impedance match between the nets and. The notion I came up with the homeless on the called a gateway and. Now you call a router. But the whole idea was it would have in their face to this network on one side. Than other network on the other side it would do all of the folks in the middle that we needed to then. Cause an exploding step to take place. That was about as far as I had gotten before. Vent and I started to work together. And together we took those basic ideas and he said well you know if you do this and the gateway the way you're thinking about it. It makes it much more difficult but if you do it that way it makes the operating system. A lot easier. And I don't know how to think about that part of it. So between the two of us we started to apportion things out and figure out how to optimize the so we're better. From the point of view of implementing the protocols in the operating systems. Making the whole system work and so at that point. It started. It turned from something that I was thinking about is this the conceptual problem. Into a real definitions phase where we try to figure out how you'd actually implement build something. And that's what led to our reading the paper to get it. What is that what it was. I mean I Those efforts were multiple networks. I have the problem every day I wake up. Figure out how we're going to make it work together. And I had some basic ideas about how we're going to do that but in order to take the next step. I needed to have more specificity and exactly what I was asking for. I mean I I was not prepared. Effort that one party could have figured out. Easily because they know about the networks. I mean DARPA had sort of. Most of the information to know that were things were going. Going forward. So I think. I just thought we needed to take one step further to specify what we're talking about and that's why. That my got together with the goal of centrally writing that paper was quite interesting when we. You know ended up deciding we're now we're already read the paper. In that conference room and think about a high it. Then night. We talk together about. You know who should too should get started. And he said he would like to get started. So he sat there with a pen or pencil in the sand. For what seemed like an eternity. And he is probably only like two three minutes. But he never put a word down on paper. And I said you know. I went back to look eyes and.

What's happening he says. I know where to get started. You know to bigger problem. Am listened to and sure how they actually get going. You know all the thoughts in his that he just couldn't figure out a good eye and entry point to the story. But if I once let me write it so I took the pen. And I just started writing and I wrote the first eight pages. And he's seen me you know write it. You know it. Break think speed there. But I was just screaming the words out. He looked at what I had and he said OK I can take it from there. So he then took it and wrote the next trunk. And then we enter it into and we went through several iterations before we. You know about it. Final and then the the only other decision we had to make is when we put this out whose name goes first. So he said we could do it. Alphabetically and I said Well how about we flip a coin. He said That's fine if we put the coin and. He won the GOING TO US. Well you have to distinguish the issue of how you do routing. In this multi network environment. From what happens at the end so I mean every computer has a different protocol then you've got the and square problem. Every guy has to know what different think is so we started I started I am forbidden I was there thinking that we got it. We should have a commonality. The same protocol running everywhere then they wouldn't have that that particular issue and then the only issue was how do you make the routing work in an efficient fashion. You know I have. Both challenge and interested in that problem from the early Arpanet days. And didn't really know how to mathematically get my hands around that problem. So everything that we were doing was sort of seen in the pants with figure out an algorithm that might work with something that might be easy to implement and I was that's where I was really learning how to think about modular software in an effective way. So if you look at the original Arpanet code you'll see that there is a module or centrally a table. That when a packet comes then. And you know we're going to the only thing you know is what line to a put it out of all you need to know. So we postulated the table that would tell you were to put it out. And the question was how to populate the table. And so the idea that the. I mean I was a strong proponent of that. And so were others who would be a module that would do the computation. Then we had to figure out how that computation would take place. You need to tell the next guy. You know what your table of like. He tells you and the computation would be based on those tables you'd figure out next tops and we do is sort of top. Kind of implementation and we knew there were some problems with that loops we knew could happen. And eventually. That gave way to other protrudes some that had. You know global mapping of the whole system and people have proposed lots of different ways to do running but within the Internet. We weren't going to have that many networks to start with. So a similar kind of thing was possible except that. Because it was so small you can actually build a whole map of the system if you want and so and something showed up. You know for human network. You could sense that there. The way we did addressing in the ARPANET was with sixteen bits of which a few bits at the top. Or at the bottom. Like six bits and actually would say which of the sixty four. Imps to use or network boats. And a few bits the top would say which of the. For external hosts or there was one internal one as well. Called a fake oath are actually three host bits and six bits for the amp. And so you could route it based on amps and then figure out which host to get it through when you're there in the Internet. We. We made the addresses these bigger thirty two bits of which we thought eight bits would be more than the for networks and twenty four would you know cover all the hosts that we can possibly imagine ever under these a million dollar machines and. You know four million them seem like an awful lot. So. So we were drowned on the network part of that field. But it wasn't very long after we started that the ether net showed up and we went from. You know five or ten or twenty networks might be all we could ever imagine to suddenly we have a few thousand rent. Rates during us in the face. So it's a matter of rounding based on network identifier. I don't know you were in the audience. So my guess is I should ask you the question but. You know I'm blanking on whether we did the presentation jointly or whether I did it all by myself or vent and. Mike Mike Valley both did it together. That would be my guess. This was not the first paper that I had ever presented remember we wrote a paper on the ARPANET input. That was submitted and presented at the spring joint Computer Conference in one thousand seventy. Frank insisted on giving that paper so I didn't even go. I was at both a hall if you say lay at the time doing testing on the embedded U.C.L.A.. But this one. Both went and I think it was fairly well received I don't know that anybody really understood the full implications of it at the time. We were talking about leaking the other if you know the Europeans will probably say OK. This way we get

to be used for the US. Some of these network connections and. We know within the US. The connections were to pack and radio nets and with their own a few and they were mainly experimental and not used by the publics so. I'm not sure people understood the implications of that in the larger Internet sense but for the university researchers who were all putting in local area nets of their own whether they be seventy three so they weren't allowed of them. But a lot of the researchers probably understood how it applied to them in their own local environments. So they could. You know get the ARPANET to map into an ether net or something. Whenever it was available. Yes it. Well. The Arpanet is probably the simplest. I have also the one that's most confused and in the public media. People often argue is done for military purposes only where you know within DARPA and. And this is something other people who are making the decisions really should speak to it more definitively. But my understanding of and I've looked through a lot of the. The papers internal to the office full of this was a research project to see if. We couldn't figure out how to deal with computer research sharing. And. Affective communication techniques to do that that would support bursty traffic in an efficient way. And cost effective way. And the paperwork. You know. Clearly have to justify why you are doing this with Defense Department funds. And you could clearly make the argument about how do you know they could use computers and they would need to communicate with command and control is widely understood at the time. They were already. The only networks like audit and one that could move around so. The potential application this was sort of obvious. But I don't think DARPA was doing it. Specifically to change what D.O.D. was doing at that point time but rather the see if a new capability was possible and to start to explore it with the research community see what new things that they might do in the way of sharing computer resources. So that the sort of a separate thing I think the satellite and the radio networks had somewhat different kind of stories that go along and so let me start with the. The radio on why would you want these mobile radios we we were not thinking about getting a shirt pocket radio to every citizen in the United States at the time we were thinking. How could the military make use of a capability like this and what would the capability be so we were focused initially on what the capability. Namely something you could put the jeep and drive around with the army could set up in a camp and so they can operate. Somewhere maybe they have a satellite dish to some other system or remotely. Maybe they're on ships at sea maybe on airplanes. But we could clearly understand that it was more of a military motivation for developing this technology than with of the orbit itself as we knew packet switching work. That just made it mobile. OK And. And the defense problem. Was he their mobile or fixed it and so the ARPANET could deal with Fix sites This would deal with mobile. Even though. You'd have to move one of these radios you could put it down and leave it. Leave it where it was so. One of the of one one part of that project was how to build a technology which was challenging it was you know I was the program manager on that one at that DARPA. And it. It was far more difficult as it challenges. Then was the ARPANET project in my view. But it was somewhat still simpler in the sense that we already knew packet switching worked. So with Arpanet we were trying to show that this new technology capability could work at all. Here we are trying to show how to apply in the whole environment. So even that was more challenging the radio waves and things in tunnels and behind mountains and spread spectrum and all of those challenges them. I faced I was the one that actually decided to pick a system based on direct sequence spread spectrum. Which is sort of the basis of all of today's. C.D.M.A. typing. Technologies. And the reason I did that I was motivated by a paper that was written back in one thousand nine hundred fifty nine it was something like Plus I'm Shannon and the radio amateur who in one of the art Tripoli publications that talked about many of the issues about how to do efficient. Communication so that kind of stuck in my head but back in those days. We had no way of doing all of this brings back some stuff. Effectively. Mean the military knew about it but it took room. A room full of equipment. How do you do it in a portable kind of unit. So the units we ended up building were like Wilbur cubic foot in size. Like a bread box they weighed them fifty or seventy pounds they were luggable here in the. They were one hundred forty kilobits a second as we built them because one hundred was about as fast as we could work in a multi-path environment where you had the lay spreads of anywhere from a few milliseconds. Few microseconds to maybe six or eight microseconds but then microseconds per bit was enough to work around them only Pathan could say the amount ops maybe get of wandered. So it was. It was manageable for a long battle you know. And then. Nothing

like today that they did the our smartphones or anything. And there was hardly enough computing in these things to do the job either because when I started it. Intel and just come out with it's a delayed. Processor. Eight bits was not enough to address buffers and instruction sequences and suction sets and the like so fortunately as we started their National Semiconductor came out with me. Interesting is called the Imp sixteen. Nothing to Arpanet him. But it had enough address space to deal with and so that's why we actually use the national and sixteen's Collins radio. Built the radios then they had a separate digital section to control the radio. But once we had the plan for the lease radios in place and Collins was. I had no question that they would succeed building the radios. Because they were they were kind of gold plated developer. You know what they set out to do they usually succeeded and put the question then was what would we do with these. So actually DARPA set up a set of projects. To try and apply them. One of them was a project which was called the then stare load planning system was called Alps. A A L.P.S. I think. And the goal here was to help somebody who was loading a cargo plane could be a C one thirty or one of the big military transports with with cargo. So if you're doing a deployment. You might have you know hundreds of pallets of things they might be even things like tanks that are in there. Maybe even a crazy. I don't remember what went in there and see it have to figure out if this is an air drop you want to put that heavy stuff in it such we can get out first and drop the lights off after it was a tank landing and in a crate would probably be inadvisable not the dropping a great says. Every good idea. But if you're going to do a landing what he would take the light stuff off Earth move the heaviest a while later. And where do you put it how do you balance the plane. Well. Oftentimes these were jobs that. On a manual basis to days if not weeks to figure out ahead of time. Got to figure out what's going on there are going to package it. And so forth. But when you're ready to do it here. Set to go on the runway. No one plane comes in and so what do you do now do you wait another day week or month so you can actually do that planning on remote computers using these out for grams. Right on the runway and figure out what it was in real time so that gets planes in and out. Regardless of what shown up that was one example of a military application. Now that was not one we ran in the fire in your program has an application run in some other program by. We have of the program managers for that. And in fact we deployed this stuff at Fort Bragg in North Carolina. And they were awful who had taken over the office director handle all of the interactions as part of the Fort Bragg deployment. And he was an army an army officer. Well. The Office which was I P.T.O. state I P.T.O. for the whole time I was there. Information processing techniques office. Later went through lots of different name changes after I left. We were housed at fourteen hundred Wilson Boulevard Russell and the time fact is a plaque outside the building. Now if you've ever seen it. That was really do this deal with case ICS instigation but I participated. If we said you know. It wasn't by the bridge that arch the flood. But he basically said here is where the ARPANET and vents with the Internet was started. Nice Plec to take a look sometime if you're renown there are no names just functionality. So the office. Was I would guess. When I got there may be certainly five and no more than ten program managers. Plus an office director. I don't remember it's probably. You know six or eight. Who would be my best guess but something in that range and. Larry Roberts was the office director at the time. He only stayed here. Less than a year. Because he was he left to go around telling it. Before the year was a. And C. book is it was the agency director at the time. So the culture was pretty painless let me Larry. Set the tone. Larry was doing all the long term planning. He was deeply involved in issues that he cared a lot about the ARPANET used to his cost models and his apology models and. He was interacting with a lot of the contractors that he cared about. Like B.B.N. was one of the I thought sure he dealt with the. Howard Franken Network Analysis Corporation and probably had a lot of healings with with you and others I just don't know who all he dealt with but it was a very yella Tarion run off with Larry gave. From my perspective. Very high professional. Consideration that everybody that was there. Well I felt in terms of member. What. What I was doing when I first got there was planning so. I mean the authority to plan to loose a no brainer. And he is could figure it out of then surely you have to put something together and they would have to get approved and. You know I my recollection is that you know everything how to get find out of the office Larry had to see everything that was going to go out. So he was surprised that there were in that was going on basically agree with that in fact when I became the office director later. The thing I used to routinely go through sometimes was the only way I could know what people were

