> ## INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS
>
> ## CENTENNIAL TECHNICAL CONVOCATION
>
> ### October 8-9, 1984

MONDAY - OCTOBER 8, 1984
P.M. SESSION

SESSION I

CHANGING THE SYSTEM

INFORMATION AND COMMUNICATION

FRANKLIN INSTITUTE
PHILADELPHIA, PA

BOWEN C. DEES: The speakers in this part of the afternoon session are Drs. Lucky and Kleinrock of AT&T Bell Laboratories and UCLA, respectively and as with the earlier session, we shall allow you to read their biodata and I therefore now will call on Dr. Lucky to start us off. Dr. Lucky.

ROBERT W. LUCKY: Thank you. I have this curious sensation that with all this equipment around, I'm not really giving this talk in real time.

(Laughter)

You know, when we come back in a 100 years from now and they have a program just like this to celebrate the next century, the room is going to be the same, maybe there will be some pictures of some of you people up in these empty slots up here and the people in the chairs are not going to be very much different than you are and the only things that are going to change are these things, you know. The technology is going to (inaudible) and this communication, I think, when you come back in 100 years from now, meetings will run differently because of that. But meanwhile I'm stuck with this 100 years and it's slightly intrusive.

But, let me get right down with it because 30 minutes is not a long time to talk about an interesting future in communications and information.

If I would go back 100 years....I'd like the first slide, please....if I would go back 100 years, maybe if I push the button....could I have the first slide, please....no, that's the second slide, can I have the first slide....I go backwards, okay....100 years ago we had an old digital network that spanned the United States....

(Laughter)

....It was owned by the largest corporation in the world, Western Union. Now, it's ironic that after 100 years, we're striving now to get an all digital network that spans the country and by the year 2000 we will not have yet accomplished this goal. But, of course, the goal for many in telecommunications is ISDN, the Integrated Services Digital Network. But Alexander Graham Bell invented analog and analog took over and through clean living and hard work, Alexander Graham Bell's company became the largest corporation in the country and in the world and for this he was rewarded....

his company was pulled apart....

(Laughter)

(Applause)

Now, I'm not here to decry the death of the Bell System. Nobody in my company does that anymore, that's water over the damn and what you get is your own problem.

(Laughter)

But it does remind us that the future in communications is not only belongs to technology but it's a socio-political field, also and that the events that take place in sociology and politics are going to make just as much difference as the technology is. Many things we can do with technology but the economics, the acceptance of the people, are going to determine what comes in and what doesn't come in, as we've seen many times in the past. Now like Bob Frosch, I want to make a caveat that you can't really predict the future and furthermore I want to go further and say that technologists are especially bad at this. The problem here is that we are....

(Laughter)

....that we're too aware of the problems and we're aware, more than other people, of why you can't do things. It's part of our tradition and therefore we are really pretty bad when we look at the future because we see the problems and just don't let our imaginations roam free as to what might be done.

Furthermore, this is a particularly significant year to look at the future because when I was a youth, one of the things that really impressed me was to put 1984 and you know, like many of you, I thought we would never get there. And here we are there now and then the book of course, the invention of the telescreen was what really determined the inslavement of the people. And in fact we've seen the opposite has happened. Actually, we don't have telescreens, yet. We don't really have two-way video. It's been one of the real failures in spite of the fact that the technology is sort of there. But the technology can also affect politics and it hasn't worked out like this in....at least in the free world.

I want to look at the trends in technology in transmission first and then switching and then networks

and then look at what it means to people in their
everyday life, in what remains in the time I have.

First, transmission. You know, back 100 years
ago, the only kind of transmission we had was wires....
were wires and such great breakthroughs that came from
the early AT&T, as the (inaudible) pole....

(Laughter)

....which is a space division multiplex.....

(Laughter)

....a way you get more and more conversations across
the country. We're still trying to perfect that.

(Laughter)

But, you know, it was only 1961 that the microwave
system went out and now of course those that are taking
it as a matter of course and they take the lion's
share of all the long haul traffic across the counties,
carried by these microwave ties and yet they only came
about in the 60's. So that's fairly recent history.

The 70's then was the decade for satellites
and satellites opened up worldwide communications and
today, of course, they're important but it's ironic
again that in the plans, the long haul network in our

. country, probably satellites will be phased out. That's not to say that satellites won't be highly useful in communications, because they have many, many roles, but probably not in point to point communications in the long haul telecommunications network.

I have a picture of a recent shuttle launch, in case you don't know how they do these things....

(Laughter)

We're working on cheaper ways to do this. But in the 1980's and the foreseeable future, as far as I can see it, is going to be owned by optical transmission.

