Steve Crocker
Oral History
Interviewer: Leonard Kleinrock
Date: 08/16/2014

When he introduced. Some like. Way you or. Pleasure. So my name is Steve Crocker. Was a graduate student here at U.C.L.A.. Intermittently for some. Well for some long period of time which I'll cover in a second. And by being here at the right time. I was involved in the initial version of the Arpanet. This was of course the site where the first node. Was put on to the ARPANET and a handful of us graduate students were directly involved. Both in the work at U.C.L.A. and. What turned out to be. Probably more important. Helping to organize the community wide effort to design protocols and help each other and figure out applications and so forth. And then. And so I was here from. Summer nine hundred sixty eight. And then I took a break and didn't leave school officially but I went off to DARPA. What was then called ARPA. In one thousand nine hundred seventy one. Spent three years. There as a program manager. But purposefully stayed away from. Mostly from networking and focused on other technologies. And then came back to Los Angeles. In seventy four and still had my dissertation to do. And finally completed that in one thousand nine hundred seventy seven. So in that. Let's start with the U.C.L.A. and certainly when you hear what kind of a man it. Springs and its management and its. Well. Of it. Couple different aspects. I had come back from MIT where I had been a graduate student and was planning just to spend the summer here. Working in a group that Vint Cerf was in and working for Jerry Estrin. Previously. As an undergraduate I had worked for Jerry. And then I go off to MIT and. And I'd introduce vent and. Jerry bit was looking for graduate school. Vint had applied he'd graduated from Stanford he had come down back to to Los Angeles and worked for a while and he had applied to Irvine. And they had turned him down. Which was astonishing. And he wanted to stay in the L.A. area. He had just gotten married to. Sigrid and didn't want to move around. So I knew some Jerry that was easy and. So vent came here and flee the same time I went off to MIT and then for summer of sixty eight I wanted. One of the summer job. And it was instrumental in arranging a comfortable arrangement here and I came back for the summer. It was during that summer. That the ARPANET project. Spun up. There was a graduate student's conference that the DARPA office. Sponsored with graduate students from the different projects in the early part of the summer. June thirtieth July one in a linear way. And during that conference and Barry Wessler was there he was the only person from the from the dark office and tried to get us interested. All of us graduate students in the ARPANET and. It was interesting how little interest there was but it was. Not all that of much of a surprise because every one of us was focused on some other piece of research which all of which was being sponsored by the same office and. There was a little bit of interest some few people but mostly not. And then in August so a couple months later. There was a meeting called at Santa Barbara. Elmer Shapiro. From Sri came down to lead it. And a handful of a couple of representatives from each of the first four sites from U.C.L.A. Santa Barbara. Utah and from Sri showed up. And it was the first time that the idea of this network. Became real in the sense that. Here. Here we are getting together to contemplate what we're going to do with this. The. I don't remember the exact state of affairs

for the our P. But certainly B.B.N. had not yet won the contract had not yet been. Selected and. But we knew it was can we knew that there would be a network which is you know the precise details. And so we had to begin thinking about it. And the most important thing that came out of that meeting in August. Was a agreement that we should keep talking to each other and followed instantly by decision that we would visit each other's laboratories. Which we we knew. That's all it was all one thing we. We knew that it would be useful we knew that it was important to do. And we also knew that it was entailed a certain amount of travel and which was ironic because they were really supposed to allow collaboration with all travel and. And as you know then eventually my travel got to be so expensive you had to get a contract modification just to support my my travel. So that was. That was the beginnings and then there was a series of informal meetings as we visit each other and began discussing ideas which I'll come back to another time. The. So getting back to your question about management style. There were two or three aspects first of all as I said I was officially working for Jerry Esther and he was at that time I think still the principle of this to get or for the contract. Vent was working for him and handful of other people. They. And then. I don't remember the exact timing I'm sure you do land. The management of that contract was moved over to you. So from my perspective as a graduate student. I was reporting in a sense to two different professors. Jerry Esther remained my thesis advisor. And you were my formal boss from a contract from an employment point of view. In neither case was there a very heavy hand at all. We were. We had a lot of freedom. There wasn't. I'm sure there was awareness of what we were doing and if we had gone way off into the weeds somewhere I'm sure that would have been some some guidance but to very large extent. Our initiatives both in terms of what we're doing for the ARPANET. And what we're doing in our own research we're encouraged and nurtured rather than directed with heavy hand and stream a positive environment I mean that was. I had been as a set a graduate student at MIT and I had found that I wasn't fairing well. In that environment. It too was an open environment with all of the law not a lot of direction but it wasn't very nurturing. And when I spent the summer here in sixty eight at the end of the summer. As I was preparing to go back to my he which was the. The basic idea found that I was fretting a lot about that quite a bit and I went talk to Gerry and he said I want to come back here. Make it very comfortable and spend another few days thinking about it and said. Yes I got to do that went back MIT closed up the apartment that I had sublet for the summer and said goodbye to them and came back here. Class. Yes. I want to live. Here and close to. What was in nature. That interaction. Cross boundaries and management of the jobs. So a long time ago after a member of the pieces. So the graduate students. There was a there was a substantial number and we interacted interacted more closely with the few and less with some of the others then and I went up sharing a cubicle in thirty eight zero four. John Postel was there Mike Winfield. Charlie Kline had been an undergraduate and. Don't remember if and when he became aggressive soon I don't recall him being arrested but he was active. Part of my recollection issue is that. I went off to MIT in January. In the January one thousand nine hundred eighty seven and Charlie was around then to I think was around. And there was a task to do. To implement a an algorithm that I had developed when I was working for Jerry before. And I remember vividly we sat around estimating how long it was going to take Charlie to

implement this. And the and the. The estimates vary between six months six weeks and six months. And I came back here and Affleck are still wasn't done. And there were a bunch of reasons for that and they were all sort of ordinary but I just remember that sequence of events and. And then of course you Len had a whole sequence of graduates and say these are many other names are on there who were. From my perspective. Extremely strong in mathematics and somewhat theoretical as opposed to oriented toward building systems. And so there was just sort of a bit of a distance. Not so much. You know forced way but just in terms of where tension was. Meanwhile we were busy trying to bring the Sigma seven up to speed. So the Sigma seven is a small story that might be worth including here you can cut it out. If you wish. The computer science department was in its earliest stage it was just in formative stage. Across the research community. Timesharing systems were beginning to show up. Not so much in the mainstream. For campuses but certainly in the in the research environments. At MIT for example they have had this modified seventy ninety four that turned into what they call the compatible time sharing system. They have this massive project to build a state of the art times a sister called Multics down the hall in the Artificial Intelligence Laboratory. A group of very bright kids. And they were they were kids in many senses of the word. Built a very efficient and very slick operating system called with a certain edge on it the incompatible timesharing system I.T.S. using. P V six which was the same architecture as the P B ten in the Deck twenty. Later years and. There was money available. Apparently to buy a machine and. I don't know all of the decisions that went into it but Jerry had been impressed with scientific data systems which build very good hardware. D.S. nine thirty and ninety three hundred and so forth and. Probably less impressed with digital equipment's equipment at the time. And he chose to buy a Sigma seven so S.T.S. had been purchased by Xerox. And it became Xerox data systems and Xerox than brought out this line of computers the Sigma five and Sigma seven and so forth and so we had the Sigma symbol the operating system on it was sort of a different era it was basically a batch processing system and we knew we needed a time tree. System so we sat down and tried to designed from scratch a timesharing system to put on there and pattered it roughly after the incompatible time show system which I knew something about the internal design. We found that there was another version of an operating so another time sharing system up at Lawrence Livermore Laboratory. The Butler Lampson had been introduced to meddle in helping them build. And we took a look at it decided that they were ahead of where we were scrapped what we're doing took a copy of that and put it on the Sigma seven. Continued to make some modifications of it and after a certain point. They had called their system gordo. After the cartoon and. At some point we decided that we had made enough lot of cations that we could choose our own name for it. This will come right back to your question about management style in a minute. So that was the activity that was taking place in fall of sixty eight. Pretty much as we were putting all that together. And then we had to think about what to do in from a network point of view what do we how we're going to connect. Machines together and have these different discussion. So that process and the small group of us. U.C.L.A. who were working on that kind of self formed a team and. I'm not sure how it happened exactly but I affected became the defacto manager of a but I don't think that with formal appointment I don't think the piece of paper that was ever created or an org chart or