thinking of they would necessarily tell you ahead of time. Because they were working out their own plans but it was when you would see something concrete show up at your desk you know they were serious about making the fab. But sometimes a be more long term planning. I would describe two kinds of efforts there were the ones that were driven by the office. The ARPANET was a good example. I mean the community didn't go to that he's going to talk to various people like you know if you talk to somebody like Marvin Minsky. Martin will almost surely tell you he wasn't sure it was a good idea what he's forgotten. But he thought we ought to solve the problem getting to programs on the same machine to communicate before we spent all that extra money to build this national network. So. These were things that were during the networking stuff I was involved in was being driven by the office. By me in particular where Larry before that all of the commanding control testbed like things were all being driven by the office. I mean. No You know I'm a researcher at some university said gee I think I'd like to do a communicant protest that it's a military base that just come up with technical research ideas. But I would say. When I joined the office. The majority of efforts that were funded. Came from unsolicited proposals from the research community. Into the fun project areas. Santa project area on speech understanding or automatic programming or artificial intelligence or whatever the particular program was. And then decide which of them. You want to the continue but usually those proposals sort of showed up in an informal way here's what I'm thinking about the want a full proposal or sometimes it would be a draft of a proposal which you could then enter it on because this is in the era before the seeker. But for the most part. The I would. I would say when I first got there. Most of the proposals were just research idea of the game for the community. And when I left I would say it was. It was the next maybe fifty fifty. Depended on who you were dealing with. Mean in the pack and radio program if somebody was coming up with a good bulky hop algorithms we probably were not in their knickers. Every week. You know what algorithm you thinking about next week and how we can to do the analysis and what we just you know. At the end of the year. You know. Excited take stock of. Was that effort making progress and. And so forth on the other hand if you're dealing with somebody who is like building the technology. And you are worried about. Well. OK you know want to make a change. Filling in an extra half a million dollars to make this change somewhat what management system are using in the you should. It should be a register that you change. Not not a half a million dollar effort to just rip is it something. So maybe we want to detail management plan open to report in every two weeks or every month of the what they're doing and maybe you'll go out of them after a time in the come to the phone. Depending on the performer. What you were expecting of them and how would how they were doing. Be nice if I could go back and actually get the numbers but my recollection is that when I joined P.T.O. It had a budget that was in in the low tens of millions. It could have been forty fifty million. But very quickly and that's why where the confusion is it went down. Much lower it went down. He was like forty million by the time they were all the commanding control test been than a through it so what happened was. Let's say we had a budget of fifty million dollars. It could have been that forty of that was really research and. There was another five that was for. You know buying wine for Arpanet and things like that not really research expenditures. Or maybe it was forty and ten or something like that and also we had more left research programs in there was this program that got started called him in experimental evaluation of major innovative technologies. And then the well the military test that stuff was in there and suddenly found that the actual money that went into basic research. Had gone down from the B. fifty fifty million or. When when I was. Let's say. Maybe went down by as much as fifty to seventy five percent from the basic research. The time of six one and six two for research. That was every bit as much. Six to money but some of it was now on tested programs as opposed to basic research for the nature of the program. Changed during that period. It would be really good. To actually go back and get the historical numbers because off the top of my head I'm probably off. Some here but. It was the Vietnam war. And the Mansfield Bill record everything. To be described in military terms. The. The defense. But it proceeded all through the early part of the seventy's. I mean that and more didn't. We didn't stop or involvement there until was it. Seventy five maybe after Nixon left and Ford came in so. I mean the universities were who are not very supportive of the war a lot of changes were taking place. Many people who are involved in the community bailed out. In fact the Iraq spark became a major research player and a lot of them came from the DARPA community. I was one of the few of that time. That

actually decided to go into the Defense Department. Mainly because I thought the on this is the problems we're having in Vietnam our Defense Department problems there. If you've got a problem. It's a national for national policy issue. Take it up with the Congress and the president. But the Defense Department was doing its job there for the most part. And that's where the research when he was to me this was. This was an unfortunate in their reaction between the university community and. And the fence that caused that downturn during that period. That was. I went through a series of steps. I became. I think I was appointed chief scientist. And then deputy director in the office they Brussel with the what happened when I came in Larry left. And Al Blue took over temporarily. Al blues in the ministry of the system and then little lick came in in January of one nine hundred seventy four. And lick didn't last that long because George Howell our then came in I think January of one nine hundred seventy five and he hand and lick later did not see eye to eye. And so link ended up leaving. Roughly in August of one nine hundred seventy five. And I remember George invite me to his office explain to me how the community really thought I should take over the office but he did want be running it because he wanted to really control the office and self and. Since George and I had both been graduates of Prince that we knew each other well for ethical. He just didn't want that relationship so he put Day Russell in as head of the office they was an Army colonel with a Ph D. in physics. Very good managerial type. Very much a good soldier. And George really wanted to run the program more than a thing from the director's office which he that doesn't want to run it through me. So he said. You can have you know. Freedom to run the programs that. That I don't care about essentially or they'd they've agreed to let you run which all the networking and commanding control stuff and a few others. But I'm going to have a day ruffle circle the wagons and kind of hold his feet the fire for the time he was there. So that's what happened. And I took over the office and. When they've left in the one nine hundred seventy nine. Both have passed away. So you can ask them directly but my sense is that LEC was very supportive of a research community that needed to. Not be too tightly controlled. And George was of the view that this research community and a high. Had been funded for a long time by DARPA and needed to have their feet held to the fire. So they could start to do productive things for the Department of Defense. That is it wasn't enough to say you know I want to think about how the brain works for another five years when you've been funding people who work on artificial intelligence for ten or fifteen years. And hope something comes out he want to know what what what are they going to do. Let's let's let's plan this more carefully let's have detailed things to go after and. We wasn't really interested in forcing that on the community and. When George insists that he do that we lost some of the people. Is bailed out at that time. I think for example. John McCarthy want to know. At the level of John McCarthy got totally turned off I think Alan Moore will have the same reaction of the senior people were very much. The ones that were the P.R. is there a guy like pharma Minsky might have been a level below if he was in. L.C.S. or where the funding was maybe with the a lab and that once that was running it. The could be insulated but the people who were directly in that the line of fire looked did not want to impose on them. And George felt it was essential. So it was a fundamental conflict. George wasn't opposed to AI He just wanted and it's like. Despite the rumors to the contrary. He actually never cut the budget. One penny. There with the basic research that actually was slightly larger already of the big AI applications program he then funded out of six to funding. He just wanted. He just want to resolve. Impact. Yeah. That was the pits. That was a position many in the community had in the early days. But you know it was DARPA's decision and DARPA have the money and so. Their views were just there was so much. It depended on the program manager and the pen them on the program. I mean in my case. George often told me you know look. You know much more about what you're doing then I do. I mean he was just very candid about it. The things that he cared about were whether the documentation I produced was understandable. Whether it fit within the scope of the program when there was any bowler ability. You know he's acting more like lawyer and bureaucrats. Relative to what I did and not technical micro-manager he never did that and he might at some point if I said George are. I want to start a program on a low cost back and read when I was really small he might say well. I don't think we need that just yet or we have other priorities that he might interact at the macro level. Whether you should have a program or not and if you ever bought a program to his attention which I did once in and they are IA where he had the expertise. I wanted to build a. You know a portable display. Terminal for the pirate radio stuff. And that

was George's specialty he was Mr liquid crystal display as he knew about every possible way you could do and I was going to do an electro forensic display and use the technology at Philips the do that and he never work you know it's to temperature sensitive here you know big enough sensitivity there I mean he was into it. Two levels of detail more than I ever would have gotten and. Finally with it all that he said look he says this will be my argument was. I just need this to demonstrate something. So he says well that's all it is he says I'll let it go but keep in mind. This is not prime time. Stuff so. Usually it left stuff go if I wanted to. But on the regular paperwork. He never ignored it. I mean he would walk home with a stack of stuff this. This high. Every night. I mean it all. George's variations. I mean it's like unbelievable I would say. And he'd mark up everything I asked him what this means what does this mean. But in case he never he never put any impediments or obstacles just made to work. But it was his way of learning. In other cases. I don't think we should do this makes no sense a duplicate. I mean he'd be interacting in a much different level. It was an ebb and flow. I mean P I meanings happened for a while and are some of the early ones were out on Harbour Island. At that Travelodge sure which is probably no longer there. And I think those P.R. meetings were interesting because they gave the community a broader view of what was going on when I became office director and so I mean I only had to pee I mean ings one shortly after I took over to explain what was going to happen with the office because we had just gone through a very severe. Around the budget cuttings before I took and I was in the process of the growing the budget back. In fact in my tenure there we went from being the smallest often darker to being the largest. So this is very unusual. Well I guess when I took it over. It was around. I want to say forty or fifty million. Total of which a lot of that was not basic research. Anymore. I mean not even really research. Grew up to about roughly ninety million by eighty two or something and then I started the strategic computing program which is sensually took the budget up to about two hundred fifty million. And by that time. When it when they got to that level. We were on track to be the largest office didn't last for very long and I'll tell you why. But the bigger offices. The biggest office the time was actually moved out of DARPA which was directed energy office and became part of the CIA Oh. Office. The Star Wars of so-called star with office. The. The biggest issue that we had or had to do with the applications that were put in that strategic computing program. I had thought that if this is a five year program to build technology and we can go into the program later if you want that we should start the applications until we have the technology. But it was a political issue in the agency the director felt that you've got to get the other offices involved. You can't take all the money given to you. Mainly I P.T.O. you nothing this is the Reagan defense buildup and. Nothing to the other offices and expect to have a stable political situation. So got to find a way to get them involved that was his choice. And you know. We went along with it and so we set up a number of application programs and. He wanted the application programs managed in a very different way than the basic research. Was being managed it was hard to put a timeline on things. A type set of timelines when the technology was going to happen for five years and you wanted the plans back here. So in some sense the timeline that we're talking about that were were. If not fictional they were at least constructed. Timelines. To meet some reason Taishan object in the Eventually what happened was another office was created. Those application programs moved into that other office. Run by a phone in Clint Kelly and eventually the Congress. Killed at least if not all of those programs. Because they could produce anything because there was no technology to actually do the applications the way they were they were laid out. And eventually that applicant. That office was. It was set up temporarily do that after I left the office went away and. When Kelly and his operation of strategic computing was moved back into my P.T.O. at that time. They. I always had them for a purpose. And then it was either to tell people what was going on in the office to get them a view of how we were thinking let them. You know interact in the like you know. Or to develop some specific ideas that that we could pursue and I think both of them turned out to be more of the form of the than the latter. There was a lot of really interesting and substantive discussion. That took place. I remember at one of the P.R.I. meanings I guess. The smith when the first one. I was asking the community for really good ideas that we ought to get involved with. And we got a list of about twenty or thirty. I'm reminder to have taken copious notes on what they were. But they were never of a form that they were really. Actionable items. Because anybody who had a really good idea. Didn't want to bring it up in a meeting with all the other P.O.'s whatever reason newer ideas

