Gordon Bell
Oral History
Interviewer: Leonard Kleinrock
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Yes. Yes. Yes. Is that. OK. OK. My name is Gordon Bell I am a researcher marriages. At Microsoft Research. I joined Microsoft. In one thousand now gets one hundred ninety five when we set up when Jim Gray had set up the San Francisco. Research Lab and. Prior to that time I had who's retired. I was living in Silicon Valley. I came a Silicon Valley in the ninety nine hundred eighty seven or so timeframe. I had served kind of as an angel. During the seven two are actually not not true. I was the. Came in to finish off the the engineering work at a company called. Aren't computer. And I was yours a company I had helped fund. Help find not fun help. Found in eighty eighty five eighty five eighty six. By On my call and it was a graphics. Graphics workstation. Prior to that time my. From eighty three day to five I was sort of a vibe I had was when the founders of Encore computer company. And we made a a multi. A general purpose. Multiprocessor. Which by the way. We should get into because we did DARPA for funding. During that here and it was funded during that era to extend it to large scale multiprocessor. And then prior to that. I was head of engineering and. I had Digital Equipment Corporation. Actually I was vice president of R.N.D.. So the research and development organization. And that was from the one nine hundred sixty. I mean. One hundred seventy two to. One hundred eighty three. And then. Prior to then I was head of. Sixty six to seventy two. I was a a so shit professor and then a full professor at Carnegie Mellon University and then prior to that I was was an engineer. And then head in the engineering and computer engineering at Digital Equipment Corporation. Sixty to sixty six. And then I had spent a year before that. They had had spent a year and MIT as an engineering a so or a staff engineer. Where I was sort of doing. Speech research and then also heading down the Ph D. route. And before I joined it all. And then I a year of Fulbright scholarship and then my my. And you went to MIT in fifty two and graduated in fifty seven with a master's degree. Worked as a co-op student at General Electric. So that's my. And then before that I was a journeyman like like Trisha in for working for my father who had electrical contracting business. An appliance store and. Oh and that I. We you miss the N F F Yeah I missed that one of the key periods that I worked on was the assistant director for computing. Which is called computer and information science in the engineering which was named by. My boss Eric Block who hired me in the one nine hundred eighty six data when I was there as a as a director of or. It was called the assistant director. It was an assistant director of in S.F. but for for computing. For a sigh. Though is. Yeah. Well. Yes. Well. OK. When I got to Carnegie Mellon and actually was Carnegie tack. Carney and became got a melon. Something that sometime around one thousand seventy one Mellon Institute was joined with CARNEY The Carnegie tacked to form Carnegie Mellon University. When I joined. The Carnegie tack. DARPA and our. I don't know where there was our prior DARPA at that time. I had just started to find. The barrier. Three universities three. The principle funding was was. I had MIT and then stand varied. And it. Carnegie Mellon and. So the three three universities were were fine got the main bulk of of our profundity in there. And I don't know. And from

then on. You know that I will get in a dart of funding because I don't know the history of but. But certainly there were there are three major fund. Major recipients of DARPA fund that. That point and we maneuver seas and. And it was to find now on Pearl S. and P. and L. A new all. And that was. And so the DARPA fun drill the was Do used to start to build. And to build computer science even though. Carnegie Mellon was about Carnegie Tech I think was the second or third official computer science department. When I joined it was the system for each system sciences or something i Pad. So I was a joint appointment with. With that department banner. And with electrical engineering. Back. You know I was in the print so. The principal investor. Investigator That was Alan. Alan Newland Alan Pearl S.. I think maybe Alan Moore was maybe more P.R.I. then than Alan Alan Pearl S.. Herb Simon what I think was also one on the Grand. Certainly part of the hat. Finding so. DARPA that fun. Funding carried was really a number all of thing for for the Department for funding the computer science department for what became a computer science department there. Had a number of us that were in there at the time that. You know it would be nice. I remember all of you know. All of the people that have our faculties were that were funded there but certainly that carried. And that's that work there are that funding there carried a lot of the different activities and. For example one of the system professors that were being funded at the time was Dave Parness. And Dave. You know as very well known for all of his work and of information hiding and software engineering and so. Friend remains. Remains so I'll leave. Yeah. This is why I said. Yes. You. Like. Well as the time I think you know it was. In many respects was quite well. Who wonderful because there was not. There was really no strings attached to anything that. The idea no requirement. So I came when I came in is an action Associate Professor without tenure. Remember I was I and Bob Floyd were the only two. Non Ph D.'s in in the department. And one and only two of the three anon beasties in the whole school. So it was quite a thing for them to go on for Nolan Perlis to go on a limb and actually And also. ROD WILLIAMS And doubly which he was not. Not part of DARPA funding to to bring somebody and they didn't have a Ph D.. But. So I hear I was given tremendous latitude in try and in in looking deciding what. What to do what I was going to do. And I was still. I had left digital. In some sense I think because I was burned out. Hand rig or really worked on. The mini computer and then a large timesharing to Stehman and. That was the first six years of my career. And when I came to Carnegie. I really wanted to kind of reflect. Because I didn't see anything. In architecture that you know that was going to be significantly changing and. And in retrospect it was a great time to not be in industry because this is the transitional time from trend. Transistor circuits to integrated circuit. And then. And then the reason I came back to digital in one thousand nine hundred seventy two was because the microprocessor had. Been invented then or not it's hard to say isn't venture and but it had been developed in one nine hundred seventy seventy one. Actually sixty nine seventy. And I saw that the world was going to go to large scale anagram circuits and you're going to print all this stuff and. So I saw that was important for digital or digital get into the integrated circuit design business or a large scale in a grand circus. On this year's. Late. I mean. I'm not I'm not sure I ever saw the saw the proposal or the kind. Contract that was being done I think you know I or. If I thought. I am. I I can't recall who's seeing it or maybe and why that when I wrote is a second I'm sure I