These half-in fibers can carry an enormous quantity of information and I want to convey to you a couple of things. One is that today this is a primitive technology. I have never seen any technology change as rapidly as optical communications is. When you come back 10 years from now, you'll think what we're doing today is just....we didn't know anything about it at this time. We're doubling the rate at which we can transmit over optical fibers every year and people who work in this field will give you arguments why we can't . go much further than we'll be able to go in a couple of

. years from now but I think history has shown that

whenever you have an expendital trend in technology,

it tends to keep going regardless of all the reasons

why you can't do it and if you'll look at the theoretical

potential of fibers, it's five orders of magnitude away

from where we are now. Five orders of magnitude. And

I think that that will be a tremendous forcing factor

to determine the future of technology because of the

enormous potential that fibers have is an unrealized and...

in an unrealized form.

The information carried by on-off pulses

transmitted by lasers that are teeny little things,

this is one laser shown on a cube of salt, in case,

just to calibrate our thinking. Everything these days

is small; everything is fast and these are getting

faster, if not smaller.

AT&T Communications is busy putting these

across the country as well as the other common carriers.

All have plans and this is an old viewgraph so that

it's somewhat different now but I do want to give you

the idea that in this decade we are spanning our country

. and the oceans with optical communication links, which,

. within a year or two, basically are going to be obsolete
because of this expendential change in the capacity
of fibers.

The metropolitan areas are already criss-crossed
with fibers and the point where they're not is they're
not out to the end customers. They're going out in the
local loop as far as the serving point, out toward the
residential customers and in the case of some businesses
now they're going into the basements of buildings. But
the work of the rest of the decade....of the rest of this
century, really, will be to see these fibers come out to
the homes and to the offices and bring us enormous capa-
city out to the end user.

Now, of course, I'm aware that two-thirds of
the cost of communications is in the end access and when
I look at what fibers might do, they might make the
long haul part free, relatively speaking, and leave the
bottleneck, as it always was, in the local access. I
don't expect to see that change. But what I would like
to see happen is that's been made available, I would
like to see voice channels transformed to video channels,
. to use all of this (inaudible) that we have available.

I think this....so that the cost of a call probably won't change that much. But instead of getting a voice channel for your money, you'll get a video channel, a wideband channel, and that will be how this excess capacity is used. I think it will be a tremendous forcing function toward video. There's also the possibility that there'll be a glut of capacity available, with everybody putting in these optics and with the capacity doubling every year. Everytime in the past when people have predicted gluts and capacity for information, it hasn't happened and I have a feeling that we'll find a way to use this capacity but I could be wrong and there could be a time, not in the near future, when we really overbuild in capacity and it probably will hurt the relative economies, the long haul carriers.

When you look at the future, to give you just an idea of what's going on here, we have....if you'll look at the attenuation and we get a little technical here, just for a minute, of a fiber as a function of the wavelength you've transmitted, there's a well there where you have a bend with it, you can trasmit. I want

to make one point and that is that we haen't used any

of that bandwidth yet. We're transmitting a single

wave length. In some cases, two or three, but basically

a single wave length. It would be like A.M. radio with

one channel on it. A television with one channel. And

yet there's room for about 5,000 channels in the (inaudi-

ble) that we have available currently, they're optical

channels. Each of these 5,000 channels could handle

at least two gigavets (phonetic) of information. That

would mean that on the single fiber you would have on

the order of 30 terribets of information, a theoretical

capacity. That's enough to give every single person in

the United States a 64 kilobit per second channel and

multiplexen on a single fiber. So you're talking,

theoretically, of hugh capacities. Now, of course, my

friends in the business would argue that they don't know

how to get to realize that capacity because there are

some key inventions missing. In the microwave and radio

area, we can do mass amplifications of signals and we

can do mass regeneration of signals. We can't do that

in the optical world yet. You have to be able to handle

all these channels without having a proportional cost.

You can't have the cost of "N" channels be "N" times the cost of one channel. We don't know how to do that yet but I predict that we will learn how to do that and we'll open up these enormous capacities.

I want to make the point, once again, that if you look at the unrealized capacity, and that's basically what the two colors show on these slides, that we've used up all of our other media and optical media has five orders of magnitude, theoretical capacity, that remains to be uncovered in the years to come and so I think that this will color and flavor and force the communications revolution in the years to come.

There are other factors I want to mention before I leave transmission, one of them is cellular, mobile and this is only one element of what we call bypass. I think everyone will want to bypass the local telephone companies, including the local telephone companies....

(Laughter)

....and it's going to be an interesting world out there. There are many, many ways to do that. The cellular technology could become the basis for home phones and

for office phones and for everything. We could change the world into....instead of a fixed location, into a logical location and remove place as a constraint in placing calls. But there are other possibilities for bypass, atmospheric optical, microwave radio collection. There are many ways and many businesses, of course, will go with high speed digital lengths directly out into the long haul network and it will be a very interesting, not only from the technological point, but from an economic point and the survival point for many, many companies who are trying to get a part of this business.