that were. You know like what was an example. We ought to create the algorithm to pose. You know what Al Gore anthropos is. It's a but sort of a. You know a robotic humanoid kind of system with an example. Kamikaze in that little that cyclical ram into a new damage. I mean those are the kind of ideas and really translate into programs that material as well some of the idea of actually influence of the things we did. There was also a good chance for people to. You know object I mean a lot of the community want to get rid of the commanding control testbeds like nobody's business. Why can't we just get rid of that money. Taken put it back into basic research. And the answer was you know. That's what the Congress is looking out for tangible results so he get rid of that. We're going to jeopardize everything else and so little by little people got to understand the politics of the situation by virtue of those meetings but they were very friendly and. I think productive meetings. I only had two as I recall both in Monterey. I have been to the first one was funny of the of the seventy nine. And second the first seventy nine the second eighty three or maybe was eighty eight eighty three. Something like that so many years apart. That were basically all the P.R.I.'s we didn't you know invite levels down below so I'm guessing maybe we had forty or fifty from the community. And maybe another ten or or so from DARPA might have been fit your sixty people at those meetings that could be off by going to be an eighty and I'm missing something when but that's my recollection. Hearing. You know I don't have a clear recollection of how many they were or where but there were some. I know that. Whether they were Annual I don't know but I do know there had been you know the invitation to graduate students. Some of those meetings in the early days. It was really very little of that. That I fall ater on the people who showed up at the meanings when I was running the office. We're more concerned about the health of the of the agency. Early days. This was a pretty by bring community and they hadn't yet really felt the brunt of the Vietnam cutbacks. Really have taken hold yet. But the. They started to in the middle. One nine hundred seventy S. And by the time I took over there was serious concern about whether this was even going to be a viable. Institution going forward. So part of that first meeting was devoted to getting people to be aware of the fact that you know things are turning around we are going to have a research program that's going to be growing in the following area of. I had just started a below side design program which helped to get us back from the fifty million the hundred million level roughly. So people. At least left that meeting thinking that. It was a hope for the future. But it hadn't really shown up yet. By the time I had the second one I was to report on all the new things or. We now have this strategic computing program in the works we had the below flood and design program going full bore. And now the discussions were all about Will. What kind of computers will you have in the future will move from time sharing the workstations and how is that going to work and so the. The community actually got engaged in some of the more serious planning that went on and that needed to happen. Concerning what we should be doing to support the research community infrastructurally going forward. Pretty minimal pretty minimal at those latter meanings. Except for sidebar meetings. That. Well the thing that the Internet that from my perspective. Was unable. People to think about projects that could interact with other projects or or or funded contracts that can interact with efforts with the funding contracts. Now. I think pretty weak because we didn't really have a vibrant Internet and so the early one nine hundred eighty S.. I mean the thing that provided the funding for most people to get high speed network connections. Workstations and out that themselves was the strategic computing program it's one of the things that's a little understood about that. That's what really made the Internet become real. Because before that. Mainly had. You know the the old elite. DARPA supported institutions general one or two before I'm sure if systems. And most of their work with focused on the use of those system so we were into the distributed computing. You know. World that we now know of with microcomputers it to happen yet. So that really occurred in the early one nine hundred eighty S. and computing was the forcing function that allow that to happen in most places. That's what you have before. I mean you had e-mail from the early one nine hundred seventy S.. You know whether they were simple programs. Or whether they were more complex and. You know in the early seventy's. I mean he took off. You know except for people who just happen to know people in other institutions there wasn't a white awareness of what was going on at those places a lot of the faculty got to meet. Learn about the other faculty because now he may love the possibility for the social implications that were profound and the sort of the stitched together a community that really hadn't existed as a community before it

existed and a lot of the C.S. departments but now they suddenly could they sort of talk to each other work either here's the thing I'm working on you could ship it is an empty people. Mean so we didn't have the Web as you know it today but we had the functionality of the web. In terms of interchange. You know back in from one hundred seventy three on really. So the social aspects of that were growing. But people were constrained into what you would think about the you would think about a mobile app. Made hundred seventy three one the you couldn't communicate mobile A and nobody knew when an app was new would have the power there anyway it would be somewhere else. So literally as the computing power increased in the devices and the technology changes that the possibilities were were were much broader. I mean I engineered the very first large scale by a worst stations which. DARPA funded which went to Berkeley. In maybe nineteen eighty one or two which enabled who went along with our funding bill joy to Bill in virtual memory. Version of Unix. And they needed space to do their applications and try things out. And so I remember Berkeley had submitted a proposal to the was called the C E R program and N.S.F. computer. In their resources or something and. There were six proposal for elected for initial funding. The cost of the Berkeley proposal which was like six million dollars more than the cost of the next five. So I got a call from N.S.F. at that time. Since both nine hundred eighty and said Well. Are there any of these five that you'd be willing to fund. And I said well the only one we have anything going with the Berkeley but we don't have any need to give them. And we can maybe develop that. The other five organizations we don't even have any ongoing or planned research with. So N.S.F. made the decision. At that time to fund the five. They didn't fund the number one they went to Berkeley and they told them something like well maybe DARPA will fund. I don't think that went over very big Berkeley. But I managed to then. We now have six million either. The fund that at that time. But I managed to make a deal with Gordon Bell. Who was then had just moved to Dec was in charge of their research in architecture program. Whatever they called it. And he put together their six pack program where he would make available. Six lakh says for one hundred eighty thousand. And so suddenly had the ability to buy multiple machines for an affordable price on a DARPA contract that not deck was interested in that because they wanted to see what people would do with mobile or chains. And so we got you know sixty machines to Berkeley and it cost us a lot left to fellate one point eight million instead of six point one to. Going up the paper in suffer. So this was a test that was done in November of nineteen seventy seven. That involved a number of different. Participants. This is not the first time we had done multiple network testing. Although it is just like you know when people ask us where with the press shot of the first insulation on the no to U.C.L.A.. You know. It was on the loading dock Nobody thing but it took a picture. To take a picture back then because in thing like that big a deal. Now people say well Psystar it was the golden Fike you know Goodman. Inhabit well. Some of the first tests were just that they were test nobody took pictures of it nobody argument it but I am sure that the B.B.N. we did you know some to network testing. Make sure that the gateways were properly or that. I guess that was before get was just to make sure that. Whatever it is that had to happen. You know. Was working so they will be it was building the gateways. By the early seventy's. So yes that's the period we're talking about. So they had to be testing it with two networks so I'm sure there were two network tests that were done there. And we had. Satellite met was certainly tested with the ARPANET. So they were. So there are a set of pairwise tests that took place. So this is the first one that tried to do more than just to show. And you know this was kind of an orchestrated test. Where. Traffic would be generated from a van in the San Francisco area go through the pack and radio net go into the ARPANET be transmitted across the ARPANET then go to the fact that satellite into Europe. There we end up in that computer at U.C.L. as I recall and they would then further. Or maybe I know if it went into the computer but then it ended up going back to high as I think. And then suddenly something came back through I.S.I. maybe through the seal network and for the British that were back through the ARPANET and. Back to the west coast and feet actually were echoing characters of this time which was a long way to act on them. But it was just a proof that you could actually connect all these things and everything could actually go through and come back OK so it was. It was a documented. Milestone. One of the first. There was actually. Nothing going on back and forth Xerox had put a tight lid on what was going on apart couldn't talk about it. They couldn't participate in fact Bob Metcalf was part of my original pack of radio working group. And at one point he said I've got to get out because we're doing similar things that whether he

was doing before or after. Nobody will ever know but he had a drop out and so we never knew what they were really doing inside at that point in time. So they were just really independent things the only thing I would fight is that what we were doing was trying to work the problem in in the multi country international space. And what they were doing was sort of totally within the control of park so if you want to have and network somewhere else you can put it there and maybe they'll figure out how to connect it with a. You know a wire direct connection or something but there was really no. No real interactions I talk to people apart from time to time. You know Bob Taylor was very interested should they started back in radio programming park. And I said you know. Feel free to do that if you want. But I think we're going to go. I mean the power out there. If you want to demonstrate that we could probably make back and radios available to Gov and I remember the exact discussion but try to persuade them it was not a good thing for them to do it the tide. Might have been twenty years later. That's actually a very interesting story and it's I mean I was the one that was running the PAC and was program initially for the first experiments that we ran with simulations. And Jim four D. had. I mean Larry may have been involved at this stage and because he was thinking about the boy stuff as well. But I think Jim forty had a play out. Tape of a conversation and. We chopped it into parcels of like twenty milliseconds each. Then from a source. Over the ARPANET. The goal was to send. No I'm pretty sure I was running this is the thing. The goal was the sand. You know a continuous stream representing the packets of we now have the data. So we set. Because we were sixty four kilobit for second. In the open It was only fifty kilobits we can actually send it. But we wanted to see what the effect would be so we'd send a sequence of twenty millisecond packets. Through the Net. And we record the timing of them on receipt. We could see when things were lost when they were out of order. What the random this was. And we pick a delay period so let's say we'd wait a half a second before playing it out. So we can deal with Lovering. And what they would do at Lincoln was play out the appropriate segment. When it arrived in sequence. Or if they didn't have one they have a gap in the play had maybe a quick or whatever. So we actually able to show that you could send this and even though things might happen to the back and start a route. You could get continuous play out at the other end it was kind of an emulation. If you will. You never really sent the data but we sent the the. The timing stuff. So that you could figure out the timing at the other end. Do it realistically. And then I started the real program. We have a speech working group. We leave. We insisted on moving down the lower speed because we want to do the tests on the with the real Arpanet. In order he knew the first tests I had to get B.B. and then to change the way the internals of the Arpanet work is if you recall. You could just send a continuous train. Send a message. Go to the UK then they would get put together you get something called Rough. Ready for next message back. Roughed up. And so is from the law I mean that was going to screw up things I just want to see what the late. The native latency was so I went to B.B. and that actually showed up in the dark office at this point. And I said I need you to create me a new type of packet. Called a type three pack and I just don't want controls on this. Well. They do that because they were afraid it was going to you know. I mean in their benefit I would say. They thought it was going to harm the net. I mean their reputation was going to be be smirched with the right turn of and they just didn't want to do it. And I said look it's just. In to be from one place to another I want to be able to kowtow characterize what's going on in that they didn't want to do it. And so the he did and they came back with all kinds of reasons why it was possible to do this and so finally I called their bluff and I said OK. I mean I was not a good programmer. But I could program. And I knew the code. I knew every line in that code was all written in Honeywell machine code D.D.P. five six the machine code. So I said fine. I have the code. I'll make the changes myself and in seventy three. This is it. This is the time express what's what. What good is a timing spread of measuring a rough times. So they wouldn't that wouldn't do it so I made. Sensually thread I didn't want to hear you know. But I said fine I will. And I didn't phrase it as a thread I just simply said. You know fine I'll make the change myself. Now. They Walden who's very sensible guy. And the deep down. Basically came naturally have that we figured out how to do it. The some but you've got to promise you will open it up everywhere and for do if the limited times they were. So I said that's fine that's all I really want. And so we ran the the tests knew our grant. And then we did our packet boys test later we did at the same like a limited number of sites. But we kept the type three packets around. And we dropped them we kept going down you know I picked L.P.C. ten as a goal. But we did tests with