wrote pieces of what well. What am I doing so I know I've read. You know I did various things during that. That period and in sort of remember going to some various ARPA contract meeting. Contractor meetings. Really for quite some time. In architecture and sort of where more machines were going in and all of that. But having just having the fun trying to go back in and look at what I what I was. What affected. The contract had on on me. On Me personally I was saying well gee. The main thing was there and able to Helen knew all nighter writing a a textbook the first book on sort of. Computer Architecture and so that was the that great flexibility allow that. And then. Thing that I don't think of very often but was very important very actually very important was. Timesharing was coming in during that time. Well I had left Dhaka. When we had just entered deuce the first commercial time sharing. System and say in sixty six sixty five for sixty six. And then I came to Carney Carney had had just acquired an I.B.M. three sixty. Model sixty seven. With alarm. With a a large large store and. So at the time. I. I started to use the machine. Found out that. It was a two car door hand it was with less than what I was used to. And so I said I'm not going to bother with this stuff. And because I came there thinking. Well I'd like to work on computer aided design. And so I really scrap that fairly early. But what I did do was I got a student and we kind of in I'm really was a mockery of. I wanted to show that we could take the smallest computer in the world of P.D.P. eight. Put this was a whopping drum up on it and then outperform. This machine. You know for. Fifty thousand dollars. We get outperform a machine then who was like a five million dollar. Computer and. Turns out that we did put that together we did do that and that. That funneled back into digital and it really even though digital had a large machine time sharing effort it actually funded. Funded back into the many computer groups there. And then. And then tech started making very small. Timesharing computers out of that So I mean this is just kind of one side or thing on the effect but that. That was one of the things I worked on as having the freedom to just do stuff and and. But the main thing was that the you know that I really worked on this. This book. And then we had just a. And I think just being there. A lot of the people that went to. Park. A fog founded park. You know. I were. People lie and. I had a tot to him. In my graduate course and computer architect years. Yeah. Yes. Yes And so I didn't have. I don't remember when or. When I was that it was like OK Gordon you. You've got to doubt pull your Wade. And I don't I don't think ever recall having at discussion. And all but basically I started getting an F F contracts. So we brought more money. DARPA you were used in that regard for or for you for letting other people go off and get get their own own funding. They very often and that. At the end I think there was one that. I remember with Alan Kay. Whether Alan. I think Alan was the chairman or something I tell and looking about about big big machine. The other thing it happened was one of the students there was a guy minima Tom aquarium's he was a came isn't a graduate and he build a. He came in and I mean that's a. I think a freshman and started building a very accurate. Logic simulator timing as timing. The very. Dealt with timing and. And. And then he. That actually that work all mentally was put back in a digital and we do we adopted. The core of that for for simulation and. Tom was also a student. That was. We had a little student study group looking at architecture and we had come up with a large scale. Design for a large scale. A What we said and they I'm ashamed. And it was a computer with a big cross bar and. Tom

Then when he got his undergrad. Degree went to Stanford. He on another student who took bad and went to Livermore and actually built the machine called the L.. Think it was called the L. one or like that but it they virtually built that. Identical machine ever say. Sixteen processor heavily pipeline machines. So but it was just having basically having the freedom to sort of do all this stuff that was written that was very very important. Of. Oh I had I was trying to think who who they were at the time. I had I had by. I had had a relationship with. With slick lies or because liquid. Little either. Was a used. P.D.P. one that we had designed or hid you. A ball Brannigan Newman had bought it. P.D.P. one and they started using that. And then. Then we had built a special. Machine for four for B.B. and for timesharing and. And it was one of the. One of these early prototype. I'm sure in computers that was was. It was in at the same time as or slightly after see the MIT C.D.'s S machine. To Jack. Well I like I or you know it was just just are wonderful pay that it should then. You know he was there. Always on this computer. I remember him as or playing on them playing on the machine working on this was this would have been one teen. One nine hundred sixty sixty one. And that period were much much longer much before we went to our pride I remember when in fact he did go. Sixty three OK so he. He had had that sort of in a sense EPP period where he was playing on our machine. To kind of did a feeling I mean the. OK. Get in get in get you know because I remember him there writing programs I don't remember what they were they. You know they were blow your socks off. Kind of program or programs the cars and he was in the. He was in a blow your socks off program or that program. But he wasn't a an absolute killer programmer I mean for example like what Larry Roberts was a killer programmer. But not. Not like a liar but he was just very thoughtful and and. You know worried about the interaction all the psycho psychological psycho. Facts with the because he was and I think as I go to station. And you know of course very bright and and and very thoughtful and very nice. I mean a real gentleman I think LECHLEITER was. Just a great car. The culture. You. Oh yeah I think definitely. His feeling there with T. and Taylor had written a think about that and I think it pretty much reflected as far as the thing. To feel our the kind of the culture that they were trying that he was trying to be indoctrinated in the current. There is a livable wage. There. I don't think that that that any there was any notion necessarily of our deliverables there in the. You know the things. I'm trying to think of what meaning you know a new or a process of course of Moyes was tending to work on programming languages. But that we hadn't had an interactive. System or the department had which is a ran on their loot on their large machine which is a Bendix G twenty and they had. I remember having. That is one of the. One of the thesis and I can't remember the person who wrote it. But I had done a graphical light pen based. Editing program. You know. Much before you know what's before the. Anybody else had done that yet. You know he was. As you remember being able to sit. Watch him do all the editing so. So basically I gotta say when you know. I've been doing this stuff we've been using a light pan I've been using a light pen. Because I had spent a year and MIT doing speech research. One hundred fifty nine. January through the summer of sixty. We know. And that the TS here I know I plan on ahead. And basically then you know frankly when the data did all of his work. It was like oh. What I don't get this. What's the video. Me. So it was like. So it's been one of these mysteries of life that I don't understand. There was really no none at