anything. This was at U.C.L.A.. This is is this is just the internal to U.C.L.A.. Piggy Sealy was a member of that team she went off and married fridge Snyder who was the systems minister for the seventy ninety four I remember. There was another woman. Surely or sherry redhead. Interesting personality. Maybe somebody else of Bill Miller of course. Stan was. I met him because he was a high school student and I had previously a few years earlier. Been teaching. Programming to high school students different story different time. I came to U.C.L.A.. First as I school student and then started as a freshman in sixty one. And quickly was involved in the computer club and created a project to go teach high school students how to program. And we visited the local high schools. Uni and Palisades and others. And then set up some classes and invited. Ice cool students to come to these classes. And so we ran. Seven sections three two and two in Fathi a similar language and five in Fortran. Three or four of them on a Friday after afternoon and the rest on Saturday morning. And the sofa all up in the business school where the computer club was at the time. We were over running Western data processing center. Talk about challenges to management the the adults there. Watched all of this and were alternately. Really enthusiastic about the initiative and the all these unkempt kids running around it. What was a more buttoned down environment. Professor Charles Brown Tompkins. Got hold of me and he said in effect. His words were much more genteel but he said. Nice try kid. If you want leverage on this you gotta teach teachers. And then they can teach and the next thing I know he's arranged a course to be taught in extension with and funded. So that they students which were high school teachers could come for for free I think I know too much. And get credit for it. And next thing I know on Monday and Tuesday evening for a whole semester. Four of us including. I think Bill Miller. And I were writing notes furiously all week and then teaching that material that evening money to see night. And. And then I made one of the mistakes of youth I said. It's great to of teachers we should have a few students. High school students sit in so that the teachers will be able to see how the students do. Totally backwards the students of course out shine the teachers. We kept grades and they did a whole great point better. No book full of all the data and. And it was intimidating to the teachers. So I was an important lesson from that point of view and Lieberson was part of that. Member. Tony go mass and we hired. We did talk. Well. We needed more help and. Tony showed up and. Tony Tony had a reputation for breaking into systems. And I had the thought that if we brought Tony to the inside of our group and gave him the keys to the kingdom. That it would remove the motive motivation. Now. Probably one of the things that. That was part of my thinking was that an MIT. There were hackers and. They had dealt with them in a smart way. By making it easy to break into the system so in the incompatible timesharing system they had an instruction called gun and execute that you brought the system down. And so they said look we'll make it so easy that it's an interesting. And it was a pretty pretty smart thing in a way. So brought Tony and. Tony unfortunately. Was good at breaking into things and he wasn't. That's that was what his interest was. And he didn't turn that into how to be constructive. So he took the knowledge of how the systems work. But he was unable to do all that so it was a but I checked them out and did some reference checking and I called over the main campus. Facility where he'd been banned. And I said yeah but how they sit stay away from them. And I said. Yeah but tell me as the smart as you know

anything to get him out of here and they could not have a coherent conversation they just mention his name and they were hanging from the rafters. We brought him in he was it was the sweet kid. I remember vividly sitting in the one cubicle. Planning to go away for two weeks which was a long time for travel related to the opera net. And I'm turning the management over to Bill Naylor. And I had previously had several conversations with Tony. You know this is going to work and you know and sort of put him on probation in a sense and. And then I told them. One point the got to go and he gave me a sob story about his girlfriend and everything in sight. Will give it one more shot. And I'm having this extensive conversation with Bill Naylor turning over of one piece after another and telling what state of affairs is. And I could see that he's waiting to hear how we're going to handle this and how he's going to deal with it. And Tony came by in its usual happy. And stuck his head in. And I said Tony you're fired go check out and. It was a very almost casual throwaway thing and I turned back to Bill and Bill what. You know like. Problem solved it just disappeared like that. So. So it's a lot about Want to get. Yeah. So as I mentioned. The first decision that we made in that very first meeting of people from the foresight to is that we should talk to each other and with so we set up. Series of meetings that each of our sites to visit. Partly to get to know the work that was going on of each of these sites and and and to get to know the people and each of them. And then during those visits. We would have free wheeling. But as. Focused in and. As intensive discussions as we could have about what we're going to do with this network and. So the basic environment that we're working in as we did not have a spec for how this network was going to work. Because as I said B.B. and Henman chosen in even after B.B.N. was chosen it took them a little while to to design what the interface was going to be. So we had a rough outline. You mean. We knew that there were fifty thousand bit. For second. Lines connecting the machines. And we knew it was going to be packet switched. And that was that was it basically. And then we knew a lot about our own systems we knew about timesharing systems we. And we because we were not only U.C.L.A. but it each of these other places. Reasonably up to date on the state of the art with respect to programming languages and compilers and operating systems and so forth we we were comfortable with understanding what our environment to look like and then we could try to imagine how to hook up this communication thing. Machines of those days. Tended to be. There were designed if they were the center of their own world there was no obvious natural way to connect two computers together you could bring two computers of the same design same manufacturer together. Or different you put it next to each other and the only interfaces that were easily available. Were as if they were the master and. There were peripherals whether it was a disk unit or whether it was a tape drive or teletype or printer or a card reader. They were all things that responded to and talked into. So there was no peering. No peer to peer kind of that when you have those words in those days but. So that was one challenge to think about just from my architecture slash philosophy point of view and others question what are we going to do with this network well quite easily. We knew that we'd want to move files from one place to another and we want to be able to remotely log in. But we also knew that those were nearly trivial from a conceptual point of view no matter how hard it was to implement. And that there were many more sophisticated kinds of things to do. And that came about and largely because we were in fact in

a research environment. That was you know. The name of the agencies the Advanced Research Projects Agency and so all of these projects were pushing the state of the art. And in some places around the community there was at Vance graphics and other places there was a multi computer architectures and trying to build. What you would call a supercomputer but kind of limited. From today's perspective. Advanced Programming layers artificial intelligence. Database technology all sorts of different things and that. As we connected these different machines one would imagine applications that would make use of these specialized facilities. And so from a systems perspective. It wasn't just a question of wanting to move a file phone place to another or wanting to remotely log in but how could you have more exotic. More. And bishops kinds of ways. Working with us and hands from an infrastructure point of view. How could you design the protocols to facilitate those without overreaching without specifying too much how can we leave an open architecture that people could build on. Because one of things was quite obvious is that we could not possibly anticipate everything that needed to be done and. So there was this tension between being useful enough. Beings this specific enough to be useful. And being general enough so that it didn't close off anything so that was the sort of overarching challenge. In our discussions. Task Force. So I'm I'm going to going to push back on a couple of things that you sense. We didn't view it as designing the interface. At all the certain interface had to be designed. But if you say interface I assume you're talking about the hardware interface. And the software that drove it. So with respect to that and there's more to what you said that I want to come back to with respect to the. The hardware interface. There are two elements in the design of a hardware interface one is. How do you get into the hardware. Of our local machine. And the other is what is it going to connect to what we did not have any spec at all for what was going to connect to until nine. Recollection is like made a nine sixty nine when B.B. and eight hundred twenty two reported twenty two which had the spec the bit serial interface. Hundred kilobits was published and hence there wasn't any impetus. On how much of reconstructing how much of a memory but I don't think there was much impetus to actually focus and building a hardware interface. Until that spec was in front of us. And so the months prior to that were focused on higher level issues what are we going to do with this what was the broad architecture. The details of pushing those bits down into the operating system and getting them out through an interface. Were manageable I mean all of us had enough controls of what we're going into the operating system that we could do that the. The tasking was us deal with this imposed or what direction we had was remarkably absent. It was astonishingly absent the. There was as I recall. Zero. Direction from DARPA and. And no direction from you and I have no idea what the corresponding things were from in the other I'm but we were we were operating in secret or anything but as we were moving along. I don't recall a single time that some adult. If you will came and said here's what your task is what you have to do give us a schedule and make a plan or something like we were. It was a Field of Dreams. This present. Gift was being imposed on us and we just connect Lee gravitated to it and I think that for the people who are watching. What we're doing they were quite pleased about that I mean the fit in. It was a natural grassroots effort and. This plays into what turned out it was a silly moment the turn into a pivotal thing. After after a few months of having discussions