CATV also, of course, will be in there. Direct broadcast satellite, in many ways, and a lot of other alternatives will exist. But it will be an age of alternatives for transmission.

To summarize in transmission, the trends that we have right now, analog goes to digital, voice goes to data, for the future, voice could well go to video, fixed will go to mobile, electrons will go to fotrons, narrow band will go to wide band and the traditional access rate in the home will go from 1,200 bytes per second, say to at least 64 kilobytes per second in the immediate future.

Let me now turn to switching. When you look at the old days, we did it manually, and there was a time, not so long ago, when we thought that we would require more telephone operators than there were people in the world. There was an expendential trend in the number of operators being required. Whenever you get that kind of trend, you know that eventually it saturates and the technology changes. And in switching today we have a trend that looks just like that in that the cost of development for each switch is (inaudible) more than the previous generation so that if you follow this trend the next generation of switch would cost a Billion Dollars to develop and obviously something has to give and so it's my feeling that the big switch will stop, and you realize that most of the cost is in the software, and we will have assemblage of hard (inaudible) assemblage of little switches. During most of this decade, during this century, we have had space division switching and only recently have we moved to time division switching. And, of course, the new switches are that way. But even more so the trend and local area networks is to packet switching and I eventually, I think, that you'll

· have a world where you can plug anything in, anywhere, hopefully, and voice will probably be largely carried by packet communication. Voice will be assembled into packets and switched. And you'll be able to dump any kind of information into the local switch, in any form, be it video, voice, data, what it is, and expect the network to take care of it.

Now, again, we need inventions. And one of them is that if we indeed go to video, because of the capacity available in optical fibers, there'll be no way to switch this, using current technology at all. And we have no way. You'll dump all these bytes into switching, there'll be no way to switch them because the time division switches will never be able to keep up with the high speed of these streams. So what we need is an all optical switch. And, again, I predict that it will be done. It will be invented. Maybe within the next decade. All optical switching. So, again, electrons to fotrons and the world of switching will catch up with the world of transmission and the form will be kept in optical....the signals will be kept . in optical form as they go through the office. You'll

have variable band width, packet switches, and I said before, they'll be modular, high rocketal and build out of small, small pluggable things.

The trends in switching, hardware goes to software, simple goes to very complex, centralized goes to distributed, calls go to packets, fixed band width goes to variable band width.

A little bit about networks. Again, in the good old days we maintained iron control over these networks.

(Laughter)

This is from Dr. Strangeglove. Those are the good old days when everything was centralized and controlled by one good company.

(Laughter)

Now, we went through a period recently in networks.....in fact, we're going through it right now where we're really building a tower of babble where the computer world has given us all different kinds of terminals, all different kinds of protocalls, all different kinds of (inaudible) and networks and all these things and it's a world of logical complexity and the

technology is all there but the logic isn't all in place, how to do this, and when I look at the last decade or so, some of thre great breakthroughs were not in technology at all but were made around tables in Geneva and places like that. I consider the X25 Packet Protocall, was one of the great contributions and even more so, I think, that the open systems architecture, the ISO seven levels of layered architecture from the physical level, up the hierarchies to the application level, a conceptual breakthrough, a great contribution, a way of looking and managing the complexity of these information networks and those kinds of things are going to be the important breakthroughs in the immediate future rather than the technology itself. We have to control the tower of babble that we're building in the way we make things plug together, in the complexity of the software that we have and in the complexity of our systems. The trends, centralized to distributed, call to packet, regulated to unregulated, and public to private. Some of the things that are happening in the networks now are they're becoming customer controlled and they're no longer central. If I look at the net-

. work of the future, I expect that it will be a logical

entity out there, that you won't worry about very much.

It'll be like the electrical plugs that we have on our

walls right now. You'll be able to dump anything in the

network and let the network worry about how to root it,

how to take care of it, and even to help you with expert

systems in the access and in getting to distant com-

puter hosts and getting around this complexity that

we're building up right now. But it will be customer

controlled. You'll be able to, as a customer, to

remotely control the network yourself. You're part of

it, which will be a logical entity, not a physical part

of the network but a logical division of the network

that you'll be able to control. It will be software

defined. Many customers will have direct high-speed

access into the network and they'll dump large gobs of

stuff into it. There will be intelligent gateways that

sort out what goes in and how to handle it, how to root

it, and will take care of your protocalls. And, as I

said, expert system help in getting into that.

Well, what does all that mean. I remember

. being, at the last instance put on some talk show in

Cleveland, and I wasn't expecting it, and as I ran up

the stairs to go on television someone said, You've

got to have a prop, you've got to have a prop and so

someone handed me a piece of optical fiber, cable, and

they said, take this on television and tell the people

what it does to them. And I ran up the stairs holding

this piece of fiber and I couldn't think of anything that

it did for anybody. I'm still having that trouble.