all where I had met so. No I had met West at that time. But there was no real relay only relationship at MIT. I think he enrolled for oversight for the T.X. zero. From Lincoln because Lincoln had given it. Then to MIT but there with him but he was not managing in or anything like that and so my way of getting to digital was actually. I was doing speech research and decided to have to her. About almost a year. That it was that it was that I was not going to be that it was really research. And then I just and that in terms of doing it. Making anything sprats go out of speech looked like it was going to take twenty years. And so I wrote I was the programmer for you know I don't know why. And I can't recall how much I had to do with the invention of it but a technique calls. Analysis by sentences in the speech lab and that paper by the way is still sided. That technique is still the basic technique that people use for for doing. Building on various understanding systems. But because you may sickly. You're trying to find. You have a model. And you. You adjust the model to to what you see as the. The input or a C. is a signal. And then once you get your model and the say in the real say not to agree. Then you've got the parameter. Of them so that basic idea that feedback thing. Was saying. I'm analyzing by fantasizing. The signal and you don't matter that way it's goal so runs over a couple things but of other techniques it blows place because it's same thing and so that was an imp. You know. Working on that and speech laughed. The to exert was critical for that so we were the first to be able to do that and that's when I met a Larry Roberts and. I remember Peter Deutsch who was a. MARTIN Do I too was the physics professor and. Peter at the time was like twelve years old and and occasionally. You know. I would get a macro that I couldn't understand what it was was doing so Peter can you help me debug That's because you know. I've written something wrong and the program was following it fell and. When he joined. Yeah right. You. Know I'd say that Carnegie was totally. Was pretty much independent of the. It wasn't really a network send a sentry plays. And all right I did. I don't know that other people were using it for collaboration this is because they are this is by seventy two it wasn't going going strong I know there were the nuff. Collaboration going on at that time. So yeah. Why. No I don't know I was not part of that. I was the only recollection I have of Arpanet as I was I think it was I was at one of the meetings where there was a meeting when we're said propose the AM born not and. And that I said OK make. Make a standard syrup. Standard for the for the amp. And that's what all of the mainframes or whatever. And most them were Tan's at the time were starting to be tens. Half. Here too and that. Then that makes the connection. And the bugging and all of that very you know a lot easier. So. But I don't recall specifying what the what the what the interface was and. It was sort of this parallels channel. Interface. Back. Yeah. To see seventy two. I came back to to show. Life. The well eventually there were there was a critical component to eyes. With with that Nat. Because in fact who one of the who want to I would say a disagreement I had with with the ARPANET. Was a or philosophical one a little bit was. Wait. Why don't you just put the interface into the mainframe. And then. And use that for the switch for that and we don't need this extra many. So when I got to digital Who is ed. We're getting rid of the amp. And we're going to do. Deck Matt was used as a. You know hand. Would would do switching within the within Bax's or more than the eleven seventy and then if you know if one went Damn why you. Because it was all built built to make it work that way and that now was so deck

met. The notion of deck and came you know is heavily influenced by by Arpanet. It's. Oh shit oh well they were and they were because we had different. You know where the. We had tanned we had a whole bunch of or read different eleven different running different operating systems. So essential yet was was in one moment genius and in a nice sense you'd like there is one implementation and so. Talk about. What a world. Why you know I do when I trying to think when it really. Manifests itself. I think it was when I know. I guess it was right when I had gone. When B.B.N. came in to do to do the. And done the contract to build the are the network. Are. Maybe before. Sixty nine I and I was a Carnegie. I really worked on trying to get a deck machine. To do that that job. Because I said that going to be a pivotal thing. Getting that contract was really important. And we lost the contract. And from then on I I would say that back. Had to go in parallel atoned networking A But certainly we did we had a really good networking guy the did that mad. Stu Wacker and. And he was a Korean critical. Guy and networking. And then that manifests itself again a little later on with the. I think when I pee came on. Now I'll tell you the Brive The most amusing story I have about. IP was a. When I went to an S.F. in. And so that would have been sort of a five. For so then the capital. Architect there's a guy been there. There is a capital thing called the Capital architect. Capital architect is a physical. A guy who's the actually the architect of the Capitol. But. But he he really is you know like putting statues up and suffer like that. He also had the networking. And so he was like. He said OK. We need somebody the Arab block I was my boss. And who I hope you interviewed too but Eric. And appointed me so I went over. One afternoon and Lou Branscombe. Was there. Lou Branscombe was the chief scientist. Hand I think Head of Research at and I.B.M.. And so we were sitting there talking about what. What to do. And I think I said hey you know you've got this network a new reality is you know you've a it's IP it's been the sided. You know just get with the program how IP Unix three things are and who loose and. No way. You don't get it sits half and then I move. That would have been eighty seven hours a day or something. And I was so clear that this is no S.N.A. would ultimately go down in flames but. But it was lied to now because we were. You know already that that was self. So period to to what athame were do because a bizarre hierarchical and arcane nature that had grown up around there. The I.B.M. networking the hierarchical and. And different kinds of protocols that they had that made it work but. Yeah. So how. S.. Play. Right. Because I had gone there. And. The sort of the divisions that had. Who were there at the time there was a. I think. We had a sore and Engineering Division in more of a computer science division and then the third one was for supercomputing and. It was. All the super computers were actually Annette had their own networks they were building networks. And all their networks. Look like you might expect to each ones had spokes going out to all their their clients and say you have this sort of. You know the five of these things and they all look like that. No network at all and just a tree. And so I don't remember when it. How an exactly how it was working I actually I think the people that had to do with the networking there there were a god. The early networking guys. Walsall was the later one but I can't I really would need to go back and look at the whole whole hierarchy who they will ask the wall for is the. You know. I had luckily hired him to. You know. After how Dennis. Than a thin this from Ireland was the head first guy there. Then. Then I can no no then as Jennings.