about broad ranging set of ideas and one of the. Let me give you an idea of the broad ranging ideas. There were issues of. We certainly want to be able to have basic inter-process communication have a process running on one machine a process running another machine. And having a stream that was sent something here which help over there and get consumed and then you took those up into whatever process if you want. Another thought. And so that led to a stream of discussion that lead eventually to what we first call the host tools protocol and then through. Kind of evolution in terminology became known as N.C.P. a whole different line of thought was that the system kilobit lines were kind of slow compared to the internal communications in the computers. And that for an interactive application. And by interactive. We recognized some machines. Their operating systems were arranged so that you type a whole line when you hit the carriage return. That line would go in and get processed but for other systems. Every single character. Every single character would be processed by the operating system. And in fact. What would be typed on your terminal. Was dependent upon what the operating system said so as a full duplex. And you could type. A period for example you would not necessarily see a period you'd see whatever the computer toasted. And so there were some relatively clever. User interfaces that were extant across the community. Completing commands and giving your choices in different things. And we recognize that it was grossly inefficient. To do that sort of stuff. Across this entire net worth. So would be and discussing the idea of that when you initiate a session. When the she used the word session but that affect you and initiated a session interactive session. One of the first things that might happen. Was that a small interpretive routine. Might get sent from the server back down to the to your local machine and get interpreted. On the local machine and handle some of the interaction. And so we thought maybe we could design a very simple language. That would be implemented across the. And every one of these machines. And so the idea of a common language with multiple instantiations. Was what we're talking about it effectively anticipated Active-X. and Java. By twenty five years. And we took a crack at designing. One of one version was called Dell decode in code language in another was called Neil. Network interchange science we were fond of puns. For the technology of the day. They didn't materialize. But they were indicative of the kinds of things that we were thinking about at the time. And. And so in the spring of sixty nine we were meeting in Utah and around the table there are only remembered precise how many but six or eight of us not very many and said. It's time that we start writing these ideas down without written anything now. And can feel the pressure that you know we're an academic environment and we're working on behalf of the community we got to write some of the stuff down. And we dealt out. Assignments you've been working on this you went out you write that up they've been working on that I took on the job of writing a basic O. stills protocol. And then casually said an all volunteer to organize these notes. A few weeks passed and I had taken a couple of attempts at scribbling down. The rules for writing the notes. And I found myself walking and getting progressively nervous. And that nervousness. Was a realisation that it was possible that are active writing those notes might be interpreted as a an assertion of authority. Of grabbing territory and I actually had the view that if we did this. Some adult from the east. Would show up but you know there'd be Boston or or Washington but I was fearful that some figure of authority was going to show up and challenge us what do you guys think you're doing

Who told you to do this and so forth. And so that was what was causing me to balk and meanwhile I could feel the pressure that I had to do this. And one evening. I decided I was going to figure a way to get over this. And it was late at night three A.M. in the morning and. And I'm struggling with this. And I had sort of the breakthrough I said I'm going to write that these notes are informal that these notes have no authority. No status is a just a way of communicating. And that you could write questions without answers you could write a design without an implementation you could whatever. And to emphasize the point. I said as a matter for me. We will call these requests for comment and. And I said. And to make the notes a compact list you gotta have a number of give you a number of fast as you write the but not before you write it. There's no vetting of these just slap your name and date and your institution a title on these things and we'll get out of sequence numbers. So this was what at least I was calling informally. Network working group which was this nucleus of representatives from each of these four sites but it was beginning to grow with people who wanted to spit of that they might get on the network later so was was a close group if somebody said. You know I'm interested what you're doing I want to come with that fine. And over the next period of time it grew from the one six eight ten dozen to fifty people and all of sudden we had logistics issues of where. Finding a room that we could hold them all and. And eventually got enough. Activity going on that we had to divide up into two parallel. Meeting sessions and. I mean all the Seems really humorous in retrospect in terms of scale. But. So we were dealing with scaling issues. Organizationally from from the get go and we're. The or charter or budget or anything like to fund it. Yes. The the. And if not then. Then the exceptions were single you know. An interesting from a organization point of view. So that was one of the key things that we were all operating under the common funding umbrella. That removed. A huge amount of the competitiveness that entered into networking later. Nobody was building products that was in any financial incentive for getting ahead of somebody else. And if there had been cut throat type of behavior. It was pretty obvious that there be somebody come along and say. What do you think you're doing this is not helpful. But there wasn't much incentive for that second chance. Sure you describe the environment. Selected. Using up in that type. It's not you know. So hard question to answer. Because as you obviously it's a hypothetical about alternate history. It certainly would have had challenges and the natural inclinations of say No succeeded. Or more softly certainly the openness and lack of barriers in the environment we were working on was enormously helpful. I don't know that it's impossible to do the same thing. But it would certainly require a lot of attention to setting the rules and receipt today. In a lot of different settings. The the challenges of trying to get co-operative work. The successor to the network working group is today's Internet Engineering Task Force that is an aggressively open environment. They are very specific that it is not a representative of governments or companies that everybody comes as an individual. And yet when you look at what actually goes on and you look under the covers. There is a lot of competitive things and. It takes longer to design things and one has to look carefully all that I only look at Kasia Lee but it's hard to give a specific answer yes or no. But it certainly was not as easy today. And wouldn't be as easy in that kind of environment as it was then. So while you were late. Do you feel any constraints. Pressures motivations for stabber cations military influence

on the side of any pressure is Iraq zero. The. The one possible exception. Is that we. We had a very limited view about security. The. What we what we basically did was leave the security that was in place in the operating systems. Of the day alone. And so you would connect up to remote machine and you'd have to have an account on that machine. And the log in your password sent in the clear. Over the network. Now. One has to remember that asymmetric crypto are say and so forth was not known at that time. So the only encryption technology was. I think the US. And symmetric and so even if you had that the question of keep management would be typical. The way security was handled in those days was that the community of users around a particular time sharing system was relatively small say thirty two hundred people typically. And if somebody was making into things or doing things that were inappropriate. There'd be dealt with some administrator would say you're kicked off the machine or they go find it. But it was a very small village in some sense around each of these and. And you had kind of village dynamics. As opposed to big city dynamics if you like. We didn't focus on how dramatically that was going to change. When you cross connect all these machines and then the collection of all these villages mean you know had anonymity in a way. And it didn't it didn't actually hit full force until many years later. But I recall that the. And I wasn't particularly interested myself in trying to take on the security issues full force because it seemed to me. Less interesting than trying to focus on the positive aspects of what you could do with these machines the applications. But watch some people try to go in that direction. And I could see that there was a gentle discouragement. Later I learned or became aware of how aggressively N.S.A. clamp down on. Crypto research that was taking place outside of their confines. How strongly they felt ownership of it would inhibit publication. Even if things that they weren't sponsoring and tell tell people to stop and. When I got to arpa. There wasn't much explicit discussion of this but I became aware of that are but was not going to challenge the N.S.A. in this area. That you felt fresh it. Why you see how sense. And I don't have a specific recollection I'm sort of aggregating things so I can't give you any certainly no smoking gun or anything. Not for me. Maybe others. The. And in terms of military applications in general. So maybe in retrospect surprisingly little or zero. There was no. No issue is raised about applications no issue was raised about foreign nationals. As graduate students you had you know. I don't know if you ever had an American graduate student the. Right. The. Now. Later when I was at ARPA there were some some issues related to that and as I worked in ARPA. I learned quickly that as a matter of law. Everything we funded had to have a some sort of military just occasionally. And the only question was whether how tight it was whether I had to be. You know this week this year or ten or twenty years down the line as a potential versus a natural connection. So you moved into it as he moved in if that means. Yes. So that's why you made it. Yes. Yes. So when you got the manager. What guidelines. What would the rules of engagement. With regard to research how you can have the funding. Have a contract selection. Right. Again. The style was remarkably. Light handed the office. So ARPA as an agency is divided up into offices. Each office as a director and handful of program managers. And that was it. So extremely lightweight nearly flat structure. I joined. What was called the information processing techniques office which was where all of this funding for advanced computer science. Was coming from. And I joined.