(Laughter)

....Because what difference does it make if you've got

all this enormous capacity out there. That can make

a lot of difference and so far maybe it hasn't, except

to hold down cost which is, of course, very, very impor-

tant. But to the average home....

(Laughter)

....what difference does all this make. Well, in the

home of the future, I expect that it will be filled

with gadgets. You know....

(Laughter)

....because that's the way things are. Computers are

going to be littered everywhere. You know, when you

sleep the floors, your vacuum cleaner bag will be filled

. with computers and stuff like that. When you open the

door, computers will fill out the door and they'll be

invented in all kinds of things in the home. But to me,

the thing in the home that makes the difference is enter-

tainment. I don't care it's the information age. I

think the home is ruled by entertainment and the thing

that....the invention that has changed people more than

anything else is television and I expect to see that

continue to dominate the home of the future and I think

that all the attempts to get information into the home

will be semi-successful but they'll have to be....it

will have to sugar coated and the way to the home will

be through entertainment. Now, this is probably owned

right now by CATV. It will be difficult for the fibers

to get into the home because CATV is alaready there.

Fibers can offer switch video services so that you can

say, Look, I want to see Gone With the Wind right now

and there will be some service that can offer it to

you right now because it can be switched right into your

home. We'll certainly invent a projection of....a very

good projection television, wide screen, high definition,

high brightness, guaranteed to come in the next 10-20

. years, if not even sooner than that. And, in fact, if
you're looking at the 100 years, I would challenge the
people that make displays to let me sit down with
Archie Bunker and his family in my living room. I don't
think it's undoable. I bet Disney could sort of do it
right now. But, I think the way in which display en-
tertainment in the home probably goes through several
revolutions and there'll be a crisis probably in the
amount of material which is available because already
there are more channels than I can handle. I think
you'll have expert systems that will help you get your
entertainment for the night. You know, it will scratch
your knees with you.

(Laughter)

Anything you want to read into that....

(Laughter)

There is a place for the home computer. I
think it's in the closet....

(Laughter)

....but I don't really see a big role for it because I
think computers will be integrated into everything else.
. But computer terminals everywhere, of course, are going

· to become more and more friendly, not as friendly as

that dog, even a mean looking dog like that....

(Laughter)

....but they'll become very friendly. They'll have

speech interfaces, natural language understanding, and

the systems themselves will be the ones that people find

easy to deal with and that will be a very powerful

motivating factor and the reason why I for one don't

believe in this gap between those that know how to use

computers and those that don't. I think there's so

much money in bringing computers to the unwashed masses

that they're going to be brought there and you won't

have to know anything about them whatsoever to use them.

So, I don't see that kind of crisis developing.

There will be information brought into the

home. Videotechs is trying to get there now and going

very slowly because I think that entertainment so domi-

nates the home but it will get there. It will get there.

And I'm impressed by the possibilities of these bulletin

boards. The electronic nail in the home. The CB Radio

phenomena where you can reach out to other people. Kids,

. in some of the trials that we have run, have been able to

. draw pictures and hang them on electronic galleries in a way of really getting together with other people rather than just accessing information which I feel is not going to be terribly popular in the homes. Furthermore, there are possibilities for other kinds of entertainment, like playing bridge and other games with other people around the country remotely by telecommunications or to really get into games through interactive terminals so that you'll be able to drive cars, you know, against other races around the country, who also dial in for the Grand Prix race that night, or we could recreate the Second World War, you know, entirely with telecommunications. However, it's interesting that these things can be done today but they're so conceptually hard, with the amount of software that would have to be done, that they virtually are impossible to do really meaningful things like....I think this is a hard thing but not impossible but, of course, recreating the Second World War is really a dream that will never, fortunately, be accomplished.

Now if I look at the office, of course, we'll see the telephone and the data terminal will be combined

in some form, there will be lots of gadgets there, too,
and lots of different ways to do it. There will be
expert systems in the offices and we'll bring the infor-
mation age there. But I do note that some of the real
failures in the information age thus far have been
management information systems. As I gave an assignment
once to a group that I had that worked in office auto-
mation and the president of our company wanted office
automation so I told him to get some office automation
for him. And they came back a couple of weeks later to
report complete failure. And I asked them what their
problem was. And they stammered for a while and said,
We don't know what Presidents do. And it's profound,
I think. The problem is most jobs are....many jobs are
ill-structured and there'll be very, very hard to auto-
mate or help with expert systems, either management
information systems or expert systems. This is supposed
to be a good picture of the information age but to me
it indicates what I don't think should happen or what
I don't think will happen. I don't think man was made to
sit behind CRT displays and I think that these jobs are
going to be automated and go over the machines and I don't