From Ireland. And I think he was on loan or something like that and had been there and they were they had been sponsoring networks. There or Greece or Spain but it was part of the supercomputing group. And I don't know how I didn't. In it up there. It wasn't wasn't our you know. Organizationally I can't remember what happened. But I do what I do remember is I. It when I was in there very long I said you know we're getting rid of. We can't form a network of. So I you know. The civic of your guys always remember me as a as a dictator. Because I knew would get and said OK we're going to have a networking division. Now especially because they were all supplying their own people they. There was no reason to have them connected any anybody else. Because they you know these the net they are supercomputers still today. Don't really connect to that other than a minor amount I had others very much traffic between a supercomputer centers. But. Or than the occasional you know people when they move files from one wonder the other but in this case it was. I didn't want them because I didn't want the main one of them to work on their computing part. And then I also wanted. I saw the network as being the key thing. Coming from that and said we're not going to get a network out of this until we actually have a division so we both pull that out. Form formed a division. And then I basically made that decision. It was said networking too and I think something. Yeah. Networks. And I think. If we had any AK. He the people in computer science or GO Network. And I think know there were a few people I think maybe Farber was in that category there may have been two or three other researchers that were part of that were being fun in the computer science a vision. Were probably moved over there there was zero zero there was a kind of an AI. There was an it. One that was more aid I research and Iris and I some higher risk information retrieval. And something else so there was a man that was a. The other division. That was a was was in the seventh time. And so we said network is guy hat be. On it's own. And that was. And so that was done by eighty six eighty seven probably had him with. I'm sure that's when it was done by then or so. Well that. And what was going on at the time was the various regional networks were forming. And we and the theft was funding those regional Now we're putting a small amount of money for the regional nets to get them together and then they were Internet had the notion of Internet had been form of that time and so they were the No these regional networks. Funding of those were to get those things where were to to make those things come together. By the way there was an article. Do you have the Arctic. Have an R. and I Tripoli article that had all the networks at the time to get that do you in that article. I think Thousand really was a. I hear of it had a victory of all of the networks at the time that we were pulled a gather I think. I didn't review my history here. And I'll send you that but it was the I I wrote for the they the spectrum. But I have a. Structure Of all the networks there that were placed so in a fast and so I think a lot of the history of that will come out of that. That that I don't I can't recall. Yes. To land then fast as an affair stepped in the make to made to get all of those networks. Into existence. Well. I well I was the one thing was I knew all of the ARPA folks. Cause I had had and. I had have our head just gotten ARPA contract be for I went to N.S.F. and Encore. To build a large multiprocessor large scale multiprocessor. And I was doing that with us. And so squires and I were really on you know good terms so I knew all of the end of the DARPA people so we had. Probably the best collaboration between in a fast and DARPA that it ever existed. So in a

funny way I felt sorry for the ARP and DARPA guys. They said hey we're. You know. We're spending thirty five million dollars a year. To maintain maintain a crap and network that we can afford to do it feeding our research budget. And I said. You're right it shouldn't be doing that. And meanwhile NASA and. Adil we were starting to build their own networks two or three of them I mean the Oh we probably have a couple and. And then as and NASA had and then and. So I said. This is crazy so all of the networks are coming into a universe in a university campus and so this is a the ON A that we you know. When that one point zero. Presence is enough to to connect. So that they can connect other other universities and zone that. That was one of the genesis of. Van ran and then. And then building there or I'd say forget and ran because essentially these these other bureaucracies. Were happy to get rid of it and my and one of my goals was to get rid of it with the help they are print guys to get rid of their networking. Because it was you know what you've got to not. Once you take on a very big operational role in doing something. Then that's what swallows up the organisation is was of the budget it does. And also takes that. Norma's amount of your there and electro capital. To this. It's a funny. It's played with James. This. Well. One of the things that I mean we had week. Because we had been. We've been cooking up all these little networks the New England then I sir and that I don't even remember. And that's why we need this article. But. But the all of those so we had gotten funded those and then they were being tied together and so this was kind of naturally. Happening. But then the other problem was it wasn't. You know we need we were bandwidth. Limited at the time and so we needed more funding for all of that and so that was part of the whole thing and how this part of the thing that I don't want. That probably really crucial from a history standpoint and and. I've had so many people working on the history. Various people come in talking to you bout all of that but the fact. Timing of a spur of when they go or be. Who who did. I know that the our staff is a Steve Wolf important Jennings's and bore. Probably the most important people of of. And then there's and know. Another guy to that in fact. The writing of the Gore Bill we an affair with helping to write. Helped write the Gore Bill because the Gore Bill clearly sort of says in a fast. Were you please go off and write a proposal for. What this thing was going to look like and so that was really the charter and that was the. That was what we we operated on so I took that as a kind of a marching order there was a. Federal group called Fix it. That was. I had. DARPA. It was headed by I think one of the members. Deal we had with the head of that anywhere Jim Decker at it. But he also had the supercomputing part of of of that group. And then there was a saw I am are all who added the infrastructure ARPA kind of thing. He was a saw was aimed that. Oh are we do we have enough. Computer Science Guy me. Doing on the thing and I had. I had this. They go all network a carriage. Was a responsible for that. And I still claim that. That that the report that we wrote on that the. There were three volume report that was that was done in eighty F. everywhere eighty six there was a meeting five year or eighty seven. Where we had like three hundred researchers and. Industry people. We had. Equipment people all that and. And that was. That was really to consolidate our thought for it. But that was the baby. And then that. In that up with a report. That was free viral port that a. That was submitted. And then the part I had the networking part I had. Every The. My committee members read that and they said. Wait. This is too good and. You can't submit the S.. This has to be