the A.P.C. that the predictive coding with. Thirty two and sixteen bit see the S.D. and all those different ones we ran the tests and actually showed back a boy sexually could work. In fact it was. I think it's clear. TRIPOLI milestones and Lincoln Lab got the citation for my troubling. So I want to tell the story. Backwards. That is. I think the decision to split T.C.P. and IP. In retrospect was the right decision. But I was not in favor that initially be cause. I wanted to do something it was just too complicated. What I wanted was when packets arrived at the destination. That they could be played out at the destination. He in any of various forms. The way the original T.C.P. implementations were all done. Because nobody saw the need for anything else with the made them essentially Birkett virtual circuit protocols. If you read the T.C.P. IP ber. The T.C.P. paper. You will find nothing in that paper that talks about virtual circuits. Talks about associate creating associations between computers. The assumption was that when the packets were arriving. That the destination could figure out what to do with them. Put him in the file storage play him out. You know. Put him on the screen in the order they came out there was no requirement. Any were the people in that paper that they had to be done in sequence. On the other hand. In order to keep the flows going you have to send these acknowledgments back and C.C.P. so. The the idea that. I always had read the get go was. If this is funny and needed a continuous flow you've got to keep sending back knowledge with keep the flow going even if you're missing something. So the moment didn't really mean you got everything all it was interpreted that way. It meant that you're ready for this on the next one. And so it was speech you could take the package when they showed up and put in the file so you could actually get the real speech while. But the real time player might miss some of those packets because they didn't write in time. And so that was the idea. Read the paper and. Take a look you will find nothing in there. Now then I didn't necessarily have the same understanding of that. But I can't speak for him say that they have him in any event. My idea was that the programs would tell the protocol. What it was a needed. Like. Give me the packets. I'm just going to display him so given to me whenever and I'll just put them up so don't worry about the sequence. I thought that was the right way to go when we started. But no programs work like that. None of the applications did that. So it would not have been practical. In practice. I can say it that way. So what that what they did in effect. Unable to go forward but whether it was necessary. I would say no it wasn't necessary in the sense that you didn't need IP. Separated. In order to get speech played out. The T.C.P. protocol if it was implemented properly with the right play out. Could have supported that. OK. But I think they did the right thing in terms of in the world could understand it the other way. And that was something that happened. Years later like in one nine hundred seventy eight or so. And it's the scientists and the deputy director. I was all of those. Yeah you want the brightest smart of organized guys. To figure out the programs people with a vision of the future. Who are articulate and. Technically very competent. And you know. And that have a larger national view. You know. You know if I were to ask you run that test against every graduates and you've ever had it's subjective. I mean OK I think this guy is not interested in that or this guy might be or this guy never would be or this guy is the you know the pain of me of that. And so you know you get you get what she yet but you gotta make that judgment on a person by person basis. So as a program manager. You. The last thing I think he want. Is is. You know who you have to give direction to. And he just executes what you tell him. On the other hand. There can be programs that require that kind of function. Usually researchers from the university community are ill equipped to play that role. And just how they have been raised and some folks in the military can some of those guys can be very good soldiers and just do as told. You know they got the capability to do more stuff and so you know you got to pick and choose what you're what you're what you're looking for depending on what your needs are but but it takes. It takes an environment to motivate somebody like that to come in the first course they want to know is one of my working for. And what kind of environment is he working in. Because you know the best guy in the world is an office director and he's totally constrained by the environment that he's in we're going to help me much. So it's a systemic thing. And when people are there is program managers they learn over a period of time. What works and what doesn't work. So if you're in a world. When people give you the benefit of the doubt because they know if I let that guy go for a year. He's likely to produce something really good. Because that's what he's always been his career. Maybe he willing let that happen. But if you're in a world where. Nothing ever happens like that you feel like you need to control everybody the the day week to week or month to month. That's not

going to happen. I mean I'll tell you one interesting. Innovation I had with Steve the kids and their early as I love Steve. And he have done more for pursuing I.T. than probably most of the other our directors have but one. When I showed up my view was. I'm not going to bother Steve look a sick with anything unless it's a problem. My mom was of. I'm doing fine I'm the issues. I'm just going to go execute my program. Don't bother him. And sees you as if I haven't heard from you in two weeks. Something's really going wrong. So we haven't got on the go she said that out that was just that was a style difference but we did in intially bury the hatchet in the. Well. The biggest contract that we had was probably one of the by F.-I. Partly because the writing services for the office. Partly because Keith uncover who was running the place at the time was very much in DARPA's camp a mean he was an arp a supporter. Lock stock and barrel. And so he could always negotiate things with him so whether the money went out the door. It was tightly controlled at the source. What actually happened could be negotiated with some other parties there was no way to do that you know. He just couldn't see him out a contract the contract stipulate what they were going to do it was just no way to actually have a flexible negotiation. So really depended on who you were dealing with and some cases. We just you know kind of knew we could work with the relevant parties. And we did in other cases. Sometimes we need to know who they were necessarily because new face on the scene. We stipulate or write contracts they were tightly managed in control. So it was really there was no way to characterize in in the in a general sense in virtually anyone any of the questions you're asking don't have a cookie cutter answer. It depends upon who you're dealing with what the context is what the project is. You know and how how they're doing. During the period while I was there. During the time that I was there we had always a very large fraction of very good program managers. There were a few who are not as good as the others and he usually this tradition of responsibilities. You know would we give the most responsibility the most capable people but it was never exactly identical equal but they were all good and. The question really. For us was what. What are we trying to achieve. And so I was always up there with the kind of the mentality of here's here's what I was trying to do in the next five years. I always had that. And this is where this fits in this is where that fits in. And oh by the way this big chunk of stuff that's just serendipitous research. These these a good proposals in areas where we don't have any five year plan. Our five year plan to get people to explore this area and explore this them and see what comes out of it. So we always had this mix and. I remember there was a conference at Los Alamos and they mean one nine hundred eighty six or shortly after I left the office. Daedalus magazine was putting out a book on artificial intelligence. A little one of their publications that the American Academy of Boston. And they asked me to write an article for it because you know. I had been very well known for promoting a lot of the research in our official intelligence even though I was not far from their research I myself never pretended to be and never thought I was still don't think I am. But we did a lot of good support for that community. And so they asked me to write a paper. And I said Well. I really think it's not appropriate because I'm not an AI research or you ought to get the guys that are in that field. To write about write about feel. I said Look you're too important to the field. You've got to write something. You know we don't care what it is remember anything you like. We just want to contribution from you. All right so thout think about it. So I did I thought that I read a paper was go artificial intelligence. The reality and the mess. Remember there was this high is issue about all too much hype about AI and what was going on so I wrote this paper and I sent it to them and they had a meeting at Los Alamos. The talk about the papers. And I knew. May be a third of the people there. They all knew who I was. And the said you know. That's not the paper we were expecting you to write. And I said Well. I was told I can write anything I want it said Yeah but you were so important to it we want to know what your plan one. We would like you to actually write. The plan. You know. Because you know. We know that what happened the I feel was caused by the citizens that you made and I said no I'm not even the feel I I was not able to make those decisions. I did not make those decisions. I wrote a paper that I thought would be interesting. And I believe. So they wouldn't publish the paper and. You know go look at that are it was no paper for me in there because they thought I was micromanaging that. So people have different views. But my view as when he came to the areas. If I certainly if I didn't have any competence I'm not going to weigh in in detail. If it's an area we need output. In order to justify the input will. We'll talk about what the OP is before we put up the money but much of what we did was just getting the research community

understand what was going on in the field to come up with ideas figure out whether there was a there there. And we'll see what comes out of it. Well Charlie Hertzfeld and I did a scrub of the I.P.T. office. Started in August of two thousand and one and that roughly in October. So we're right through nine eleven. And Tony had come in and he and I had a dinner one night he says I'm told by people in the field that that IP deal is way behind the eightball now they're not do and they the art stuff. More good stuff going on in industry than is there. And he said. What's your view them as well. I haven't kept track of what's going on there. But I find that very hard to believe that people there and I know exactly what they're doing. But you know. I think what you ought to do is take a hard look at exactly what they're doing and make that judgment yourself. That was my advice to him. Tony Tether. Don't Tony of course. You know a lot of the community thought he was less supportive of them than I actually think he was. But I don't. Tony was looking for very specific things and he had some goals in mind. And we're in a different age in fact. John Mark I'll get back to the hurtful story in a market of road. Interesting article where he was really taking TARP tarp and that's great you want to be misquoted in that article. But I think it started out with Patterson and was asked if you have is a start up by saying the DARPA that produce content surfing the internet stuff is not the same. Well. I get interviewed by John I said look you know it's a different world we're living in now. Back in the in the seventy's. Were it was sixty's even the golden age of DARPA. It was not clear how computing. Would affect the military. When clear what the industry was we were in the big mainframes and the like you could put him on planes you couldn't carry him when your pocket. But and versa every idea it was a new area for exploration. She really wanted to let a thousand flowers bloom. See was going on we are now. Fifty years later. And some cases. And the world has changed dramatically. We have a big computing industry the military knows all about computing. In the sense of what it is and where they go to get it and they didn't know best how to use it. But you know it's not like. Now when we got to just explore every idea of. Come along. We want to be more focused. I think and. So I think what DARPA new NG is exercising his prerogative in trying to become more focused. For the investments they make are more directly relevant to the D.O.D. that we have today. And not the situation that we had that The years ago. Well. I mean I never got a negative coming back from the community but I did get a phone call from Tony he said you're the only one who stood up for what we're trying to do. But it was exactly right when that is the situation that they face. So you can't compare what goes on today. With what went on fifty years ago. And and and try and say Well what lessons of the past have are not being applied today because maybe they shouldn't be a play you've got to look at what the requirements are running something today. Anyway back to the story with Charlie. So I said to Tony. At that time you take a hard lucky said and I like you to do it. Turn it right around. And I said well I'm willing to do that but only if you me somebody to work with. So it's not just me alone I don't want to be just find you if we have Charlie. To agree it's a Charlie and I did it the two of us and so we went through the litany of all of the I.P.O. programs were about forty of them at the time and to be quite honest. As with any other record programs and about you waiters. I thought there was some I would have rights a higher priority than others like. If you asked me which is the most impactful program of the most scientific program I will give you rankings. Although I didn't give him. Rankings we didn't actually rank the programs. Other than to say that there was no band program in the bunch. That one. But they were all of the same level of impact and furthermore we couldn't discern a common theme in the office. That is the say. The funding a lot of good stuff but we don't know where the office is heading. If the nly enough. The person who is running the office that time didn't choose to sit in his for. I don't know what reason. On the person said was also there and. So you know our recommendation was you know. Get the office to see if they can focus on finding a thread of projects that. That they're interested in that they're capable of doing that would move the field forward in that are interesting from a dark perspective. That was the. That was the bottom line recommendation the main being comments on any single program or any program manager. That was not what we were trying to do in the fence. So that I briefed doctoring things there quite a bit. I actually wrote a report for him it was called cognitive systems like a hundred page report. And it was no DARPA money involved. And it was the layout of what they ought to do to really move the field forward. And I thought you know we have all different kinds of networking piece and in a I.B.M. was like the manufacturing program applied to the O. D. Systems. Make the less brittle. You know make them to the point