expect the information age of the future to be like this. As a matter of fact, I have a problem....personal problem with the information age, I already feel I have too much information. I did ten times as much as I can read. See, while we're busy with technology, making it easier to access and store information, you're going to have universal access and gobs of storage and you'll be able to get any fact you want, if you can pay the price, anywhere you want it, but the problem to me is a problem of doing....of changing information into knowledge and it's an enormously difficult problem. It's like the problem going back to the friendly terminal. It's a problem of language that we have built a beautiful, depending on how you look at, barrier between us and machines and that's our language. It contains such nuances and such depth of detail that even in the next 100 years I don't see machines having fluent conversations with us or really understanding what it's all about. And given this I think they'll find it very hard to help us with many of our problems in business. Even though information becomes a commodity of land, I'm going to need a lot of help dealing with it. You

know, just a mundane thing like if you want to look up some information and some technical subject and you go to the library and we've got these beautiful computer systems that will give you three hundred references on the subject and they won't tell you whether any of them are any good and you know that 295 of them are totally useless and they're going to make you look at them all, to determine this. We have to find a way to value information and to give you much more help than just to dump it all onyou. That's what happens to us right now. I get, as I said, ten times as much as I can read every day. And hopefully we can get a machine to read it for me and let me know what I have to know. But, unfortunately, I think those are extraordinarily difficult problems, even for the next ten years. Maybe the office of the future will look like this one at MIT where you sit in front of a back lit wall that has an electronic filing system out there and you can turn pages....it's the ana-log of the piles that we have on our desk right now. You can look under a pile because you remember that you have stored something three quarters of the way down on this pile up here on the right. I always do that.

. The minute I file something and put it under a specific subject, I can never find it again. But I remember where it is in piles and people like Nick Negraponte at MIT and this is his lab have done some very interesting conceptual work on translating electronics to things that we understand from the way that we run our offices right now. But, again, I think these are extraordinarily difficult problems.

I would expect to see offices equipped with picture phone meeting services or video conferencing services, I really should say, using a generic term. This again to me has been a failure of technology in recent years. The whole idea of displacing travel with communications is still a goal out there that we probably won't really appreciably dent before the year 2000, because again the nuances of human communication that we really don't understand. The technology is all there and with this capacity that's coming along from fibers and plus the fact that the bytes needed to transmit pictures is also going down expendentially and I expect to see a day not too long from now when you'll be able to transmit video conferencing material over voice bands

at 64 kilobytes per second and it will open up a whole world here of video conferencing but unfortunately I think it's much more determined by the sociology of meetings, which we really don't understand very well, and the pace of understanding that is so slow compared to technology that I dispair of making dents in that problem.

I do believe that personal picture phone will come back. I own one of the last picture phones in the world, in the last decade, there wasn't anyone left to call....

(Laughter)

....The band width will be there. I think the sociology will not. But I don't think the sociologists are going to find out for us. I think that we'll find by economic trial and error and somebody will make a business at this but it will be kind of hard. In fact, as I look at the future, let me just end with a couple of obser- vations. You know, you hold out ideals and say this is what we're aiming at. This is what we would like to do with communications. And when I think about it, suppose that independent of technology someone said,

· Look, I can give you magic. I can give you any kind of technology you want. What do you want for the ideal communication? And I think that I would like to have a wristwatch that would have a video display on it and I could call anybody in the world and get their picture and get live audio and video on my wristwatch right now. And, you know, I think we can do that in the next 100 years, but I'm not sure I want to. Because I'm not sure I want other people to get me that way. You know, if you call somebody and they don't answer their wrist-watch thing, are they dead?

(Laughter)

....You know, it's always tradeoffs between availability and privacy and we're going to fight many battles like that so I'm not sure I want that ideal in communications. I want to maintain some distance from availability and yet I want access to everybody in the world. I want to be the only one with that wristwatch video. I could go on in that array but let me give you one other ideal. There are many other senses....well, obviously, than speech that we've gotten along with the last 100 years . and opening up the video and through ogotics (phonetic)

we have the possibility of extending our manipulative

power through communications and who is to say that we

can't do smell and touch and other things so that, for

example, here is a half moon bay in Tahiti and suppose

I wanted to go there and I could run a robot and go

there via something we call telepresence, which might

be another ideal for communications to emulate. I,

here in Philadelphia wear a suit which is connected by

telecommunications to a runner robot in Tahiti and as

I move my arm that information is transmitted and the

robot moves its arm in Tahiti. I see through the eyes

of the robot. I hear through its ears. I feel through

its senses. And so that every one of my senses is re-

moted to Tahiti and so that I can walk down the beach

and as far as my body knows, as far as my mind knows,

I am on that beach in Tahiti. And as I walk down the

beach, I see walking toward me another robot....

(Laughter)

(Applause)

....and I wonder, is this worthwhile.