part of a an initiative. And they wouldn't let me basically they wouldn't really let me submit it as a directly as a as a response of the Gore Bill. They wanted to make it bigger and. And then took a month by think. Six months to make it bigger and. And actually squires and. Oh a professor at MIT now. Who. No no not at MIT. He's a Carnegie now. I'm trying to anyway. I think I've read written by the two of them. He worked for squires and. And basically they put together that for strike first one of these high performance. Brochures that said this is what it's going to like than that then those with those H.P. see things were put out an early. To them you're late this is this is what. You know this is what we're sell. This is what the research community is selling and so they basically I was my. My reported on a piece a good. You know not much of gone into that piece of that are going to networks are important for server computers and so we were always using supercomputers me networks and that was. That was to all we were selling. And I wasn't selling that I was. I said yeah we're selling that but what's going to happen in this is really the network's going to be the source of. The yeah that took a while while play all them and because what had to happen is the. The. I mean I think. Still I My contribution was in a meeting and I damn it I can't. It's one of those things that. In retrospect you never worn a story thing away. I had heard. We had been having this meeting with all these people I listen to all these reports and everything like that and I said. OK guys you know. We know how to build a network. That will do the job and solve the problem that the ARPANET had. Which is basically mail wasn't going through. That's a engine earing problem let's just go do that and so I drew these curves. Here's what we should be heading for. And those two words and that was the courier. That was the plan. And that plan was. I drew on this on a cellular. You know the old slides. You know with my WENT DOWN talked on the whole meeting I said OK. I listen to all this all is for three days. You know. We're not going to go off and do research in a fibre network. You know. We don't. And fibers were taking all that. That's important. That's research. We can have a program in that way but we know how to make actually a fifty meg switch. But we can't afford it. Let's get our. Let's first off. Fla Fazio is make stuff we've got work just just work because operationally this is a dog. So we've got operational problems and then a year of that and then we should be targeting want to have magnet. Switched back and network. And then I came back home and and iced tea I think it was I believe it was Steven. Wolf and I said look we have no business running a program like this. We have no. We have no staff have to do this let's let's get let's go to C.N.N. our I. So we got bent and by came in my office one day and I said you know you guys we're going to give you a contract and it you're probably agree so you go off and hire the Hire have. Decide who's going to run it. So they were the group that actually sponsored the bake off for. For potential contractors. And I remember digital bid on it. And but. Howard. I would dig of it are always somebody else. I think. But there were two or three big two or three contractors. Probably including B.B.N.. And who actually got it was the University of Michigan and. Doug Doug Doug Doug Doug. When he had been and he had been a Carnegie. He had been really very tight with I.B.M. and I don't remember in what. I don't know whether he ever worked for I.B.M. or not but he was very very close to I.B.M. whether it got in there. Pretty much with car and while I was in conning your non but. But anyway. They. They got the con. They and I.B.M. got the contract for basically putting putting the first and ran

the gather. And then they ran that in there I remember. I don't think I ever went to Michigan but I remember service talking to them about me out. In this is what we've we've got in and that was the basis for doing. And rent to do which is to get to fifty fifty megs and. God. Anyway. You actually are. You. Yes. Yes. Well. Now. And my. I'd say in my interaction with DARPA. I don't. Don't feel like there was any special. Where ness of. How do you spin this to do. Do a do it then you're doing something for for military. You're really doing for computing and. You know whether. But you know. Just knowing that the Arbonne network was. Yeah the military really needed networking like mad then so. You know that aspect. You know. Was there all of these things were a kind of an underlying. Now. This is these are all very important things for that ultimately have more MELLER. But it wasn't doing it as a directed shorter term. We were doing or doing invent we're doing. Either research. Advance of element or even development for for military stuff. You see the. Fuck yeah. But yeah. I characterize what it was that. You. OK I in a way. Yeah in terms of really thinking about what. What it was because I saw a difference between. The N.S.A. I have and and DARPA. I mean that was the end you know because I was really part of part of that and I and and pretty. And then I remember having a meeting with the and I can't write in fact was one of the who. The original network pioneer. With you Fareed. No no no. I think that he had formed big network. Company who was a network. Who is ahead of who who was the head of that. You know no. He was a flow. Flow. How are you Frank. How we Frank was was at came he was he was at DARPA at one point. And he why had dinner with him and. And I and I said what he did where you think of our work and I looked at the. At this stuff and I said. It's too much like N.S.F.. And it was at a period of the time when. DARPA had probably been a lot of pressure on DARPA to be a funder like in a fast. And so it was trying to flatten it's existence to you know to be. To respond to all of the social needs and everything else. And so it would basically had too many too many contractors. And so I think the big difference between the two was essentially. One is very much a Democratic. I mean as AFAIK is the ultimate in and the mocker see in terms of fairness and all of that of. We're going to get everybody in involved in all that. And yet we could only occasionally do something big enough to have an impact I mean in a sense I think you know a few things were did I mean I think the supercomputers were a big thing that they did. And again that was our program wouldn't touch that because they had no seen no. No value of what the hell was a server going to are going to do for us. You know. They were very important in fact. To the military and they are now. But it was all. Was too early for almost two or Lee did see some of the stuff that was coming out of that has taken a long time for supercomputing to Maine. To get where it is. But that was you know one of the big differences. The. In terms of talking now. In terms of looking at what. When when I was there. I remember Chuck's I was funded. Was funded by an S. an F. F. is a little low project and. Looks like a. He's really got it right there. And now in retrospect I'm saying yeah he did and I've got to I guess and I probably give him. I just wrote an article on an hour. About all this and I I marked that as his his work there with Dick. As really important first. Multi computer. And that did something. And so I got five or squires to to buy and all of that went cuz I had I had just come from him funding a thing in encore. And I I had left encore that. By then but the work had continue on and actually I when they're on to build the