This is one of the oddball marriages where the motivations were different on each side. I was eager to join because I wanted a front row seat on the advanced research that was seen place. And I was particularly interested in the artificial intelligence. I had viewed the time I spent on working on the ARPANET. As a diversion from my primary interest and. I thought you know sort of with the arrogance of youth. That the networking was not really a academically. Deep and important. Topic from an academic point of view. It was that it was useful of course. And that it would you know facilitate a lot of things. And I used to sneer. That it only had socially redeeming value. As opposed to having real intellectual depth. So I was who I was interested in AI and then more narrowly into program verification techniques and the like. So when I went to arpa. I asked for in strong terms I wanted to be involved in the AI portfolio and related things. They were interested in me because I had been active in the networking stuff and I had become prominent or visible cross the community. So. But when I went I focused on AI and several related things. And all the occasionally got involved in networking because it. And the office was tiny. We had one. Office Director Larry Roberts. We had three. Program managers. To two Air Force officers. John Perry and Bruce Dolan. Bruce. Korto green. That rotated in and was in the process of leaving as I came very west or had been there before and already left the like a year earlier. So it was a tiny tiny office where running the entire computer science advanced research. Stuff around the country. So it's pretty exciting stuff. And. I asked for some guidance when I got there. And Larry said Give me two useful piece of advice. He said learn the budget. And so we had a master roster of all the contracts and everything. We had a non-technical very very sharp guy named Al blue. Who kept our budgets and. And it became evident that the rest of us could disappear he had the people calibrated he knew all the politics and the mechanics and we could disappear for six months. And he would be able to make the right decisions about who got the next contract. And keep things going. But he said learn the budget and. Larry said and. Go talk to the people doing the work. Get underneath the management levels and which was the natural thing to do anyway. Which tell you a little anecdote that sort of perfect and I went out to the Stanford I was just will tell his laboratory for a scheduled review. It's going to show up at nine o'clock in the morning I'm wearing a suit. But the night before. I'm out there. And I decide to stop in the laboratory feels like two o'clock in the morning. The place is jumping the place is wide open the only need passes is no guards or whatever. And there's all sorts of people in the laboratory. Some of whom are actually associate a laboratory and so far seem to be street urchins who have found their way in there and like to hang out. And I'm talking to people now. They vanish that look like them as well I have long hair and a beard in the middle of it now more and I look just like anybody else. And I talk to one kid. And he proudly showed me his quadraphonic simulation of a fly. So he's got four speakers. And he's generating this fly buzzing around. And he tells me with great pride that he's consuming twenty five percent of the computing power of the laboratory. Next morning I show up and less earnest tells me that they're short on computing power and they need more computers. And I say well I've got to deal for you. So that's just the. You know. Well. I wasn't very serious about it because I recognize that this. This kid is using time in the middle of night and that that's not really. Interchangeable with what they're talking about but it was just the humor is just a

position of the two things only a few hours apart. Could have been salivating. Yeah I know it was. I mean I plot of the initiative and was the most important piece of research but it was just fun but it was that kind of sequence and that. In the context of what we're talking about now. Getting to talk to the people actually doing things as opposed to whatever story management wants to tell you it was an important part of that there was very little guidance with respect to the contract structures in fact. One of the things that I inherited. Coming into that office was the speech understanding research program. The program had been organized. Cordell green with the program manager. Contractors have been slotted five system builders. Carnegie Mellon bulb Rennick a Neumann System Development Corporation Lincoln laboratories in SRI and a small handful of specialty contracts. Speech communications research laboratory in Santa Barbara Haskins lab in New Haven for I know. I thought I had been formed yet. Anyway there was a. One guy in Univac in Minneapolis. And I went and visited. And the handover to me was the decision's been made this guy's a good guy he was so unvisited but the cut they had not yet been a contract. So while I was there was asked to speak to their contracts guy in the contracts guy asked me a specific question he said. Should this be a time and materials contract or a fixed price contract. So I'm very green and. I think about what I know and I've looked at the budgets. And the budgets all have specific amounts that are a nice round numbers. What plan to be spent and. So I take that as what we know how much it's going to be as it was just so I says express contract. And then I went back to the office and repeated this to Al Bruin Al blue said. I don't think we've ever had a fixed price contract. So it was learning by. You know trying to do something in good faith and then finding that. That might not be exactly right and then depending upon what the magnitude of the of the difficulty is either having to back away didn't have very often but it did happen once in a while or just learning. The the byways no formal training no orientation. And no support structure either today they have what are called Sita's support contractors that do a huge amount of the work. It's by lack of logic. Well we had a lot of flexibility in those days. The very deep in some set of files. Associated with every contract is a one page memo this starts out I have selected. Filled up the page and has my signature at the bottom and that was the same as what everybody else was doing. DARPA in those days had enormous authority for. I'm not sure I got the terms right but it was a form of sole source Alexion. There are some subtleties in language that preceded the creation of where now. Broad area announcements broad agency announcement. Which is they kind of the brokering of how do you have some degree of openness in the competition and still a lot of flexibility in the selection as opposed to a very rigid are being competitive. Carrot selection. I. So so to things. My interest in going to DARPA at that time was a bit different in some ways a bit more naive than. What is common today. I did not go with the idea that I wanted to create a program. I went with the idea though and to see what was happening and be a useful pair of hands in nurture the community so I went with no agenda. Of my own did not have the perception. Or the idea that it was my job to create programs. I tried one later. Toward the end of my short tenure there to create one. But I was really a viewed it. From personal perspective as a piece of my education. As a kind of a specially constructed internship in a way I mean I got paid well and I was treated as an intern but from that from my picture of myself. I was still in learning mode and wanted to be