(Laughter)

So, let me end with one of my favorite views

of the future, an aspired cartoon. It says, if you can't read it....

(Laughter)

....And in the immortal words of Al Jolsen, You ain't see nothing yet. Thank you.

(Applause)

MR. DEES: Kleinrock, you're on.

LEONARD KLEINROCK: You must be kidding.

(Laughter)

There is no way to follow Bob Lucky....and David.

(Laughter)

Well, my first task is to comment on some of the things that Bob said. I'll start off straight, if that's possible. Visual fiber optics is a very serious one and a very wonderful one. Bob lauded its properties. I'd like to say a few words about that. I'm sure most of you are aware that a fiber optics channel will carry light much more effectively than a copper wire would carry electricity. Just look at the distance between the repeaters. It's made out of glass so clear that if the oceans were made of it, you could see the bottom of

the Marianna Trench from the surface, the deepest
trench in the ocean basin. One of the problems Bob
mentioned was using fiber to switch light (inaudible).
A more immediate problem is tapping light out of a
fiber optic channel without much loss. That's needed
right now in our local area networks. We don't have
that. And those two developments are right now im-
peding the implementation and the insulation of fiber
optics. It's coming, it will be here before the end of
the decade, probably.

Capacity glut that Bob talked about. He men-
tioned we're going to have packets switched data, we
have it. Packets switched voice, it's about here. I
wonder when we'll have packets with video. We've pre-
dicted packet voice and packet data. Nobody as yet pre-
dicted or calculated when packets switched voice will
be more economical than circuit switched....the video
will be more economical than circuit switched video.
And the funny thing about video is, it's the one
resource, it's the one media, as Bob mentioned, that
can possibly begin to use the glut of capacity that
we have. Now, what is most to video. It's entertainment,

as Bob said, and when is entertainment, at night. That's
when the burden will be on our communications plans.
Which means the night time rates are going to be high
and the day time rates are going to be low and business
will love it.

(Laughter)

Bob mentioned that we need access to the home.
Right now we have 1,200 bytes per second, perhaps, at
high cost, and we're looking forward to 64 kilobytes per
second. In fact, developments are moving very quickly.
Today, you can manufacture for $5.00 a 2,000 byte per
second modum which you can install in your personal
computer right now, that is available, and moving up to
64 kilobytes is something that this decade will surely
produce and much more than 64 kilobytes, once those
5 optic channels that AT&T is talking about installing
reach the home.

Bypass. Sad fact of life is that 1% of the
business customers generate 40% of the business revenue
for the Bell operating companies. If that 1% bypass
the revenues drop by 40%. That is a frightening fact
of life and yet we constantly see in our trade magazines

. that bypass is the thing to do and they'll give you a

list of ways to do it, they hold conferences about it,

they write articles about it and if you can't read,

they'll give you a little do it yourself chart to figure

out how to do the bypass.

Bob said quite a few words about fiber optics

and some words about semi-conductors and he talked about

communications. We are aware that on a chip the majority

of the silicon, the real estate, and the majority of

the power loss is devoted to communications and yet some

of the principles, the modern principles of packet

switching, broadcast communications, shared dynamically

allocated capacity, are not yet applied at the chip

level or within the computer industry at the CPU design

level. Have you ever looked at the back of the CPU,

it looks like that first Western Union picture Bob put

up there. It looks like a rat's nest. No clever commu-

nications yet being used by the computer industry itself.

Bob also said a few words about memory. Just

like to add one interesting fact about that. Predictions

are that by the year 2020, one video disc will be able

. to contain everything that's ever been written since

. man has come on to earth, one video disc. Now we can take that and put it into Bob's robot and then you'll wonder if the robot is going to want to talk to you. It will have it all.

(Laughter)

Well let me say a few words about what's good and what's bad. Let me begin by talking about some of the....well, one big success we've had in the last decade and that is simply that we can move data from one place to another, quickly, reliably and cheaply. 1970's produced that. A major failure. We have no idea how to either design, evaluate or conceptualize about distributed systems in general. And that's really what Bob was talking about. A distributed world of communications and processing. We don't know how to deal with that. People are putting them together all over the place, personal computer networks are arising, nobody understands what the tradeoffs are and what the appropriate design philosophy should be. And so we find ourselves in the following kind of an environment. In our laboratories, business places, homes, we're seeing large collections of devices, terminals, that want to

attach to processing devices, to goodies, storage

devices, processing capacities, and people at the

moment are connecting them up in a traditional way

which turns out to be absolutely wrong because everything

we've learned about communications in the last decade

says that you do not want to isolate and allocate a

single communications resource to a single user. It's

absolutely cost ineffective. Rather, what you want to

do, is to basically bathe everybody in the common commu-

nication medium and have them share dynamically as Bob

suggested. So the things which have come about in the

70's, first of all, was to provide valuated networks to

connect all these things together and then to devise

local area networks to connect you at the local level

and I'm showing you here the three well known solutions,

common solutions, local area network gain, the bus, the

star and the ring. Now, the other thing that has developed

and developing in the 80's and 70's, is that there are

lots of these networks around. All over the world. And

the problem of having them talk to each other, they're

incompatible, they don't use the same block size for

bytes, they don't understand each other's protocalls,

one must introduce these protocall converters, these
gateways, which allow dissimilar objects to talk to each
other, very difficult problem, usually very bad solution
to that problem. And, of course, each one of them has
their own local network for gaining access and then you
will come along with your terminal and you wonder where
to stick it.