thing call them. The multi Max They're the ultra Max. NATHI. Yeah. But then I am but then. So I was work. I is architect I was working with squires to to help on the H. P.C. stuff. Because that that been kind of my my my interest professional interest. So. Oh yeah out. OK. That they were right that. You know and if asked. Has so many constraints on it. Him to the funny way it's just like our Paulie. The constraints are just a lot different. And how when I met how I fret our Frank. I looked at his press program in an arc and. I said you've got too many people working. You know. And too many different things. You're not going to be able to get that sort of critical mass you won't get any. You know your portfolio. You have no. No way of having a portfolio doing anything. And so. And if ounce in a fact is you know I look at it. Bernie often more as. Hey it's funding. Researchers. That's what it's doing. And then as I look at various programs that come. You know every time you look at a program that Arpad or anybody does or something. Some something that comes out of that some. You know big to be big effort in computers I'Anson some sense. Whether it's a network or can our V.L.S.I. design or whatever you find that there are maybe a half a dozen guys that drive it. You know in V.L.S.I. always meet him and Conway and. You know Niven was in there little bit in the back and they didn't. In the very beginning but it was really me that drove it. As a semiconductor guy and then. Conway was certainly important there. But in terms of proselytising it. And teaching and all that and. And then. Then you get a fan out and then every. Then you get lots of people that big get that are just a little bit. Under Cover me he'd. That are that are that make that start making contributions the. One of the other one that there was a very nice study done by a researcher at MIT in the business school. On the research and risk. Architectures and looks that light same way there were like. Six hundred. Proposals are six hundred projects that were funded and stuff like that but you know after the first ten. Then all these other six hundred are doing. Are sort of polishing the. The cue ball hook over there and. All of the New concerns there are really the. You know an affair fad. Within that from time to time getting political constraints I mean they had. You know we would we would get staffers. Cave in to go buy this machine for somebody or go. So we really define the particular thing and. DARPA. DARPA got a few of those. But it's when the damn politicians get in and tell you tell you what kind of computer. To use or what. You know where to where it's got a got to do that that that that and that you know the trouble comes with the conflict comes in the in the design but. But no I'd say the more the as everyone's are social as. How many women are you funny how many. I'm you know black colleges. So we hand. You know and it was getting to that point not to the extent that is. Today where it's very democratic and terms of all of that but certainly all those. Those were all. Always there. Of being a very careful about what you. And DARPA. You know I look at DARPA as having programs that it does and then it's able to in his heyday. Or when he's working best is it find something that really. Crystallizes as a as something to do. And then it focuses that and said and. And the and the people managing managing it. Has that responsibility to to feel like they have the responsibility to deliver some to deliver an X. with this. That performs in this way. As opposed to an a fab which is. These guys all they have the program managers at N.S.F.. All they have is responsibility to hat to ensure that the perp that their proposals are are fairly judged. And that they pick the best proposal out of that. And that this is just and that. And that

they get get their money's worth for that piece of research. But they
have no no I didn't know care about whether or not that goes anywhere or
not or what. What our. Oh. Yeah. Well. Well. Well the. Certainly the the
an affair phase that you know of smaller. I mean it's funding everybody
that's the problem it really is it has to find as many. It's in a way
it's. It's judged. Do you have fifty he said. Do you have something in
every one of these fifty. Categories. You know hopefully five hundred
thirty two or whatever it is they know they love to have five hundred
thirty two buckets and and they have it all equally drop in each of those
buckets. But. So it's just sort of how they are. How their day. How they
made. You know in a way little bit how they measure themselves. And the.
And the. Well of the. You know as I have had. I think those are typically
three year three year kind of grand. I'm not sure. You know they didn't
have any lasting grants then that anything that you had there was an
institution. I mean the. The original grants a part when I came to DARPA
was G. This is kind of a away with their funding the environment at there
and you go to. And then I remembered. Going later on. Over the N.S.A.
Evan I said when him and Carver Mead was complaining to me about. Gee I
can get for me I waited out a guy what's wrong with of. What's wrong with
this picture. Third people that you just find. You know. But technically
I couldn't really do that in fact is very amusing story about. But I have
one of the and two and like that I was at a MIT. Par. It was big big
party. I don't remember what it was for but I was right there with. I
think Khan was. I think we're seeing in the tape with Bob Kohn And. I
think Mrs Licklider was there too and the theme table or something like
that and they were telling about all of the great things that are bred
done or MIT a done with DARPA and all of that. They got to that and she
said. And she was complain. They didn't really really mention like in all
of this role in this whole thing in this way. And then kind said. He
realized he would have been thrown in jail today. If. There was lying in
bed by then you know in a way that aged that that made plain a stream it
was one point in time. Look I'm going to fund these three senators I
know. I know fat I know the MIT guys are well. I know Mark. I'd work with
McCarthy in headstand Verd because look McCarthy had a big said he was I
think the big fine. Fundie at at Stanford for a while and then knew all
was in fact the grand man of psychology and no you had missed in all of
the guys. And all the work at the time and I'm mighty and so. So the
heyday got you know. To get if that whole concept if you'd drop that in
an hour and at. And then is that it would have been. First you know
because you've got people from all over there. As program directors and
had met up and down the line. The idea that we're a fun tree centers. Are
you your Gore who would you know you've been at that point it would have
been a foreign foreign concept. Have opposed to this is very much. An
elitist. We're going to fund things we're going to get for. We know these
people are going to get results. And so you know and I and I'm a bit of a
whole pathway and terms A G L. It's better if you just fundies. These
people that. That you that you know are going to give you. Interesting
results. So. That I. I yeah I think by the way I think the program
managers are critical. And are you know. As opposed to the end of again.
The N.S.A. have division leaders are are managing. These things and you
don't have it and it's just a different place in the networking I think
it was a stream of something that happened at one time in one place. But.
And you know at DARPA. I believe the very thing about. I think the
program managers really are very much a product. Feel like they are a