helpful. And at the same time. Have the benefit of a front row seat on everything that was going on so from that perspective the answer to your question about selection was steady as she goes and some light. Trimming bring in new people occasionally you know. See where things are going awry in a few places and maybe that's time to call. Call them out. But not dramatic changes and so I didn't have in mind. A complicated selection process. And going in your lesson. He wasn't he wasn't he wasn't the Princeless cater he was the kind of the C.E.O. if you will of the Stanford AI lab. John McCarthy was the principal scare him. Funding. Both the AI lab. And the project Max activity. Minsky at first and then pet Winston took over for the ABT trying to remember who was the formal head of the. Multics project and all the out. And I'm not sure I get the sequence right but the corporate toe. Probably lick was getting some funding in there. And the dynamics modeling tittie is a complicated structure and so there was a Princeless Gaiter and then there were effectively. Sort of separate projects each of which had a defacto P.-I but that was the reporting structure. Key demand Harvard. Nul and. Simon at Carnegie Mellon. I loved Carnegie Mellon it was just the most delightful. Good people doing absolutely phenomenal work and. Ready was there ready had come from Stanford. And he was in charge of the speech understanding effort at CMU. And so he was early in his career at CMU. He was a wonderful delightful guy. And in that speech understanding probably it's. It kicked off. Sensually same time that I arrived in one of the first meetings that we had with five year program. Thousand Words Cabral are connected speech. No limit. Century no limit on the not complication that you could fly didn't have to be processed in real time but have been recorded in real time limited vocabulary a good speech environment. Standard North American male sort about on the problem. And in a task environment where milling what the task was would help you get the right words and. Ross said I can have something running in six month and it was clearly didn't mean the full thing but he could have something. And we said you're on exactly six months to the day we showed up at CMU and know we everybody understands. That deal like that everybody's working the night before. Our night and. Another interesting set of stories about the demo that shut up but it was a chess program. And you speak. What move he wanted and then you'd watch the machine. Move or not move. The way you had and then you'd analyze what what what happened there. So. So couple one. When the king that you saw the government. Yeah yeah. OK with that typical to situate. Different order. Well that's an interesting question. The offices were at least from my perspective. Quite separate instinct from each other there was not very much of a little bit not very much Cross office. Interaction at least. I didn't have much to I actually did not know the rest of the people at ARPA very well I knew a few. I knew the names of the officers and roughly what their charters were. And I think I knew who the directors were. But my relationships were immediately inside the office. Directly up. Upward. And also with the program management office which was our interface to the contracting. Machinery in the rest of the government and other than that all of my focus was essentially if you like downward into the community I knew I knew who was doing what I was Larry acting. PM on the network inside. Yes. He was unquestionably the architect and active manager of all of this we'd companies a member to B.B.N. on one trip and he's having a very technical discussion about architectures and choices and so forth and decisions were being made on the spot and focusing on a liar. Project

that. Those projects. Well. For the for the initial period while I was there and the Bob Kahn came after a year and some other things happen. John Perry was a weather man he was a Ph D. in meteorology. Very sharp guy and his is reason for being there he did some other things but he's reason for being there was that. Our office was funding. Climate dynamics. Research. This was directly related to concerns that high altitude testing of nuclear weapons could trigger a nuclear winter. And the work that we were doing was intensive use of computer simulation of long term climate. And interesting thing is that if course whether prediction. And you have major weather prediction centers know or and the Air Force and Navy. Already. The sorts of things climate is a little bit different in that you don't want to know what's going to happen tonight or tomorrow. You want to know what's going to happen in ten years twenty years you know a thousand years. And so you have to do the equations differently. For stability reasons you're taking differential equations in your integrating them. And you can do that only for short periods of time and then the errors. Propagate So if you want to know what's going to happen over a long part I'm have to take a different thing. By happenstance. One of the major research centers in that area was right here at U.C.L.A. with Professor Yale mince and. Eric our and. My familiarity with it came from the bottom up. Number of my friends who were interesting computers got jobs babysitting. They simulations running all weekend and. So I had some the old limited from they are you just just by contact that. So I get to the are pauses there's John Perry and that's his reason for being there and that's his primary. In addition. He also had the iliac for effort. And he had the graphics and signal processing research and here he Utah. And maybe some other stuff but there was there was a collection of stuff. Bruce stolen. So the John Kerry was a lieutenant colonel. Ruth stolen was a full colonel. X. intelligence officer. And he was and Ph D. in double the. And he was handling the mechanics. Of the network which seem to be a full time job of ordering lines through. Defense communications agency to get to eighteen T.N. handling all of that stuff. As the ARPANET was growing. So he was really the the network program manager at least for that but and then Larry of course was overseeing that a big time. While the tell us about the culture. The PM meetings. Once a year. Larry would. I think it wasn't just Larry it was a tradition that were going on but. The principle vest gaiters all these products. Would come together. I think they had no choice about it as best I could tell. On the meeting was scheduled it was probably three days long. And there would be a certain amount of describing what was going on and then some topics. Put forth for discussion. And some decisions being made from my general. New programs area. Socializing something that was never one hundred percent clear to me. What the chicken and egg process was where these ideas came from but anyway I could see that there was some discussion. And there were some love. And some vivid moments. From the time that I was invited to join the Our prof to the time that I did actually show up was almost a full year. There was a hiring freeze in the government there were security clearance and whatever so I was in this. In between state where it was known that I was going to come when I was not yet there. I had been offered in August. Seventy accepted in September. And I didn't show up until July of seventy one. So from Supt temper. To July. I was in the state of knowing where my next assignment was going to be and everybody in the community knew. But I wasn't there yet. In January of seventy one.

There was a Prince where the skaters meeting in San Diego. And my first exposure to watching these people all interact with each other the speech understanding program which I had mentioned that I inherited was it was informative stage. And there was a description of it. And almost surreal. Sequence of interactions across different personalities. And without wanting to be unkind to any of the people there all share. What seems almost like a burlesque. Newell had put a lot of energy into this and I think was the lead author on the report the structure in the programming is he standing up and making taking us through it. Polly hold. And it'll hold. Stand up and is really angry he's objective. He says you can't just put words like speech and understanding and research to gather and have that mean anything. This is bad philosophy and. Newell says I don't care for the bath last the it's good science and that I feel and and a noble art is in my mind is off to the side and wringing his hands and saying I'm so happy to be here this is great and Frank Hart consensual engineer with his voice rising says. I don't understand anything tell me the budget in the schedule. And so this is kind of. And I'm this new youngster. Sitting in this environment watching these adults. Interact. In the same meeting I think. I think it was that same meeting. Larry Roberts tried to stimulate a discussion of whether or not we had anything to be afraid of in terms of artificial intelligence of robots taking over the world. Humorous in retrospect concerning what the technology of today was and. Bert Raphael who was had been Minsky student and was some years earlier was now head of the AI laboratory at SRI. And it was very quiet usually demand a few words. Listens to some debate going back and forth John McCarthy is there in Minsk is there. And finally Bert says. No I don't think there's anything to be afraid of and Minsky sort of cut him down instantly and said I would be afraid of resolution base their improver either sort of being totally dismissive a very limited piece of technology. You mentioned. Project that case involving some aspect. But my question to what extent for the search. You know that is the important question and. I'm feeling just mildly embarrassed that I can't roll off. Huge number of examples. So the natural thing to try to find examples of our systems that operated. Over the ARPANET that involved. Computational processes at multiple sites sort of that were strung together that way. And I think the number of those was relatively small. And to the extent that they existed. I did one missed part of my thesis work but of kind of incidental. But I think to the extent that those things exist they were more like building common application so Danny. Cohn did some early experiments in packetized speech. And so that meant building the corresponding processes on each of the machines that was going to protest be hooking up. Diverse. Systems that. Then functioned as I was a functioning system. I don't know how many of those actually existed however. Big however much more subtle and less visible but probably extremely important was the interactions in a different level. The interpersonal interactions people being aware of each other's research and being able to interact and. I suspect that quite a lot of movement of data sets cross. Places. Was important. The other thing is that people who build something. Are not always the people who understand best how it gets used. The applications people. So you might go to medical community and I or you might go to the NASA communion mean look the World Wide Web came out of the physics community. So looking to see those sorts of things might be I mentioned that when I went to to our power was in my mind in learning mode I wasn't trying to create a new program. But toward