(Laughter)

Well, that's a problem we're facing right now. Of
course this is not the final picture you want. This is
far too complex as Bob pointed out. No way does the
user want to see any of that. He wants somebody to
surround it with....you can see that about as well as
I can....to surround that with a service which provides
the processing component, the electronic mail, storage,
huge data bases, education, printing devices, and, of
course, entertainment. Now, as soon as you create a
situation like that and that will come in the next
decade, perhaps, if we're lucky, as soon as you do that,
you automatically introduce a series of problems. First
problem is one of standards. Now you and I know that
the U.K. and France will never agree on a standard.

(Laughter)

It must be imposed from above and that is what the
Swiss are doing in Geneva with the CCITT. That's only
one kind of problem. There's the issue of protection.
Are these networks private and secure? Absolutely not.
Many of them are broadcast networks. Anybody can listen
in, if they choose to. Then there's a question of
nationalism. Is it true, for example, that when any-
thing crosses your sovereign or national borders, as
in export, it must be subject to duty and customs. Or
if it comes in as an import, the same thing. And is it
true that data is an export and import. Well if it is,
as the French absolutely say it is, then it must be
interrogated, understood and customed and protected.
There goes privacy, for example. Major legal issues
about transboaded data flow, another problem we have to
face.

Other issues in nationalism and legal issues.
Certain countries have certain customs you must obey.
As you know, in Japan, you can't even talk about
installing a telecommunications network until you go
through a Tea Ceremony. In Beirut, you cannot install
a telecommunications line, the terrorists will blow it up.

. Third world countries, they don't want to lay copper
wire, they want to fee d their people. So how are we
going to get this international integrated service of
digital network in the face of those kinds of problems.
Sociological problems. We now have a new term in our
technical vocabulary, it's called technostress. We're
told that technostress is absolutely a home wrecker,
destroying the family, marriage, people are spending
too much time at home.

     (Laughter)

We're told, for example, that in the office place it is
not deliberation of the office worker but they're being
chained to their terminals, are fatigued, possible
radiation hazards, there's going to be a reshuffling
that takes place until the skills of the individuals
match the technology and the conceptualization matches
it. Business, employees and skilled training is going
through an enormous reshuffling to match this revolution
that we're facing right now.

     And, by the way, there's another sociological
issue we can refer to. This reminds me of a story told
. to me by a Professor John McCarthy, who is currently at

. Stanford, he was going to write a novel one time and the plot was going to be the following. There's this great professor and he builds this enormous computer and he begins to converse with it over the teletypewriter and one day the machine indicates it would like a voice. So he goes to Bob and asked for one of those telephones and he gets the telephone and begins to now....in a speaker and begins to talk to the professor and eventually he makes outside calls and talks to the rest of the world. And very soon it begins to engage in business and international intrigue and multi national corpora- tions and really has a wonderful time dominating the world. Meanwhile, the little professor is in his basement with this machine back there, walking back and forth, and the machine looks down and says, You hate me, don't you. The guy says, Yes, I hate you, you don't discuss with me anymore. The machine says, Well, you know, you can always pull my plug, which is the solution to most of our problems with robots. Professor says, Yes, I can and he actually pulls the plug. And the machine winds down and the room is quiet. And the . professor begins to wonder, he says, you know, the

machine knew I could its plug, why did it coax me into

doing it. So he plugs it back in. The machine winds

up, comes alive and says, I knew you would do that.

(Laughter)

He says, you can't pull the plug. Not when you commit

your national economy to an autotomoton, such as that.

Well, given all of those things, and you can add to this

list better than I, you come to the bottom of the list

and you finally find, yes, there are some technical

problems left. But they're easy. They're handled by

people like you, from the IEEE, scientists and engineers.

People who understand how to solve a technical problem.

Unfortunately, this is not the stumbling block, and

Bob referred to that problem, it is these softer issues

which will determine how quickly we reach the kind of

system and eventual ideal that Bob and I have been

talking about. Thank you very much.

(Applause)

MR. DEES: Thank you, gentlemen. This was

most stimulating. Have any questions been stimulated.

The questioners will please identify themselves. Who

has the first question. Dr. Schwan.