project engine. Here in some sense. The ultimate. Probably a program engineer I don't know what the right term it is but they have some feeling about some particular area that they are managing it they want to see that go. Go somewhere. So I think it's very much a. You know I'm not here just to dole out money. I'm here to take a given area and I have a vision of where I want that area to go so I think it's a very personal thing I think it's really crucial that they are. Vested with something that they they feel is very important in be. You know it was too broad. Then it's very hard for them to get any of the Sandton Pharaoh. I don't know what their duration is. Maybe Fiat where they have a five year. How long they last there. But. It's very hard by the way I think it's very hard to get get the program directors or. Our division or various things within and. These are these are terrible jobs and. One level. One level you've got a lot of. You've got power because you've got money and. I never had so many friends as I was when I was and then as F. but but but the. The. But having to work within the government. Constraints on one side. Whether it's. And I and I don't know what they are so much in in the are buying you know I know what they were at N.S.F. it's sort of his Democratic you know it's like if. You've got to do it fairly well whatever you do is to. You've got to be fair. You know I you can't. You really get it almost takes out the idea that. That one idea is better than another idea and then betting on one thing you know because I did you know. I fall or it's more the other day and he said. Now I write and we were super you. Supercomputing the conference. And Larry said yeah Our remember going you came in and you told us all. We were that we couldn't run. Our favorite operating system. We were all going to run. Unix. And you did that and whether there were there IS UP evil. And I know you're going to run your to do it. But. But to say need to do that and then there was a lot of shit. Oh and you get a new or miss amount of shit I love it when the Arab Lockwood King came around me once and had this funny little grin on his face. Because I just told a Nobel Prize winner. That we're not going to give him any money for for years. Favored hobby. The no no and we have a hobby door. And we've got an operational door. You came in the operational door and yours. Stores to deliver computing cycles. If you've got a year we've got of a hobby shop if you want to come in the hobby door. Senate Sabia proposal. And so I wrote the president. Of Cornell back saying. Pound second you know. Now he can't the we're not going to fund them for this this obviously. But and then. I have the same thing with super computer guys of you going usually an age. And you're not going to have your own network by the. Constraints are here. Oh yeah. No I think on that. Yeah lion and. You know depends on sort of what's coming. Coming down but if you look at them I think they adenoma fide with the subject. Tremendously. You know. Because con Conroe. Did part of networking and so he was one of the network fathers and so that the fact that he was managing that stuff good is good stuff. I don't know who. I would say a similar kind of thing happened with feel a sigh because I mean. Conway was at DARPA. I and I don't know whether she managed. V.L.S.I. at the time or not or how that. That was how that worked. And then certainly. Steve had a view of computing there. And supercomputing all of that and. And then I you know. If you take every one of them. And just look at the at their the program managers their. I suspect you know they were all fairly deeply invested in. In that. In the discipline that they were managing. And that's not that's not true in a on the other other areas. Could be interesting to see how it plays in.

And then I for example. Arnason any. And I being the big actually. And I probably. They are you know they they maybe could take a lesson from from DARPA. And then. And then and similar there's. You know I don't know what the. How the how do you know he works there too. But I mean they are the big funders. You know research funders and what they have to deliver. You know. I think can go back. You can go back to the hierarchy there and see just what. What are the. What are the management goals or what are the goals and constraints you place on the on the program directors and me. You may get the answer. You know. You might end up with you my for your your your work. Heck I can imagine that this table. Of characteristics versus the debris as a various organizations. So. Well this. Well you know sometimes I think it was. It was a matter of the time it was that it really there what everybody was working in and. And an area that you know and now we go back and look at the dire. Dobra try a tire tracks model of. You know we were developing anti while timesharing is just the whole notion of. We didn't know exactly how computers were going to be using now they were. And then. And then you to layer on top of that network and how they're going to be networked together. And then. So you have a sort of an open field for that. And then you have I. There's been nothing like. People having to deal in a situation that they've had with Moore's Law. I mean. Moore's law. And then the constituent parts of that fall. That have been dragged along whether it's storage or not have been and so I really kind of. Certainly at the B.N. beginning where all of these who are the Ambrose's embryos of every one of these areas goddess families. You know whether it's graphics or databases for example. I mean. Sure what's happened. There's been stuff and databases and databases are totally different now. But the principles and and a bunch of the people I work on them are still have a volved help to help that evolve but they had to start some start somewhere and they did in the. B O O O O O O. Yeah. And it would be interesting to see. Because you know. Be to see well we wouldn't have developed without our and it would. It certainly would have been harder. You know I can't quite imagine. I mean networking. Wouldn't you know. Now working really was something that. That without our why not a night not of come along the way it did it all. I mean it would have been and. I think it would have been a disaster frankly again go back and look big. From what I know of a T.N.T. and I.B.M.. The guys that were really the dominant players at the time in the cable industry are cable T.V.. Well they. They were able to buy stablish sort of embryonic technologies that in fact. Allowed it to grow in a particular way. Yeah and you know I don't know whether you can draw analogies. For it. Nina networking is kind of a good one there because I think it's you know had. You know you can. That there was an established now working. A strong. Super strong networking. Industry. Of public utilities and. This totally disrupted. Disrupted probably the biggest institution you could ever ever get rid of not change. And there's still and there's still room still reeling from and in a sense. Have to do that. Well I think maybe just a just a prize a project. Of having to overlay on on top of that. Of that the computers were something different than than that were being supplied. You know you have to give credit to the guys who. Me me me me. They saw the potential of. Maybe the I don't. I doubt they saw the potential of what it would ultimately be at all. You know just as. When we wrote that. And I said when we wrote the dark. When we wrote the Enron proposal. We had and I had no idea that. World Wide Web would come out of that and then. The minute I saw the World Wide Web.