the end of my tenure. I did actually try to create a program. The impetus was. Software is big problem for you remember. Major reports about the cost of developing software and how the gate was in waterfall model forces spiral models and very Bains reports. And so I'm sitting there and are missing. In effect sort of like I got a new hammer the ceiling find a new nail. And the new hammer. Was there are Panetta. So the question was Is there a way to use sort of a. Seems like almost a silly question but is there a way to use networking technology to improve. Software development and. What occurred to me was to try to stimulate the creation of novel tools and make them available over the network for people to use kind of a marketplace. And so I formulated something that called the National software works. And I wanted. The idea was people would build special purpose tools and then they'd be accessible. And today's terminology would be software as a service I guess. And so I sketch that out and. When up to brief the director of DARPA. Steve look a sick and. He was warm to it. And he said. Nature of a program like this is that you should do it jointly with one of the military services go find a partner. Have it co-founded caution me that to get snookered into starting it up with the promise that they joined later they had to start at the same time. And I recognized the voice of experience. And so I then went around and chatted up. Army Navy Air Force people. And eventually made a deal with the Air Force. And we started that program. And it had some positive benefits that came nowhere close to the kinds of things that I had in mind but that was an application using network to do cooperation in various ways customer work. I don't know. I may not even be even close to the best person to talk about what. Cooperate of things came out of the fact that people were connected. Certainly movement. As somebody move from one placed in the net to another. They carried within the context and the connections and the cross cultural fertilization THROSSELL hundred and one thing that I did notice is that it was enormously important for people who'd been on the network to stay on their work so the idea of moving to a place that was not on the network. Was like being banished to Timbuktu. And for those outside who understood the power of one that wanted to be on the network or to join a place it was on there were very important. So. But trying to identify precisely how that. What the embodiment war. Is it is a bit more subtle. OK. You know is it early days. Now you. You made it were you aware of any. Almost the reverse. Tell you two anecdotes there tangentially in this. When I was a grad student and MIT. There were a handful of arms in the Minsky's laboratory. And they were mechanical nightmares. You couldn't get them to do anything they didn't work all the time and so trying to get something close to robotics. Was very iffy. I met somebody at Draper laboratory who said look I can build you an arm that really works. And I thought this would be good. On make a gift of it to mean ski. And wrote up the paperwork and had allocated some funds. Wasn't a huge amount of money. And the roof came off and came off twice. Miscue hated the idea he knew the guy. Draper and. Wasn't there weren't love with each other by a lot but the other big surprise to me was Larry Roberts said you can't do this. I said it says here you're building robots. And I said yeah. He said We've never said that we're building robots and I said. What do you mean I've got I've got these things all over the community. Just know if you look at the paperwork says we building intelligent systems we've never said anything about as close totally escapes me that. The paperwork. Had never ventured knowledge and then she had to withdraw tins and not do it but it

was a bit of an education about the subtlety of the presentation of were doing versus what was actually having for the. For the National software works project. I decided I wanted to actually know what was happening in the services in the various military branches. So I wanted to talk to people who were real. Now in the funny word. Interacted with Air Force roam laboratories office and they were search efforts off scientific research. Army Research Office and Durham. But they were like us. I mean more so I mean they were focused on research and when I talked to the program manager equivalents in each of these events is what actually happens is that I don't know that there are no more contact with the real military than I did. And I actually had to go. Push hard to find people who were connected to what actually happened in the day to day military and in the real projects and so forth. So from my point of view I was pretty far pretty disconnected from anything close to war fighting now all of that is changed hugely and with the success of DARPA's had it's also gotten much more tightly. Involved with the. Though in this project. It was part of building a relationship that the case of Tommy had to go. Go create one. Took me a couple of layers before I was anywhere close and and close wasn't up at the top of the front lines at all I wound up with a deal with two star general in the Pentagon. Whose territory included. The. The base. Software the software that ran on Burroughs fifty five hundred. That was running on each of the air bases that was doing personnel and and. Payroll and support staff and. And he was running the data center. In in the Pentagon that had the Multics that was the advancing and feds him some. Another relatively high end operation and. There were the colonel who ran the gun her operation. Came to Washington and I met him. Then later I went and visited down there a few times and he listened to what we were talking about. And his eyes lit up. And he said he had a database of the hardware. Glitches in these machines. And where to put wires. That would fix these. And he won. He could see that this would be a good way of distributing then information on a timely basis. And I thought my God now where I got I was going to operational need to understand all this and you know enormously. Capel of understanding the technical consequences. And he runs us and. So starting with. Bob. I've seen any military motivation. Feel that. Well I don't want to. I don't want to be that. Black and white about it. Mansfield amendment was everything we wrote. We wrote up. Paperwork on why we were doing something. There had to be a section in there that drew that connection. But as I said earlier that connection did not have to be. You know this is going to have an impact on the system that's going to this command for use this in this theater for example is nothing like that but it would be you know. The military has a problem of the general nature of this research will have an impact on that. And why were we connecting computers gather because there was a lot of computers that had different nation in them that needed to move from one. And solving that problem in general would have an enormous impact on the military. Tech. And the. Well I wrote it for my programs. Made it up out of. Either whole cloth or general knowledge. Later I came to understand it would be smart if I made the P I do it's not enough to do so much work with the P. I took the CLI for basic research didn't have any better idea that I did of what was going on and then. I suppose there was some level overview but it was. Wasn't. You haven't made the justification strong enough so therefore not going to fund it I mean that was kind of. I think there was an understanding up and down the line that. These things had to fit into a

general narrative of what class work we were doing and why we're doing it so if I had wanted to. To fund something that would be pure fun and totally unrelated to. You know I'd be very hard up with a straight face to make any kind of claim that would have been troublesome. But that wasn't. I mean there was enough overlap. Huge amount of overlap between stuff that's generally useful and stuff that was useful for the military use of the military is a bunch of people a huge amount of bureaucracy and systems and so forth and it. It's really too much but it's almost incidental that what they do with all that is going to war and on the just enormous big business in a way. Time lost. Academic. Bob Khan had joined a year after I joined and. I think he came in to me to do. Large scale manufacturing stuff for advanced manufacturing stuff and wasn't in the middle of those conversations but he didn't materialize I think that was a case where Larry couldn't sell it and. But what did happen was that the application of other technologies the extension of the packet switching idea across. So packet radio packet satellite and cross connecting networks and out of all that emerged the Internet technology. Became his focus and. You know had a huge impact. Let's talk about the packet. Volved of us has this. You identify with the. Five years. And us. It was a large yes. It was a large effort and. I'm not the right person to tell you the bulk of the story. Precisely because I had as I said. Moved my attention was focused on the AI and in neighboring things. And some other things like computer security but not primarily communicate by can tell you want to anecdote that. Played a role in the period when we were first building the ARPANET and. There was became evident as we expanded that we needed to transfer the knowledge of how you connect up a computer to and how work to the next guy. And so it was kind of in each one teach one scenario and. We identified a handful of people around the network. Graduate students principally who had some experience and I wanted to be able to tap. Use them to go help this guy out on an informal basis. Dubbed them network facilitators. One of them was. This kid MIT named Bob Metcalf and was a great guy. Very friendly and smart and witty and. And we became friends. And he he went to he did a. Invited me to come to its final of the Sith defense and Harvard he was. He had been an undergraduate and. I think as an M.B.A. from MIT mud. For reasons that I never understood he went over to Harvard for P.H.D. and still working at MIT and invited me to join him at his final oral. And that he was going to do that and then he and I were going to get on a plane and go down to land exceed to networking meetings. And I my first look at his thesis was over lunch. Prior to the oral. Darkened restaurant I'm reading this thing and I'm thinking it's not. Not really holding together very much. Kind of bits and pieces. So I sit in the audience. And the Harvard professors. Started asking him what seemed like the obvious questions and it's not going so well. And then they ask him to leave and we all leave and does I'm about to walk out to they asked me if I'd stay and phenomena very awkward position because I'm there really is this friend asked me to stay because I'm a program manager at DARPA and they want to know if I think that there's something important here and so I got navigate that very carefully. And then they asked me to leave. And they deliberate for a few minutes. And then they bring him in and tell me failed. And now. That's a that's a very awkward situation. I don't know how often you've ever had one of your students fail. You gotta go tell its wife. He's accepted the job park he's got a call of Bob Taylor and say I've failed. And he's pissed off a self court. Well he goes. Top Taylor says. No problem come