HERMAN P. SCHWAN: You were talking about circuits, (inaudible) systems and how to handle that. And how difficult it is. And that was very amazing to me since it reminds me about something else. In our old distribution system we have....been able to figure out how it works. We have many generators from the (inaudible) and they are all intertwined but we really don't know how it works. Please, can you tell us here.

MR. DEES: The question has to do with the parallel between the distribution systems that were being discussed and the distribution system up here. Are there any parallels?

MR. KLEINROCK: Well, in response to that, there's really very little known about what goes on up here. We don't even understand how we implement memory much less computation and logic. I dare say that the research in that direction will take many more years before we make any progress but once we do it will far outstrip any of the artificial intelligence we've seen in the computer industry. Artificial intelligence is able to make a big splash very quickly but signifi-cant progress will come only when the physiological

understanding comes about. Now, I'm also intrigued by the parallel. I have no idea how to approach it. It's a leaky system with heavily coupled transmission, everything the telephone company does is to isolate transmission with insulation and shielded cables around it. The communications system up here seems to depend on all kinds of leakiness. Okay. You can cut half of it away and it still functions, sometimes. Well, you can't cut half that telephone system away. You can't cut half the power system and expect no brownouts in the world. So it's a very difficult system. I believe our approach in computer science is not at all parallel to the way in which physiological systems work. In one ant, you've got more capability than the world's computing power right now.

MR. DEES: Do you have any comments on that Mr. Lucky?

MR. LUCKY: Well, maybe your mind works differently than mine. I'm just kidding. I agree with what Dr. Kleinrock said. The only point of disagreement is you can cut half the telephone company away and you would half a telephone company.

(Laughter)

DR. KLEINROCK: That's what happened.

(Laughter)

MR. LUCKY: And also in the talk so more, possibly by Carver Mead or someone else, this issue may come up again and if you're interested in it I think tomorrow stay tuned in.

MR. DEES: Another question.

PAUL HERNEY: Paul Herney, my name (inaudible). We're having enough trouble (undistinguishable)....
....but they won't be able to sit down and read anything or write anything. How can we keep that (inaudible).

MR. DEES: Hold it just a second. Could you hear that.

VOICES: No.

MR. DEES: The question has to do with the fact that with all this entertainment coming into the home our youngsters are not becoming literate. How are we going to cope with that problem.

MR. LUCKY: I think what you say is....I think it's true. I don't know if the data really backs it up but my children don't read that much. But I do think that there is a lot to be said about sugar coating

. education and bringing it into the homes of the future.

I think there's every potential there for bringing

education into the homes but whether the people in

education can package it in a palatable form remains to

be seen. And, also, I, you know, I....sure,my parents

worried about how I was getting ruined. I worry about

how my kids get ruin and I'm sure my kids are going

to worry about how their kids get ruined. And kids are

pretty indestructible, you know, it's amazing.

MR. DEES: In the back.

MR. COHEN: I would just make a remark to the

last question. It's been found that when the personal

computers have been generally used by students, it is

(undistinguishable)....

MR. DEES: Couldn't hear that.

MR. COHEN: The composition ignored it....

has improved greatly since they've been using word pro-

cessing to generate their assignments.

MR. DEES: Any comments on the comment.

DR. KLEINROCK: What I'd like to embellish

on this issue, slightly different track, though, one

. of the things we're very proud of in this country is

the fact that our youngsters are so good at the game of computing and information processing and writing programs and being innovated in new structures. And it was mentioned earlier this morning that we face a threat in terms of the number of imports we're receiving, challenging certainly the camera market and the home entertainment market and a variety of other devices. And we pride ourselves on the fact that the Japanese so far are not as creative as our youngsters in the same game. Well the reason our guys are so good, and our gals are so good, is because they have lived, they have grown up with good computing facilities, good hardware, good software. That is now changing. Countries around the world, Japan in particular, are providing excellent computing facilities for their youngsters and they're going to become every bit as good as us very soon. So in terms of making our youngsters capable, we've got to somehow find a leap forward again.

      MR. DEES: One more question. Who has it. Mr. Hargons.

      MR. HARGONS: I believe everything you tell.... (undistinguishable)....how many pages will we need on the bill.

      (Laughter)

MR. LUCKY: It's going to take a number of pages just to have all the decimal points.

(Laughter)

MR. DEES: The question has to do with the fact that with all of this added capacity, how many more pages will there be in the bills we receive.

VOICE: Till we use up that (undistinguishable)

(Laughter)

MR. DEES: Say it again.

MR. LUCKY: Oh, I just said, it's going to take all his pages to have all the decimal points, you know, associated with what you're going to have to pay for all that.

MR. DEES: Very well. I will excuse you two gentlemen now and will ask the final....the last two panelists to come forward.

(Applause)