where they understand their environments and they know what they're doing they know why they're doing it in. I should never have a computer. Where I got to look at a manual to figure out why. My screen is raised up a quarter inch from the base system should know why it's there that's what you will but then the quarter inch or. You know you're off kilter of something. Why is the right half of the screen blue in the left they are red you know what you make it all one color. Like the system want to know enough about that. And what use is it doing externally specially. D.O.D. deployed systems. It was a really nice report. It's like. You can say so myself and Tony's style of operations with the. He writes on the jelly market up in the back to me and said I like it. But the only part of that to be picked to work on internally in I.T.T. go. Was the part that had to do with making people more capable by external support from a computing system was a program. Assistant for learning program. That was the inverse of what I was recommending make the make the system smarter but they put a lot of really good effort into that kind of a program and. I think you know in all fairness Tony was looking for. Ideas that were were new and could really make a difference and I think everyone. Every doctor director that I've known. Has had that kind of interest but they're all idiosyncratic Soviet a doctor director to they are interested in this set of things. And get our Connector then they were it's in that set of things. And so. I think from the point of view of. DARPA the mission of the agency hasn't changed at all. It's still viewed the same way they have a tighter relationship now than they ever had in the technology area. With the military services. So the military services Waffen look to them since are no longer trying to killed arpa. I guess that stopped about thirty years ago. Because they didn't want DARPA in the first place. They thought whatever daughter can do they can do and why give the money that they would just like in the Army Navy Air Force. Rever for they actually will strike deals with DARPA and DARPA will work on projects that are more near relevant to them. And so you got of evaluate in the context of who is making the judgment about what's going on if the academic community they're going to have a set of things they'd like to see happen. And they can articulate them. Today you can find a half a dozen very articulate spokesperson for. What the academic community thinks should be happening with DARPA should do. Well. DARPA has always made its own judgments about things. They have their own priorities. How did they get to them. Well. That's a question. I mean you might say. DARPA should make its decision making jointly with. Extra community. But it's and that's what N.S.F. does to a large extent. But. DARPA's got a defense mission they will do things the relevance of the D.O.D. So whose judgment should it be as to what. What it is that they do or they don't do I think it's got to be. There's in fact somebody who go to DARPA and say before you decide what to do. You better if the military services. What they think. Because that's who you're doing it for right. And if you do that you're very likely to find that every good idea you have has either been done what the weather has or not is that relevant. I mean when we were doing packet radio. The Army. Always told us that their Gittins program that everything we did. Well. It really didn't but that's not a group. You can ask if you're trying to change in effect their behavior. Somebody shows up to you and says. You know Len. I have been given the task of modifying your behavior or advising you on how to modify me but you have to take my advice. Is it my job to ask you. I mean with that big. Good advice. I don't know. So I think. Been well served by letting him keep their own counsel. Figure out what they think they can do you know maybe be a big surprise neighbor with everybody will look at it and say you know. Well I've done all you know why in the world of me doing it then that's politics thing go fight it. Fight in India the fight with the White House fight it with the Congress. But. DARPA's real mission and. And then six parties has been in coming up with these new ideas maintaining the technological vigil in. I think that the do that themselves. And everybody will do with a different way. I mean there is no cookie cutter way. I mean you know you certainly. I mean I guess I would strongly oppose a view that says the DARPA director shall come up with all the ideas. By himself or herself. Talk to nobody in the process and just let everybody know. That's it's not really an outsider itself to Fenian every possible way you want to. You know get community believes that you need to talk to people you need to talk to people inside the agency and he talk to people outside the agency in the to maintain technological awareness you need to read the literature easy read the papers you got to see what the problems are. And somehow collectively formulate a process. You know in G.M. brings in a new C.E.O. to run the company. They don't say go read the manual on how to run the company. They say enough is your head you may hire you for who you are and what you might do for us. So. And you've

had you had the same thing in your career and you know you've reacted to various things that have happened in different ways. Did you read a manual to figure out what to do. I don't think so. Well the only thing I would like to mention is something that's not within the purview what I think you wanted to talk about which is what I've been thinking about working a map. Last. Actually since leaving DARPA. Which is how do you use something like the Internet to manage information. As opposed to just move bits and. This is not a topic. We thought a lot about because you know with within the Internet context. If. If we succeeded in making it possible to get information from one computer to another computer. We considered. The problem solved. In terms of what you know as long as you didn't have to figure out what net they were on and how to log into routers and do everything manually. We solve that problem. You know as but we left. Most of the issues of. What do you do with this capability to the Field of Dreams of people who figured out what the and it was good for we have some things we knew we could do with it. We're doing before you can send e-mail we knew we could move files. And you know the Web kind of elaborated on that very seriously. Starting in the early ninety's. We knew that all kinds of other things were possible. But today people are still struggling with damaging information back in. One. Well Shannon Shannon had the office a few doors down from me and MIT when I was on the faculty there and he was an amazing. Applied mathematician. He really was who understood company torics in a way that few people had before him and what he was looking for fundamental principles that could who apply for which they were mathematical expressions that could explain. People thought in the world of wireless for example a way to get more oil billet he with a hike the power for low bandwidth. And Shannon said look if you give me a certain that a barrel of certain power is actually this number here. You can go above that rate. And oh by the way there's a way to get to it. But you got to be clever. Tell you how to how to be clever. And people spent years trying to figure out how to be clever to do what he said you could do. And he could prove mathematically you can do it by some exclusion principles that ball you know. Averages and things like that. So. No no I mean it's it's exactly. It's exactly right. And I and I mean in some sense. I wouldn't say what he did with information theory is what the Internet did. But you could make that linkage. And that is in the sense that. It's interesting also I gave a lecture at Prince than at the I guess was the centennial of during this. Birth. Because he did his Ph D. work there. And somebody with say that during his work was going to one dimensional work of his being infinite loop. During tape. And when John von Neumann built the very first. Computer here I guess you have some competition from England. He had a random access memory. Instead of this infinite loop tape and that was two dimensional version of the Turing machine. It wasn't quite two dimensions of infinite dimensions but. And then somebody said and L. I'm the Internet is the three dimensional version of the tree fishing I said you know. I never read any paper the Turing ever roadracing anybody ever wrote about touring that applied. The term networking to anything he ever did I just think that sort of so long but it's kind of an interesting comment. So if you think of the Internet is just seeing how to get the information from here to there. You could make that analogy. But the real question is you know how do you manage information if you came back. In some future incarnation and said. How do I. How do I get a copy of the paper how do I print out or look at the paper that I wrote back in. Nineteen fifty eight and MIT or Thursday two and your hundred years in the future. What machine you go to command the A You've got to ask all these crazy questions. So the model I had of. Well OK. You go to a registry. Sort of like the Google of the day it's a little got to know more than just what he can find by. You know scraping the public web. And you say you know. What's the identifier for Klein rocks. Paper that he wrote in one thousand nine hundred fifty two at MIT back comes back the identifier the paper and then. Because the whole world works that we take that identifier and you ship it off to a system. And you resolve it. It says. OK here are the places where on the version of the Internet today maybe it's a. Seventy fourth generation or net all works on gravity waves but here the places you go to find those papers you say OK. I'll provide that identifier to that place. And it says this paper. And oh by the way it comes back in the form that your machine can understand it. And it doesn't depend on necessarily knowing about Piaf or both script because those are hundred year old things and all these Cup. Programs anymore. And now suddenly you're here in business. So that's what we've been working on it started out with an effort that that my then in the six. In the in eighty's. Which we call it was before we had any real funding here from the government source we were going with our

seed startup when they. We call them mobile programs a namely game and the men were not knowledge robots that we're going to sit at the keyboard and we instead of being glued. The screen with your fingers on a keyboard. That you would program one of these mobile programs to do what you wanted to do for the day. In the task was often we go into them through your body and come back and when you have the time or felt like it. You go and get the answers you want to know what's the price and China. Teen. You know what happened in Gaza yesterday and. You know what about whatever. So Joe all this stuff go collect it. And we wrote a really nice. Draft report that the. We wanted to get a patent on. And about guys. What do you need to actually implement this. Well. It was a bigger task. So what ended up happening is we split it into two parts one part had to do with how would you manage. Information if you never had mobile programs. Everything was sort of static at his information within a police. And you could get to it from a place versus. We're you know. Maybe the information is actually most of all the time here. So we split the motion part the static part in the that a part we call the digital object architecture. And the mobile part we called over grams or the bots that was the actually got patents on both of them have been chilling. But the essence of the mobile. Program one I can talk about right now. Even though we've implemented although tell you about the. The static part is most people relate to that most people don't think of their stuff as Johnny on the M.T.A.. If you will as a Charlie Charlie on the empty. Thank you so I guess the idea is that you have an identifier. That is unique to piece of information. It can be an identifier for every individual. On the net. That it resolved information about the individual that's relevant. Like you know. Maybe public key is. So you can dial of these them maybe contact information if they want you now with every resource on the net. And then when they then a fire. Every piece of information on the net. Can have an identifier. And other things that you may choose to identify like flows and things like that can have their own identifiers. And they're all structure in the form of digital objects which or machine independent data structures. Was Like. Today you think of the piece of email can be understood on any machine. But you probably need an email program to do it but in general it's because these are structured in their structured ways that are understandable by everybody in every part of the structure of the digital object is called an element or type value pairs. The can actually parse these anywhere you go in the types are identifiers so you can tell what type of type it is from the type. And so that's the model of the future that we're dealing with. Furthermore it has a protocol. Called the digital object interface protocol in the documented. Call digital in of the interface vertical and that's where that I do you document of a good. But the thing about that is allows for interoperability between arbitrary systems which is sort of what T.C.P. IP did but only up level getting the bits there. Not at the level of what the information is the still not. We're not at the point we want to stood how to get a machine to understand what the information was all about point of this is war and peace and you got it there were going to be sure you can print it out to look into the screen or maybe even understand the method A that about war and peace. We're not going to say that we know how to solve the problem of understanding with that book was all about. That's yet another level of cognitive comprehension. But how do you just get to the stuff in the first place and make sure it's understandable. So that the system that we developing has three different components. One isn't and. This is sort of starts out as you can argue which is most important here. But the repository. Are places that even stories objects and get them back over time. Based on the identifiers. And it's independent of the systems that are holding him. Because it's just an interface. Protocol and. So you have commercial storage cloud storage. Gravity storage in the future whatever it is to hold the interface only wants to deal with the end of ours. That's all of them. And furthermore the interface is such of the last interoperability between any systems that use this with like T.C.P. IP in a way. So two systems want to move things. They can one take actions they can't all based on identifiers and afar as for the actions identifiers of the targets. Things. And it also allows you to not have to store as objects. Everything that could be drawn from another object so if you have a movie. And you want to only get the first minute of it. You want to have them what object that's the first minute in the movie and other objects as the first two minutes and for the first minute the fourth minute. You're just saying. Here the parameters and I want you to play and skewing it. So repositories are places where you can store digital objects. Second thing that's important to our register he's well. Repast a tour has a registry so you can figure out what's in the repository. But registry is also useful for the finding collections of things that might exist

elsewhere. And those are based on netted a records which restored reponse to Tory So the two are sort of now intertwined. You can use it for what's just there or for what's more global. Either way you've got my den a fire from somewhere. So the identifier. Might say. Len take a look at it at this thing with this identifier or maybe the registry comes back and says here's the identifier for this document from one hundred sixty two you're looking at sorting out identifier. So when we did this with the D.O.D. they said well we want these identifiers to basically cryptographically generated so there's no information in them. So you know how this identifier and. Let's say for the moment it's cryptographically generated. What can you do with it. Answer is nothing unless somebody tells you that there's a place that will tell you something about what this means. So there's a resolution system. Week we called it and then it was handles. Generically their digital object identifiers. And the publishers you mean if you look at any. Major public you know the looked at and I Tripoli publication lately. You'll see the site all the articles as digital logic then a first look at an E.C.M. Journal. Deal wise that's the technology that we've built. So you take this identifier. And you give it to the resolution system. And what it gives you back. Is state information about the object. It'll tell you here at ten places on the Internet you can find it could be IP addresses in the future you could be whatever. You're using there. And maybe I mean before be six or maybe some completely different. In the future. It might say hey here's a public key cause you need unlock something or validate something. Or maybe this is the digital object that has to do with with you just wants to know what's what's the public key that goes with. Well. There are probably. I don't want to two hundred million. Did to lob jacks that are made available by the publishers. This way. And goes back to want to mean I AAA have a contract with cross raffle which those this is a business they create the identifiers they create the meditated. They store it put it in the publication so when you get a publication online. It's all clickable. And it's persistently clickable so you never have to worry. If you came back and I wondered years and you clicked on one of these I AAA think it'll resolve. He even though everything about the Internet may have changed in the meantime. We tend to make our software available free open source. So you can download all the components. Hope and source so they were right now there are three compound it's in there was their reponse atory software. The registry software which we're going to integrate. So will be one package it can do both the handle system software which YOU to all the handle resolutions. With or deal wise or you know it's all the same. And we're in the process of specking out with the R.T.A. the type registries that. I think the whole community will use. And where I think there is a very broad acceptance of. This isn't. There's no other reproach. That is as comprehensive the guys at Park are trying to come up with one. It's the. Then Jacobson stuff on contra content centric networking. But they are there decades behind us in many ways. And what we've done is we've gone international. Because the question has been raised. Originally by the Europeans. About with whether. They would be able to make use of that within Europe for all of their big day that research they the stuff. Research Data Lion says room with the effort set up by the U.S. Europeans and Australia to manage it. So they're looking at that issue. And it's being led by Mox plank in the case of the interactions with us. And so they said well what happens and see in our manages this whole thing and we have for the last twenty some odd years. That is the identifier part of that's the only part that's managed. Right now because the information is all generated. You know what we do is manage the system. The way hits like U.C.L.A. I'm sure. Is using the system. In your library because almost all the libraries or what U.C.L.A. does is it registers. Once you download the software for the identifiers. It basically creates a public private key pair you keep the private key never see it. It generates a public key and puts in a site bundle were you brought up the software. Sensitize census. Could you please register us. In the global registry. And oh by the way. Give us a prefix to use for purposes of our in the straight shot to the way. You distinguish your identifiers from somebody else's. With it so U.C.L.A. maybe gets the you know thousand and ten. And so you can name everything one two three four five six seven and somebody else to do WANT TO three four five six seven. How do know it's your one versus one. The prefix and so the precinct think of the like network identifiers. Which is his for routing things. But you can do whatever you want post. Behind it. So given a prefix the way identifiers constructed by the party has authorized. You put your prefix in front of flash. And then any string you like after that anything in the scene UNICO through me a foreign language or whatever out of the system just resolves a bit string. And you get the the can all work or you put into the system. So whatever you wanted somebody you