out anyway and. So he goes out to park. And we see. We stink communication. And he visits me one day. And I put him up on a sofa bed in my living room and. I have only recently met. Norm Abramson came through the art of office. And I not really paid attention to the low on that and so I'm chatting with them informally while he's in the office. And he's explaining this idea of the Aloha net and. Charmed and surprised the boldness of the id's transmitter and stay below certain threshold it sorts itself out. And I'm quite amused. And it's going to get quite personal here. My design style is more like solving puzzles than it is to do big statistical things. When I was still a grad student at U.C.L.A. and thinking about protocols. One of the specific problems that I took on was suppose. I have an initial connection from from you to me. But what I want to do is check your log in credential as and then hand you off to some other server. And I want to build that as a general mechanism. How do I tear that apart into its pieces. And I decided that a building block mechanism. Is that I would treat it if I had a connection between myself and somebody else and I had a connection to you then certainly it was within my purview to take everything you send me and send it to him and vice versa. And so as an optimization of that I oughta be able to introduce the two of you together and. Since since it's within my capability do that then to move those bits then you ought to have complete trust that all of that's been done so. Down at the protocol level I added some commands that I would introduce to you and him. And now the. When you think through the consequences what happens if you're in the process of trying to hand me off to somebody else. And so you know if you have a B.C. Indian vs trying to connect in C. and C. is trying to connect indeed you want N.D. connect that. So you can say OK well will that figure out what happens with all these messages. Well what happens if there is in fact a circle. And then Everest trying to hand off their own. So I worked out. It's almost a compliment to the firing squad problem of how you do on it. And that promulgated that. Through the system is socialized it wrote it up. And in one of the few instances in which there was direct intervention from ARPA a very west are called me up on August fifth one thousand nine hundred seventy and said. The communities complaining this is too complicated. They have to give it up really the the ARPANET community the people within the other sites that were complaining that the felt like I was pushing it too hard and. I had to give them and. In fact I think you know in retrospect it probably would have worked the way I wanted to and. So it's just interesting to note that he was sampling the feedback. But along the way. I had an interaction with Will Crowther who was the lead programmer. B.B.N. on the M's. And Will said very gently. Why don't you just send out the reconnection message and if what comes back is I'm in the process of reconnecting to want to just give it up and start over and. You know eventually you. And I was stunned. I was just absolutely stunned. Because I could instantly see that that would likely work. That same statistical effect and. But I also immediately understood that it was outside of the set of ideas that I was likely to generate myself and. So that was in in a moment of introspection. Of. Why was it that my said if your wrist ICS for how to design things. Didn't include that. And. And I sort of went into a hard. Moment of internal thought. And had a piece of Inside the came out of that. And the next thing I said to Will was what did you major in. And his answer was exactly what I expected. I was a math major. He said physics. And therein was the small difference. That Heisenberg is

real in his world. And I was much more of a as a sample solver kind of mathematician. Well I remember the why. Somebody. Play. Mean a plain man. Then of puzzles. Or bunch of guys sitting around the small but it's a lot of money. That was you know it was. It was part of the environment better than but also sort of part of my childhood nature of and. So back on the statistical stuff so I met calf. Visit me and dispense a night in my house. And I've taken home. The paper. That was in the proceedings. About the Aloha net. And I've got it sitting on my coffee table and Metcalf visits and I said Look at this. This is interesting and Metcalf a bit of me reach the thing in the evening and starts to react against this is this is this is a silly design this math is wrong and so he starts to tear apart. And the next thing we know he's taken those basic ideas imbedded in the cable and invented the ether net so I have the singular honor of being the host of The Father of the three net. And it's all documented somewhere and he's agreed to the same story and so. Just one of the amusing things that comes out of this is a lot to that. I'm sure I'm sure. But so as I say I don't know. The majority of the rest of the communication circuit I know Sri did a lot of pack radio stuff in there the van that and thing and all kinds of fun stuff but I was not directly part of land that has seen octane. What other. Well Craig fields came up an Air Force officer. Carlton. I can't remember a first name. Good guy. Effectively doubled which was big deal but it wasn't all that many people in the end. Bill Carlson and. Steve Walker came. Both of whom I really crew did had some effect of recruiting. And they came. Essential after I left. How many of those. What do you mean by. Well provided. Issue. I see. Well. I thought maybe you are referring to what I call. I I P A's inner governmental. Yes I think so. So I think there's two separate mechanisms that you both of which are interesting and which when you're asking about the worst are slots. Could be filled by either civilian or military. The military people came in and. Well regarded. They had to be successes within the military. It wasn't a dumping ground. There was there would not let somebody come. I think this was the I think inside the military not inside DARPA. They would not let somebody come who was not a highly regarded representative. And so. Or. There were instances in which somebody was extremely good technically. But had not been a success in their career. Partly because they had done too much stuff technical and had fit in otherwise. And they couldn't get the transfer and the flip side of that was that it turned out to be extremely hard to reenter the military after you've been it. DARPA So it was a career killer for a lot of people. People who were on their way up to become general spend time at DARPA and then never make it back. Like that. So certainly John Perry and Bruce Dolan were military people who fill military slots and the. The idea of having people come in from academia or non-profits and benefit from the salary that they're making there and do better than a regular G.S. salary. It's used heavily now. I don't know how heavily it was used then wasn't what I did and. And I didn't know anybody who did it although I was vaguely familiar that the process was available. You know. They were of limited duration. By practice. Not by definition. It was. It was the pattern and the culture. But wasn't backed up by regulation or structure. Generally. So for example in my case I came in as a regular civil servant. G.S. thirteen later promoted to a G.S. fourteen. And then I left. And it was expected that you would stay for a while and you would go. Every once in awhile. There would be a problem child. Somebody who came and wouldn't leave. And they were civil servant is very hard to fire

him and I had a. I remember listening to Steve look a sick describe what he would do in a case where you want to get rid of somebody any can fire them. He would simply take away their budget. Take away all of their toys and things and all their perks and put him in some office out of the way. And the people who are most difficult to rid of were the ones who had no ego at all like that so there was this. Slight difference between the practice and the say the underlying structure which is why I gave you a sharp. No I don't know if there are changes since and I'm we're going back forty years so I don't I don't know. Could well have been some some changes but at the time that wasn't the name mechanism. Like. Yeah. Well it's pretty painful actually. Larry. There was competition between the offices which I was aware of. But not directly involved in over budget if nothing else. Larry. Was treated very very well by his boss. Look a sick and his predecessors and. So whenever there was some shelf falling of the budget. We wound up with more money the other guys went up with less money and. It was clear that as long as he was in place we're in good graces. But that the long knives were out and ready. So when he left. We had no natural successor. And we had a big vacuum eventually lic stepped in and out of the goodness of his heart. Did not work out so well because he was by this time quite a bit older and the environment a change quite a bit. Dave Russell was installed as as his deputy who had not had a deputy before. And clearly given orders to run the place. Tightly. And I had a little bit of interaction with him because he'd been in the nuclear monitoring Research Office. Using up a lot of really act for time for something and. And is very genial easygoing guy. And in the first meeting in a very small conference room that we had. He use military presence and command. Command presence voice and they think you know we're all standing at attention. Not standing but sitting up. Right. And I've had one semester of our T.C. while I was an undergraduate here I recognize the exact kind of amusing. But it was no last. Things change. Back. Specific change. N.C.L. the men. No no it's just you know much more mundane it was the our status within the agency billeted get things done and. I remember being a very unpleasant time. And now trying to instantiate that takes active what the details were a little. You couldn't count on any easy. Interaction or camaraderie. Craig field. Liquid could Craig. I took made a point of trying to take. Craig around the community introduce him. Craig's attitude was. This is all broken I'm going to fix it. And it broke my heart. I was. I was in grief. Mode because as I said I'd come with the attitude that this is a great community I want to support it. And I could see the damage that he was going to do. And it brought me to tears I was really really quite Now I was quite young I should I should have been a little you know tougher about all these things and have a kind of longer view but. Then I'm sure he thought he was doing the right thing that drove me quite the wrong way. OK. If you can summarize you. Some character. Calls for. It was very much. A combination of finding. Very strong people with good ideas and giving them a lot of room. And having those ideas in areas that were broadly fitting into the nature of what we're trying to do so for example if somebody if some super smart mathematician. Showed up and he had a great new algorithm for something like this came close to how many for energy or programming using distributed computing across the network is understandable. But not something that we were going to do just too far away from the focus of the system's kind of building that we're going to do. And. And then giving the people a lot of room and expecting. Good