Oh yeah that's why it worked for me. It wasn't about man with it was about latency and and. But. And but that wouldn't of. Certainly wasn't coming about just doing business as usual. And so I think that there. And similarly if you look at the Alice I making that. Democratic and. As opposed to industry have ing to evolve. Whatever it did to get the things done. You know that. That was so I was so critical. Because and before. Be before. Carver you know that all of this. The designing chips. You know it's really something quite right arcane. Now start of who would have had could have come in or when I started to did come in in that thing but and were doing things that were. And that ultimately were more were that that. V.L.S.I. my design. You know. Berkeley ended up being the. Probably the key part of the L S I design I mean they they took over. And actually made it all made it all happened by. Actually Newton and having a Newton in your Viney whatever his name. Is no. This god. Yeah. Yeah. Of. No I don't know you can't I wouldn't have gotten. Yeah. You wouldn't have gotten there sort of various forms of critical mass that was necessary death. Move it rapidly enough together to get a kind of a skate blossom A So I think. I think that to me is the. The important thing that all of these things took an element of focus in mining projects that were beyond beyond the individual researcher. That they are many times are that they were beyond any kind of N.S.F. kind of. General will will advance research or research. You know looking at. So of looking at all of these things the. You know whether it's. I think V.L.S.I. being. Being a critical one. You know you've got to go away the graphical graphical stuff. And those who. And that was very important for all the. G.'s all the simulators military needed that like. Busters and so. Just having that was. With that those my to that one you just sheer engine airing power might have gotten you there without. Without that kind of thing and then the stroll think what would have happened. Happened that way. But you know databases. You know. Parallel Computing a whole bunch of things. That were done. You know to make these. Make these things happen. I mean I think the dire. DARPA tire track modeled. This is a. You know in berries. Depending on what you're dealing with whether or not. I.B.M. or a or Bell Bell Labs are started. Would start something first or whether it appeared there. And then ultimately gotten taken over because then a critical mass. Mass took over I mean. Really type this is the DARPA. These are the DARPA tire track models. This was published by in the National Academies press the two This is a two double zero three version. And then there's a later version here. This one is. I don't know. Why the same thing but. But it sort of traces the traces where the idea originated from and where the afeard came from and then how that flowed over time to to all the mentally create an industry so the different things are. You know where did it come from who. When did become a product and when it. When it had become a large market trend. Yes yes yes. Ryan what. Well I think. I think be. The idea or inertia of the. It's the transition. Of the people actually doing the work. Keep it moving but the. The direct the program director whatever. They were they were critical. In five years you couldn't or two year or even two years or something. You can have a great impact of this design this is a got goal I think very often the important thing in all of these is setting. A target. It's like I'll claim. Some value. In the Internet for setting for this one little diagram I did because I remember doing the diagram unfortunate don't have the goddamn original. But doing that diagram that morning. Telling all these people. I've left New You guys for three days

and. You're all telling me define more money for research and I'm telling you know. We've got will fund a little bit there but it's in the short run. We we can now deliver something and it's important to get this network. Into an operational state. Screw the research. It's an operational problem. Yet. Yeah. That was in a theft comment. But it's when. When it takes over. Hey the research is all been done. Is not a big research staying. You you guys are here is researchers. Forget that you know. And by the way they did. And research in optical switching is shit. In there isn't a as far as I'm concerned. They're still there throwing switches to to to do. And then in the high free. It's just bad bad stuff and I but. So I think it's really the original or it's an combination of need what the windows the industry. When can the an industry take on are. You know in and do something with it because these are all or all all different kind of stories I'd probably should add a mop and or somewhere to the ideas come from but certainly the. All of them have a component of there's a significant piece of directed focused work that has to take place where there's in the demonstration that this really is is something. Something different than. Business as usual. And I know. I mean looking at you know all of these. Yeah I am no I don't know I think the. I think the car. The self driving car is a great. There's got to be a great. One tire track for that this wasn't on their IT ALL. But that's probably a good story by and Selvin. DARPA's played a major major role in that. DARPA's played such an important role in speech and. And. Ma speech. But certainly it can claim I think that claim the self driving car in robotics says it's its territory. Because beef. Before you we know where where those things were. You know industrial robots were. Good good thing first industrial robot was not a. Not a research project it was a guy. Meant you know making heavy duty factory. Arm. But. But to go beyond that to you know. Is taken. You know people were so art at that for so long. But just the idea of a self driving car mean. Carney was I think first in that whole whole thing. And they could have done it without. You know an F F wouldn't have funded that. Because as you know it's expensive to do it. And you know you need a bunch of budget people. V.L.S.I. I mean I think you look at a bunch of these and say where every And you know this. This doesn't tell the story of the sort of the effort that goes into. To each of those. And each of the areas and what were they critical ones that the that move it. Move forward. Yeah very much. OK good. Thank.