know about your record. So we're hand out the identifiers you get to do them. You could call this one contract the Swiss. You could call it one. You could call it. Crypto whatever system. Though that really care and. It's been on the internet for twenty years we managing it twenty two actually going on and so we got approached by those guys in the film A What happens at sea and I goes out of business. Then what I said well I'm sure it's like. What would you do on the Internet than a. If I can went out of business. The you think everything would come to a grinding halt. You know you've got to know something to take over and managed. The IP addresses in the dim that's all going to happens to be a different group of people imagine. So if we went out of business. Somebody else would figure out how to do it because it's too important. You know. And so the lots going on for us and. So they were happy to know that we would have a plan and we're going to plan with them. And we got approached by some other countries including some that were not terribly supportive of the U.S. being at the core of anything. And they said they'd like to use it to but only if they can manage it. And I said well we can't work that out. So to make a long story short. What we ended up agreeing with a lot of those countries were more most comfortable with the I to you playing that role they trusted the I Do you has been has been at the core of a lot of the controversy because the folks in. And I can others are concerned that I do you might want to take over what they're doing. It said no you know. But practically speaking a lot of the countries would like that to happen that is going to happen. Because the U.S. position is firmly about the private sector being in charge of that. Rather than a governmental control body. But here we are with this thing and so we finally got agree with everybody that. That they would be a foundation in Geneva to oversee it. Think of it like an F.A.A.. But the actual operations will be through a distributed set of the ministry Toure's around the globe. Of which we will be one. But there will be others who could potentially be many. And they all have to coordinate and collaborate in a secure fashion. To keep the system working. Reliably. So then you get in to these questions. One was. You know well. Who gets to pick the next administration five the star who picks the six. You know we've been doing that all along so we said well we would be happy to do it they said no the Sunday sions good idea because if you can do it under policies that we all look at who gets assigned all these records because P.K.I. is that the coup at the core of the security parts of what this happens. How this works. And we said well we've been doing that since day one we could continue now that gives you a special role. The foundation can do it. And then comes the showstopper what happens that foundation goes out of business and that that's been the hardest political not the work that out to the satisfaction of everybody. About what happens in that mode. And it involves the Swiss government getting involved in I.T. recommendations on the board of the foundation and so forth. I think. I think that's why. Actually a lot of it's legal and my wife the traces been that the core of trying to sort out the legal stuff. In fact she's been pretty heavily involved in a lot of the architectural part of that. Looking at a little legalize. And so we have something and very workable right now. We have the foundation we have the. These multi premier administrator set up. And it's going to get rolled out. I think this could be much bigger than any of the current Internet governance. Questions that were know having. I'm getting older. Of this. And well you know the things we're doing. I guess the biggest issue right now right now that we have to remember what Moses was OK. So Moses. The end he was a big player in the keep was proud of it too and he was there. Well most of us was at was actually my project. I ran the that was another thing I started DARPA infrastructure and. That was intended to lead people in the university. That was part of my motivation for getting the university's read up because they were really in deep funk at the end of the seventy's. That suddenly let the university get more involved in this deal of thought revolution for the you take ideas about computer architecture and design and actually work out and get things fabricated. When. Before that it was almost impossible. I mean even if all of the design rules were publicly available would be impossible. Because no human can you imagine a big foundry what he did with a lot of researcher I mean teach him how to work with them and for which you know I mean money to pay. When about. So number of years ago. DARPA tried to get the memes community in the United States. Which is the micro electro mechanical systems guys guys who make chips of moving parts. To provide a similar service that the design community in the US and help grow the community. And I couldn't agree among themselves who was going to be in charge. So was it MIT in charge or was it Stanford in charge lose a case. North Carolina Michigan. Berkeley I mean the the they try for years. They could be any progress they find. So

the. They came to us and said Could you help in the center. Be happy to try and. So we hired a guy who had expertise in that island. My expertise from what we did with the Moses stuff. And we actually built a capability to do that so we've been running something called the men's. And now it's meant as an adult technology exchange for the last fifteen years. In support of the research community. And the biggest challenge I have right now is to figure out how to make that. Self-supporting going forward because most of the support for that community came from DARPA originally. When they cut back on that this question has hurt really badly. There isn't a big community that's able to do that anymore. It's still important. And so that's one of the challenges I'm working on the phone a personal technical what we've got all kinds of interesting things that we're working on that one example we just got funded from N.S.F. to help figure out how people can generate a made. Generation amenity the records for research data sets. So let me tell you the problem here. There was a memorandum. Out of the White House. I think in her early two thousand and thirteen. That mandated that all. Research were from several funny how to be published because maybe some period of time it had to be published and made to be a liberal. And some of those have. Simple things like a Charter table it was generated by a spreadsheet. But increasingly people are going to want the backup data to it. They don't want the table I want the spreadsheet to and while do you get the Excel version of that maybe then the Lotus one two three. So there's a question of. It's that gets back to my digital logic problem. So the question then was how do you. Centrally make that available. Well to be some part of that. That the publishers. Digital or otherwise are willing to make available. But a lot of what goes behind that are big research data sets that exist in the home institutions of the researchers that they never plan to make available than they may hold or whatever and so on the whole question and suppose there is a big dataset it's that U.C.L.A. or no idea whenever I look at all kinds of stuff about research that you did on. You know the atmosphere. How does anybody. Understand about what it is so that you can actually get into it. And so for the purpose of making use of that data set and so you know you're not going to go to Google and say. Search on research data sets for such and such and have them know because it's not a visible data set they can scrape it and really I don't know what method they know the collecting flee you know what usage people are capable of making a. So we've generated. It's sort of like you know. You can argue that it's hard to create net the data for normal stuff like. Let's say you've got a collection of digital material. You've got five hundred articles and who knows how much other stuff letters and whatever. You could sit there one by one and you could create the meditator records for everyone but it's pretty tedious. And you probably know what to do that and you probably won't get it right anyway. Yes you can do this to say well heck with that. Let's just index on key words. You can generate that minute they don't automatically put it on the document. But then so he doesn't remember what key words you used to mean you used. The U.C.L.A. machine and they're thinking to host computer and they can't get any matches so they can't find it. And so the thing that we get funded to do is to build an automated system for generating med a data for these research data sets. Without the need for. Researchers to create them at a date in the first place it's and to do it automatically based on transactions those like you know all that. That data that the phone companies can get on phone calls its collective a manic Lee. You know that somebody's not pray to say OK let's rock just call the Bob Carr the asking about such and such so let's put a record and then just automatically put in and so the question is how do you do that for these large data sets and that's what we just kept on the deal for that's going to be an interesting challenge. We're making major progress on on the design and building a pipe or just trees. Because you're going to lob jacks you going to want your own way to describe it. You know want to have to find somebody else's notion of what a pipe is and how to fit it in. You want to be able to create your own have them understood different languages and the like. So we're doing that will put the temperature astri's software up like a Oracle database for doing that and hope for shade that says what is tight have to look like. And you create your own sites. So we're doing that. So when I started at DARPA and. Agreed to get into networking. It was sort of just me running the program. And it was a technical program. And I invited them to come and join. Of the DARPA. He formally got hired by DARPA in his August of eighty nine hundred seventy six. At that point. The programs that I had been running I turned over to him to run. So he then took over running the unit program at that point. And I got into some of the larger issues involving the office like trying to design the deal if I program

and things like that. I was also the deputy director of the office at that time so. You know that was very active with the community. And he works with the community very well. And I remember at one point. Just having this discussion with him about what happens when the amnesty you see. You know I'm back in the soup again because then I've got to take a where your do and get back in my head again in your very good at keeping me apprised of what he was doing. But much of what he was doing was you know working on a lot of the. The details next steps. And the like and working with people in the community. So I at one point went to him and I said you know I think I'd like you to set up a kitchen cabinet. From the community that you relate to want to regular basis what you're thinking I wanted them to sort of have a map of what you're planning. And he didn't take to that idea very well. But what he did do is came back with an alternative suggestion and he said look we don't have a good way for people to figure out had become part of the Internet. Because in the in the last part of the one nine hundred seventy S.. You know you want to get on the Internet. There was no Sun Microsystems. That will project the mind that he didn't start until years later in the deal as I program. And you therefore could buy a Sun workstation. You couldn't get everything put together for you you had a roll your own the add a go to maybe if you could figure it out and go to deck and give the Ellis Island and buy some interfaces. Get some software program it is a gateway. They are router. He'd have to go to somebody or other and get a T.C.P. protocol or T.C.P. IP package. Put it in your system integrated into the operating system so it could work properly. Hook it up to all the application it was a roll your own affair. And the question was how to get people to know about that and get them on the internet get into that sort of going big time like that. So he came back and said Why don't we set up some kind of a group then. We ended up calling the Internet configuration control. Group or consortium. I forget the exact name to it. And that's what happened. I think it's called the I C C C or something like that and vent to responsibility for United thing that Dave Clark. Took the responsibility for chairing it. And for a period of several years. That configuration control. Group basically kind and managed. The public knew of what was going on and work with dense. They had collectively of view of what was going on internally. So funny it happened of it I could have taught. Turn to that group and they would have been a knowledgeable active. People that were involved there. I remember the exact number but it was something on the order of ten or twelve. And so that ran that and in. Shortly thereafter I brought the following Barry liner on board. Area just a few years ago got a Ph D. from Stanford and he was very knowledgeable or that radio systems. So we turn the pack radio program over to him but kept on with the Internet program. Barry started some survivable network stuff and. So that went fine until I would say nineteen eighty two so bit left sometime in late one nine hundred eighty two to go to M.C.I. where he became involved with the design of M.C.I. Mail which plays a story in the commercialization of the Internet later on. So it fell to me to do what I was most worried about. Namely take over for the unit program again. So I would share these meetings they were called they were meeting so. Typically maybe dozens of people and their silly. There was an international one that Peter Kirstein was involved with. Sometimes these would be a packet satellite meetings we bring everybody together and we had one of these you know. Configuration controlled by meetings but they were basically way to the community understand what was going on with DARPA thinking. When I took over the number of people who are interested in listening to these discussions were very large. And you probably get some disagreement on what do you that numbers were but I want to get through was two or three hundred people. But when you try to have a meeting like ten or twelve. Let's say they were twelve people. And you got to figure out a room for three hundred nine by three hundred coordinate that. It's a big deal. But that's what I did. And then in during that year. After that led by train Barry liner. So I got Barry up to speed on the Internet the protocols in the issues and. And I asked him to take over running at that point so he took over some time. I would guess late one nine hundred eighty three but sometime during that timeframe. They've Clark was still chariot. And somehow and this is something you can ask Dave about between Barry and they have. They came up with the idea of not having to invite all these two or three hundred people to a big meeting in. And rather to let the topics that we're talking about be partitioned and let those partition meetings. Occur wherever around the country. They want to talk about you know. Security. His immediate security and privacy and privacy right out of the systems routing whatever it was so they created a system that had ten working groups and. It was all part of something called