progress. I mean spectating interesting results and insights that are than we could compute ourselves I mean if we could out think them then that wasn't good enough. Well you know they'd. They'd say what they want to do. And. And so the first filter was was that exciting enough with an interesting. And then they go do something and they didn't have to do exactly what they had laid out or they didn't have to have laid out all the details. But whatever they did had to be. Were the and make progress. And if they had a very or they wanted to expand or they wanted to take some latitude within that was fine. I give you a given it a small example. We had these five system building. Speech understanding efforts and. One of them was under Raj ready at Carnegie Mellon. And the key thing was to use a lot of artificial intelligence SEC knowledge at the top end of it. To help. Guess what the right word was after you done the signal processing and the syntactic processing of what the sentence should look like. So his first. His first experiment was chess. And so you'd say pawned King for for example as an opening move or. The go deeper name say you're going to say point to point to work seven. Well. First walk in the understand key get those words Second of all. Is there a move. Does that make syntactic sense. Then you look at the board and say Is that a legal move. And then you look at the board say is that a plausible move that a chess player want to make at that. And if it was well then I would be going if it was a totally erratic move he might. You might challenge yourself and say well I want. Maybe he said something different. Couple of a couple of graduate students said we don't like any of this. We're going to go off and do. Hidden Markoff algorithms and. No way I or anything like that and readies additive fine was a research. Pression in the university and. I would do that. So Jim and Janet. Losing last name. MARY. No no for you was that Lincoln. Now these were these were it will come back to me. There was were Carney. So they went off and they built this. Now we're talking about early one nine hundred seventy S.. That turned out to be the basis of the dragon system that emerged as the successful technology of the day. A thirty year. Overnight success as we say. As a splinter effort from the flagship main visible thing. So there's an example of where the latitude paid off in. And you know if you're being very strict and say no we want to say I approach it we're going to use all the things that we said we're going to do that would have said no you can't do that and. Although I think. Baker. Baker gymkhana bigger I think. BAKER I think that I think. Yeah. Tell us what you meant. So I had not very much a role at all I went to some of the preparatory meetings. But. Bob was really running that and in fact he was at B.B.N.. And that was the last thing he did in that he showed up for work and join the office in November. So that was the culmination. And a lot of other people in the in the community pull out of work into it. We had something on the order of fifty terminals. Different vendors in the Hilton. With one employed tips. And people were putting together scenario so that visitors come in and use these different machines and so forth. One of the things that you can do when you were logged in on a machine to see who the other users were on that same machine. And you could chat with them. Just wasn't across the network it really it was just all within that machine. And so there were some actual experiences where people who had only known each other over the network. Because there were differences to sions but had worked with each other by logging in doing this found themselves having a conversation. And one of them said. I'm in Washington where you said well I'm in Washington to where you and they

turn out to be opposite sides of the room the north no clue except by finding that out. So I was a big success of public on bailing the big story I think that came out of it was eighteen. He sent some people and looked at all of the now still never work and we don't need this and so forth. But I didn't I didn't. More look in on it rather than draw what I've been meeting in sri few months earlier in the protect preparation of it all. But I was. I was fully engaged in said he's other activities and. Interesting. Follow on things. Well we didn't hide it was a big deal but it was. And I were happy for it. Larry Larry had sort of take control of this and he was. It wasn't keeping us out but he was pursuing it and it was didn't require that we all stand around every morning and salute or. Have we weren't at all into any kind of celebrations or formalities or rituals. Change. That's a good question. I can't say that I observe directly but probably I did at some point. Never occurred to me to connect the dots this way but at some point Luke a sick. Gave an order to his direct reports to the office directors that they had to carry terminals. They had of account. And they had to use e-mail. And out of that came some interesting things can't Creswell who was the. Arguably the most visible and senior of the office directors running the Strategic Technology Office I think. And whose daily interactions with with four star generals and admirals and senior military people reported that he was in why a hotel. And he was checking his e-mail. And the hotel detectives. Pounded on his door and they wonder what he was doing the thought he was making book or something and they insisted that he shut down or they were thrown out. You know just huge disparity. Things like that. I mean any. I remember that there were two things I was going to push back on I fail at the second was way back earlier in the interview. About. Military stuff in direction and so forth. Enormous number of anecdotes enormous number of stories to follow up on. You know in retrospect. The environment here was. Really quite delicious it was really. Comfortable and supportive of me and felt felt good to come in every day. Gauging. At some point so I thought boy this is awfully loose we don't have any formal schedule and. It's hard to measure whether or not we're taking too long to do things or not but in other ways the latitude. The idea that that as gradual since we decided amongst ourselves to talk to each other across these laboratories and there was. No formality. I mean you know we were. We are cumulating some degree of expense in in travel expenses. And of course we're consuming our budgets. Our salaries. And I don't recall ever having a discussion ahead of time about whether or not this is OK or whether it was going to lead or having to file a flight plan for the whole thing. So in that respect. You know I have to applaud. I don't know what conversations you had with that with Larry about any of this or with Barry. I imagine you did but I wasn't privy to it but it. It seemed to work out OK. Right. Well the newsgroups. Emerged. When you watching too closely. The two different things come to mine. One is there were other mechanisms and they are printed there was usenet. Well be WAY before the dial up systems and bulletin boards and so forth and so there were no newsgroups on newsgroups on it and second of all. What an until we had a sufficient number of people. Beyond the core people who are designing protocols. Where newsgroups. Meant anything I mean you know you don't need a newsgroup for the twenty people who are talking to each other every day. But I remember one of the key things was what was permissible to. What kind of newsgroups were permissible and one of the one of the test cases was a newsgroup devoted to science fiction

lovers. So this is not something that challenges the manners and morals that wasn't sex and it wasn't anything else. But. But it wasn't computer science and it wasn't directly related to contract. Was this. OK within the acceptable use policy of the day. And obviously it was and then other things emerge from there. I guess the other thing which I'm which we have to squeeze in here and I've forgotten the cover. About the environment here. So we had this operating system Gordo that we took from. This will be the fitting clothes. And we we modified it and then decided that we could change the operating system. And the previous one the one we put together. We had been calling. Spade. There was a story behind that. So in changing this thing. Women had to choose a name for the for the operating system. And it was patterned loosely after the ten X.. Operating system which was for the P.D.P. ten which. And so we tried to guess what we should do with it. She would call this thing seven X. to call it Sigma X. and events that we settled on a much more compact sex. And so we not sure if would succeed we call it the SEC's operating system. And not stopping there we have the SEC's user's manual we had the six users group we had a sign that we could put on a door of the machine room saying sex is available and talk about a tolerant environment here. I don't recall a single word from you or Estrin anybody. But it allows me to say to this day that we actually were the first to put sex on the Internet. The THANK YOU THANK YOU.