the Internet activities board. I.E. be. So that was created to replace this Internet configuration control board I see C.B. That was the actual name. The became the I.A.E.A. be. Again. Now Dave Clark was in charge or running it. But unlike the previous one word this is really just a vice and what DARPA was thinking. We gave the I.E. be the responsibility be free to oversee the working groups. So we handed over summer. And Barry was more of a party was helpful and that was more hands on. And then they were really understanding what it was planning and he dinner act with them a lot but that was in charge in the New World. They was there and charged with the be reporting to Barry and we provided all the funding so ultimately we could probably strongly way into any of those discussions that we had ultimate authority and what actually happened with the with the technology per se the I be so. Took on a life of its own. And that went on for a while. That actually worked fine until such time as one of the working groups. Original tasking expired one of them was working group called Internet Engineering. One of the ten. And that was chaired by a fellow from DCA. You know. I'm not recalling you name right now. But their job was to maintain the punch list for the Internet. That was the job of that group. As these are engineering task paths design and architecture. So Sam through this is broken and U.C.L.A. that is not working and so they. It's like when you buy a new house you know this door doesn't closing the you got a drip on the Think of the foliage broken. So they were trying to get the internet up and sex. So that was job of this. This group and by about one thousand eighty five or so that was pretty much on the lawn and nothing left on the left. So in the interim the number of working groups. Through the A B. and grown from ten to some bigger number. They've can probably tell you the exact number I'm ganna I guess it was more like that the about time. The idea would have to charter everyone but they could work on different topics and the I didn't want to worry about fifty working groups. So the they charted this internet. Task for this inner working of become sort of the task force overseeing the working groups and that was the start of the whole idea process. So at that point the I.E.T.F. was so. Servian to the I.A.E.A. be and the I.A.E.A. be operated under the auspices of DARPA. As it were. They also later create a thing called the I R T S The research task force which would deal with more researching type issues than. They're both still in existence today and solely different structure. Well I left. DARPA. And Barry left about the same time in one thousand nine hundred eighty five. And at that point. DARPA decided to get out of the networking business for short period of time. The later got back in when all the fiber optics and supercomputer networking stuff. Showed up but for a period five. They had to clear their out of networking and so the people who were involved in the eye he suddenly didn't know. Julian. They reported. So they concluded pretty much and they were now I thought enough of whatever they're doing before they can just sort of continue to do but they never he was your report back to. Well. They were all funded by their institutions and most of the funds were on previous contracts that were put in place that had yet expired. And this was not the main job of those contracts. They were not to be a be member they were to study this problem to do have committed. Work on this networking research project. And so this was you know like go to conference occasionally and participate in these like that that is so. By nineteen eighty six or seven C. and I was down on his innocence and. Steve Wolf was running the networking program over there and Steve asked C.N.N. right. If we would be interested in running or running a secretary for the I be actually at the time. The A.T.F. was one level below. And then I talked about in our regional conclusion was that this is too much of a green eyeshade job. And N.S.F. was willing to take on the responsibility AND BRING IN THE MONEY. But they didn't want to actually do the. The running of it because so what we did was went back to Stephen said. We think you should find somebody else. This is not a research. Task it's too much of a bureaucratic green eyeshade job. Maybe somebody else could do in the face and all right. Go Through want to combine up. That out two or three weeks later he came back and he said you know I've tried and. I can't play a body that knows what to do a lot of people will propose but they don't know they don't know who they're dealing with these are people from all around the globe and. And they're either head into enough they. They just. They don't have to do it so would you do it again and so we you know it's an unusual for them to ask more than once and so we went back and said Yeah. We really think you should try hard it is got to be somebody around they can figure this out of the went back and a third time he came back in the said I've tried again he says. You know if you want us to go down this path are going to have to filter out here and so we finally agree. And then to agreed to take the responsibility for overseeing that I.E. be really the theft in fact at

some point he became sure the I.E. be as well but I'm not sure the exact timing of it. And I was at that point pushing gigabits. And I was trying to get you know N.S.F. interested in gigabit originally it started out with trying to convince them to run internally. That With way. My model but they decided not to started to push a one in they have megabit version number the ARPANET was still the dominant backbone out there. So they decided to push a one and a half megaman N.S.F. net which quickly became forty five megabit one. And they said we have no capability for doing exhibits. We can't leverage as we can buy it from industry. The technology isn't that out there but if you want to run it as a research program will consider supporting it so I ended up putting in a proposal to end the south to run the gigabit project that was a time when the. You know. A few years before the N.S.F. budget for network it was like seven hundred fifty thousand dollars was run by. I think maybe a liar shots when in the engineering department and. It was some small number of grants universities like. Maybe twenty four grants of thirty thousand each roughly zero faculty member in a student or two. It was not a big program. DARPA's budget was more than fifty million. In that working. When I when I left. So they said well why don't you do that and so we. And then a proposal for twenty five million dollars to run the print project. And amazingly as a put a program in place the supported they didn't give us all twenty five the most twenty of it because Pfizer that were research projects and they said they could handle the research because they just can't handle the test but part of that we actually ran the test that's of it ran that I A B P So that which later became mostly running the I.E.T.F. part of it. That's really where the work was. And later. Through some manifestations that I never fully understood. The folks in the I.A.E.A. be so they reported to the A.T.F. So somehow that they had their version. Somewhere along the way. I don't know how exactly that worked because I think the A.T.F. was better known and broader. So. It went for quite a while and still roughly nine hundred ninety than that and I started to talk about. What else needs to be here. And the question that was the it was sort of going international and we need a way to preserve the information and let people know what's happening. Talk about what's going on at that idea of meetings. So we set up. We decided set of something called the Internet society. And I actually saw the incorporation papers. There were three names on the original filing. Keys and I think you're going to harms who ran. Rare he was they had a rare and kin King who was the president and educate those are the three signatures but we put up all the money to actually create it and then made a passionate plea to Larry LAN Weber who was in running a set of Internet. Conferences for the called my net. What if you make them. Kind of Internet society. Conferences I talk to Larry as well as. Larry agreed and so that kind of all got bundled together in the Internet society got formed in. Legally and as an official organization and summer of one thousand nine hundred two. The discussion with Larry took place at the meeting in Copenhagen in something like June July or August of ninety one and the Internet society began operations as a holy holy supported activity of seeing a rifle for most of the one thousand nine hundred two is just one of our projects. And we raise the money and then when we formally incorporated it we took all the proceeds that had been brought in for membership. And we moved it over to ICE oc. And I thought now became its own organization but still had no staff. So we had a secretary out agreement with on the scene or I would actually run the secretary of for I thought. Which lasted for a few years until there was some question that was raised. We don't need to go into details but it was raised as to whether the support from the government which was now coming through N.S.F. the support the A.T.F. activity which the. That's all they really saw at that point was somehow being diverted to the Internet society. And we said No and none was. But to make it clear and to satisfy their needs for clarity. We decided. Invent the cited he wanted to stay with the Internet society we moved it out. We actually signed the lease the papers for them at a place on the Y. Actually week. Find the. What do you call it when you. When you guarantee. Yeah. So they signed the papers. We had a guaranteed. So they moved up. Sunrise alley drive here for a while and we continued to run the secretary of for them for a very short time and has as they start to get real staff on board. Then they took it in that we ended up. Secretary up there. What happened was we need to agreement with them to eventually get off the Internet society board. As we the three charter members were rear intercom and C.N.R. I got off the board in my eighty six I think it was and the agreement was that we would concede around the I.E.T.F. stuff. They would continue to go there only but we. Would agree to give up our seat on the board which means that. And so that was the way it was until sometime later this year. When the number of people in the I.E.T.F. itself.

And elsewhere felt like they ought to be running the A.T.F. themselves. Why a senior I still involved. And sorta like saying you know you from your child. Why are you my parent. You know. You know you know ask me. He said well look we created this whole thing we're funded by the government to do it. But we ended up. But agreeing in the final analysis. To transfer the responsibility to another party which happen to be new store and of the street. Up the street meaning in in this general area. And they ended up writing agreement with the A.T.F. and we have a signed a three party. Agreement between I.E.T.F. I.E.T.F. folks the new START folks and C.N.R. I. We we had a subsidiary around the now there's a rant called Fortec that was actually running the A.T.O. Secretariat for us. So we had kind of only six different parties in one way shape or form all having to agree on what the next step forwards Patrice orchestrated the whole thing. Legal Agreements were pretty amazing in the back room here we have like. I don't know how many law firms. Simultaneously. So that's another interesting question and that's all right. But you know. DARPA was never interested in running something in perpetuity. It turned out they actually supported the ARPANET for almost twenty years. And it wasn't decommissioned until nine hundred ninety. In the last No but up in bed the decision like a year earlier. But during that latter part from roughly one hundred seventy five on. DCA actually took the responsibility for running the ARPANET. So our program it internally we I mean a contract with different parties B.B.N. ran the operation center we contracted with a T.N.T. for communication lines but the actual agreement the transition the responsibility for operations to D.C. occurred in one nine hundred seventy five DARPA kept policy control. D.C. contain contain the operational control. And I actually. There were two parties to that they were awful actually was responsible for writing the agreements between Star and DCA but I was directly involved in doing that ago she asian. And the negotiation was actually done with the office that Harry the entries are in which the office of the chief scientist. And Harry didn't actually get involved in the actual arm wrestling over the arraignment or. In terms of whether they should do it at all but he was behind the scenes were some decision maker. Me How to make the decision and he had a cell up the chain at the CIA. So I guess it was maybe. Lee Pascoe who was running in an Air Force three star at the time. On whose blue ribbon panel and wanted them to I chaired. And they were dreaded decide whether to do audit into where you are been a technology. But. Estell and I did those negotiations a bit. And it was so much a negotiation it was trying to try to somehow have the motivation for DCA taking it over. Kind of articulated better. Because when we started to say want to know part of that. After they want to kill the ARPANET because they wanted no part of packet switching. They thought if they need to the new net. Fast circuit switching was the answer. Apatow I'm the part of the Pentagon that overseed the CIA or think you buy. It may have had a different name than ever for a while it was called the tax. And then it was called. You know he as a D.M. C.Q.. They had various names but it was the same organization the Pentagon. That oversaw that them and probably a lot of other things that you would know and. They had been persuaded that. Maybe packet switching was a better solution than fast circuit switching which is what DCA wanted that a whole plan to do that that was supposed to be hotter than two. So C.Q. dying commissioned a report at Lincoln Labs wrote in the lead author on it was Erwin Lebo who later left Lincoln Lab to come to D.C. to replace Harry. Then treason Steve scientist. So early in this report call for a thin line that we're using Arpanet technology. Because the ends were out there. And you know I don't have it in here and then he more. Probably couldn't even get it if you want it. But it basically put put that forward. Well DCA wanted no part of that. Now that we're winning the street finances the over there. And he's got a problem because the internal stablish Mint over there. The want. His reporting always to fight the. So they are instructed by C.Q. die as I recall. To take another look. And so C.Q. by Takes another. DCA takes another look at the position that they have and they somehow come to their pollution Well maybe packet switching is a good idea for all. I don't know how it happened. I was not part of those discussions. But that's the conclusion that came out. And as a result of that. They took the particular meant. Solicitation that they had prepared for fast circus switching. Which I think was. I don't know if it was in final stage or just a draft or just the internal notes on it and they produced a solicitation for something called audit into. How did into was to be a packet switching that. But of course. By doing the procurement themselves they thought they would get something that would serve military needs. Because how could a research thing that came out of DARPA. Actually by by accident happened to serve all in it so the and. It was a kind of as opposed to

a widely distributed system. With you know the kind of linkages that could Arpanet have this going to have a handful unknowns. Like six or eight of them. You know one in Denver one in Chicago when in doubt if one in Washington where they were just a handful of places. And they were heavy duty known staffed by a lot of people. And they were three shifts at each place because you know how could you leave the ARPANET node equivalent in there and I had somebody attend to it so they had big stamps. So is a very expensive thing. And they finally ended up awarding the contract and they gave it to just think you know I guess it went to the. I T N T. I think it like for proposals that made it through the clip. And they had a ruby if Ally was not part of that review panel. But the came back and they made a recommendation and so the director of the CIA put together a blue ribbon panel to review the recommendations. And I was the chair of the blue ribbon panel and my first question to my. When I looked at what they were both think. And and. We actually did a review in one of them was eighteen he was one of the party isn't puts a minute. We looked at it. Maybe it was Western Union I forget whether it was I.T.T. or Western Union at this point. It was one of the two. In any of that. The proposal that came in just like that are critical if you would have been a better choice. As I look at it that they were hung up on. You know security and the couple other things that they didn't think. Came with that system. So I remember. After we went through it. I have all the notes and then the detail I met with the head of the CIA And I said there are two conversations we could have conversation number one is whether the whole point here is a good idea or not. And the other one is given that he want to go ahead with particular event. One of the comments we have on the different polls. He says I don't want to have the conversation about whether it's going to be our guys want to do this if we don't do this you know we got to do this. That was basically the bottom line. So I don't want to hear anything about whether this is a good idea bad idea it's done. We did it we put the procurement out we got to provoke. I just want to know your evaluations we went through them. And I told them what my concerns were. Well the one. I mean. Probably a wall a group eighteen team might have been able to do the best job. But they sent in this really tiny proposal that says we're eighteen team we run the biggest network in the world. And you know obviously know how to do all this stuff. And the review panel that redo it basically said you know. They didn't tell us anything about how they would do this or that or the other thing so they got very low ratings of things that they were probably most qualified for in the country. Just because they didn't write the fifty pages on how they're going to routing or how we're going to back up your alley we're going to do maintenance some of those other proposals were much thicker when it's a gory detail. When they're probably inventing a real five for the first time but so they worded the contract and it. They built it harder than to deliver to the government. Sometime after nine hundred eighty eight don't remember the exact date. And one day later they cancel the contract. So I guess the most of the Western Union they were looking forward to making all their money on maintenance upgrades and operation of the system going forward. And my guess is the government canceled it so they wouldn't. They would say OK at least to complete what we have to do so but then it also got involved in. OK now what are we going to do and they ended up using Arpanet technology. But by then they have the blacker system up and developed that we're dealing with security unlike So that was for. And they go Sheesh and between that DARPA kept the policy. Control during that whole period. DCA still more along the line lost their appetite for the jungle or decided they were going to kill a thing. And so they helped to sort of manage it little. Little by little was all managed by you know Petro here for space in Florida on its Shalako was the initial guy. There were other people that got involved. Later on I'm sure. They actually did a pretty good job until kind of. They got overtaken by events what happened in the early ninety's and the early eighty's was a D.C. A was. So when the the D.O.D. had decided to split Arpanet into two pieces at that point of which one part was going to be called Arpanet. And they had something like forty of the research community sites on a million a verse and he's and the rest of the notes which I think he was like sixty although it could have been forty six the as with the sixty forty were either military sites or contractors and how to be on that they could be better protected sites and. And by the it out all the Internet technology so we could connect the two of gateways although they didn't let him go free flow. Initially they were thinking he had to guard them so you could free flow one direction but maybe not the other. But that led to the creation of this military net called Millett he had no Arpanet which was a part of the old Arpanet and MIL that Woods was a part of the all are been that the mill that was part of a larger

construct they were creating called the D.N.A. which stood for the Penn State a network and the plans to grow the D.N. were so large in D.C. it would charge with doing it. When we signed. Some of the agreements with an S.F. to help them get on board. The Arpanet and the original They have just found that overwhelmed DCA they had too much responsibility they had grown from like sixty nodes the thirty five hundred knows in a short period of time. It was taking them twice as long to order things and they did before. And they have the personnel and were given the staff and they weren't given the support. So it was a difficult situation for them. But we somehow managed to negotiate around it but that was part of the reason in a self went through only. Well again I have to give the anecdotal and information because I was not part of the an S.F. net activity. I was not part of the N.S.F. decision making process and they didn't really talk to to less much well tell you the parts of it that they do know. In N.S.F. had tried to get into that working business in the early one nine hundred seventy S. cynical thread that. And it was blocked. And I don't remember what part of government blocked it whether it was geode G.S.A. or some other governmental body. But they said they should not be doing this this is a government wide thing if they want to do it should be formal for care meant. Through some other thing I presume that's what they would have said. Anyway. And that's stopped in its tracks. And by the end of the decade the ARPANET was starting to grow by leaps and bounds and a lot of the N.S.F.. Researchers who were supported by DARPA were kind of left out in the cold. So they decided to come up with their own plan. And they understood. Eroni Asli as it turned out that they couldn't get on the ARPANET. Because that was for only DARPA contractors. Via their asked. So they came up with a plan to create something called the C.S. net. C.S. net. Was going to be based on a newly created. Public network called Telenet that had just come into existence a few years before. So the idea was that in itself with supporters researchers to connected Telenet. What they really wanted then it was telling that to connect to our panet so that it was the new guys could connect to the old guys don't tell him that was mined out six kilobits an ARP Anet with fifty. But at least the connectivity would be there they hoped. And so I got an invitation from Kent Curtis who was in running the computer science program at N.S.F. to come to a meeting that Larry LAN Weber who was hosting a lot of behalf of N.S.F. at Wisconsin the next day and or to be cynically could I show up because they were going to discuss the C.S. nothing and they'd like the benefit of our input. First time and S.F. and asked. DARPA for anything. Because we were kind of the military guys and they were the good research guys with Dillard University community and they would not much given take between a seven DARPA during the seventy's. So I thought it was great you know reaching out. You know that's what I was interested in to. So I just be happy to come. So. Adam a pretty full schedule the next night so I can only go out for. You know I flew up in the morning. I got there like ten. And I stayed until like two or three. It was enough time to get the business done. And they were trying to figure out well how are they going to work with telling them that I said Well. Are you guys ever thought about just requesting fights on the ARPANET. If that be much easier. In the input whoever you want on there and they said. Well that's not possible unless that. How do you know if I thought I mean arrest. I said my belief is that if you made the request. It would be a no brainer to prove that I said you have to pay for it. I mean every note on the ARPANET. You know we take the total cost abide by the number No that's the cost is the cost of the lines in the quest to be me and to maintain it. And then the cost of machines was essentially trivial. I could have been there of course would be no difference and which the bought it by the number knows that's what the annual cost was it came to about one hundred thirty thousand dollars a year for one No but you could put multiple sites and they could put chips are there and they could have all kinds of the conduct of any so. He said OK I will take that into consideration and. But let's do what we plan to do. So we we left that meeting when they were going to go figure out what the N.S.F. There was I said I would be happy to work with you from a dark. Perspective. And what we actually did was then kind of find the technical task of figuring out how to make the interconnection work technically. And I took on the job of working the politics between ARPA and N.S.F.. They called back. Weeks later and said they had actually decided put four nodes on the ARPANET. But they want to know if that's going to be possible. So at that point. Now that they knew there was a specifically in hand. I went and I briefed it over it's a cute guy which had the control and seek you know I had a lot of issues and concerns. But in the final analysis we had approval to do it. And I told them and. So they said well you needn't tell us what the costs are as of this I wrote him a letter from DARPA.

You know Robert from letter. Harvest a sherry and said. You know pursuant to our conversation. You know if you wish to put the following nodes on the net. This would be perfectly acceptable and hear what the costs are to let us know that simply with the letter sent back in the mail from the stuff comes a postcard from their contracts office. Congratulations you've been selected and that it ISN'T IT IS A P I your proposal to the opposite is being funded. B M E A traitor if I get so that's so that I think of the top. So as my letter proposal was turned into a real proposal and that's that's how we got funded. So they put four sides on. But it's not what they they wanted because they didn't want to pay one hundred thirty two thousand per. So they want to go ahead with the Tele that thing and. So then we kind of work to get was the bit solved that completely. And then the question was payment. So what they said was you know. And S.F. will take the responsibility for paying for all of the air. All the innocent people and get on the C.F. that Bill control that. Minute mainly they're going to put the money in the contracts to those places. Although if it was like a research lab an industry that they approved. They might pay the money directly some help. And DARPA the assume would pay all of its costs. And I said fight. To deal. It's all one once while the. You have to pay for the cost of DARPA connecting to the N.S.F. that because that's going to be another account to tell him that. So I said Well I'll tell you what tell you what. We're I prefer not to but if you want to do that I'm happy to do that but then again we're going to charge you for connecting. Your side back to the ARPANET. And the way I'm going to do that and I'm going to figure out what you would like to charge us out of Detroit dead same in the other direction so we both write checks and problem. Larry Lamb lever with the middle of that and I think their conclusion was the thing to make a lot of sense I said exactly. So that was the deal we had. We didn't charge them for our stuff they've been charged for ours and. I think the N.S.F. and ended up paying for the connection. So that's that's all that work and so that's I went to that's the C.S. network. Until N.S.F. started the big program supercomputers. Was run by Dennis Jennings. And then US came to us and basically said. Can we put our supercomputers on the Arbonne it. This is one the issue with the CA had was. You know really running hot and heavy. This is. I mean the issue with with D.C. never showed up with the four sites. It showed up with. When Dennis want to put supercomputers on because really what he wanted to do is put a small number of supercomputers on and a lot of other people on the net to use it. The green that we had with DCA at that point in time. Was that they would continue to support our Banat member they had this huge load on them for the military stuff. But that we limited to something like no more than ten percent growth per year. So with forty nine or forty machine like maybe that support three four. Conceivably five new nodes per year. Then by this time very liner was running the program at DARPA. And even though I was holding the negotiations. John Connally. Had I think it was before. It was right after then it's generally good for I forget the timing on that. But he calls Barry and says you know what's going to happen and Barry says I'll find up. Well the CIA is pushing back. Because they're now finding it say he them eighteen months to get lines from. You know for their particular mints with the airlines and they'd be there busy anyways and not giving him OK now a tight deadline to Mary's going back and saying you know it's probably going to being Haiti months to two years. And this was more for for N.S.F. because they're under pressure from the government he have this up right away. So I'm on travel somewhere at this time so John tells Barry. You know who's your contact the D.C. area gives a damn of Fortunately. Johnson called the violence at the meeting to go talk to him directly. And at the very goes along because he told you about it and I'm out by then because I'm away somewhere I don't know that this is happening and. At the meeting John. Basically says we can't afford to wait. You know. When he gets right away and he say they've within our rights bill see what they can do to expedite. What sites are they and. John unloads like to fifty five new sites. Well. I'm. Straw that broke out of back and they said no way revenue that. So that's what causes them to go their own way down. You know the whole N.S.F. that could start out with a militant is fuzzballs little fifty. That the element that. They want to get the supercomputers. And we have to go approve that all I mean we actually signed an agreement with N.S.F. to do that was official document between the two and they were going to reimburse us a certain amount to pay for the share costs of the Arpanet. But and the biggest issue there. Quite frankly was. And this is a Pentagon concern. If we open up to putting these supercomputers centers it didn't show up with that little time sharing machines. But if we put these big supercomputer centers. This is still the middle of the Cold War. And the Russians happened to send people over

here could they do design of nuclear weapons on these university supercomputer centers. Well this is a total non-starter because you know. Nobody in the U.S. community in opposition was ever going to Russia and do their research work on a Russian machine or or vice versa. But they insisted I go to air walk and get N.S.F. assurances that that will not happen. Oh. ERYXIAS we can't control the universities. But when he says I what I will do. Put in writing is that if there's a U.S. policy on this will abide by the U.S. policy or law which. You know him to his you know this is they want to control who's coming over don't get the visa. If you know it's a nuclear scientists. Alone in the country in the first place but anyway. We had to work all if out the politics of it were interesting and complex. We finally managed to work it out. I want to the How exactly was it was a matter of a later domain and in part. It's really hard to tell exactly who was doing what but finally we got the approval to proceed but in there happened as a practical matter because N.S.F. time that went through my with. You know the. Well. I'm so glad you came by the not long overdue. We had to do this every fifteen.