

Leonard Kleinrock Opening Keynote
Global INET, April 23, 2012
Geneva, Switzerland

Key highlight: Kleinrock predicts, “We are going to be able to see significant changes in the way you do things and a world full of extreme mobility that's already become apparent. Mass personalization, that's not an oxymoron. Basically [we will see] video addiction. Social networking. Applications: we can't predict them; they will surprise us. [We will see] change in the way we do everything in our world, society, the way they organize. The infrastructure, to summarize, we are going to have basically a global nervous system on this planet.”

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Kleinrock Keynote:

I would like to thank the Internet Society for inviting me to address you on your 20th anniversary. It is hard to believe. But 20 is a small number given what I am going to talk about now. I am going to discuss essentially the brief history of the Internet. Now that's a topic that's challenging at best and difficult in the easiest case.

Let's talk about the brief history of the Internet. What is the Internet? An innocent enough question. My ophthalmologist, Larry Garwood, had his father ask him that question, “What is the Internet?” And Larry came up with a terrific answer. He said, “The Internet, it is everything; past, present and future.” His father being a bit of a wise guy, said look son, I was in the Canadian Navy in World War II and I was commander of a landing assault craft, No. LCA 1375. Sonny, you go find that thing on your Internet. Now this is a half a century after the war and Larry has to find this on the Internet. He went [online] to the Canadian Maritime Museum after searching Google – that didn't help at all – and he found this picture [shows World War II photo onscreen]. This picture shows a ship that carried his father's assault craft just coming around the Straits of Gibraltar to engage in the invasion of Southern Europe in World War II. Trouble is, these folks hit a sea mine, blew a hole in the hull of their boat, they plugged it with a lifeboat and basically lumbered off to the Greek town of Pylos to get it repaired. They spent two weeks getting it repaired, and these fighting men were getting impatient, so they hopped in their landing-assault craft and visited Piraeus, the Port of Athens. The German Army was there, expecting this invasion. The landing craft assault comes over the horizon and the Germans panicked, blew up the factories and evacuated, [which was] lucky for these guys because they had no armament. They were basically undefended. So they came in and the population said, “You have liberated us.” And they started socializing with the sailors on the ship. [Kleinrock shows a photo from that day] And, guess what? *There* is his father's landing craft [showing photo of the craft]. And guess what? [showing the photo with a person's face circled] *There's* his father.

That's the Internet. It's all there. Ask the right questions, search around and you can find it.

So let's go further now. 1969, a very critical year in the history we are going to talk about. What happened in 1969? For one thing we put a man on the moon. Second thing is the Woodstock

festival took place up in New York state – a bunch of crazy people running around doing different kinds of things. An event with probability of zero occurred, the Mets won the World Series in baseball. Charles Manson went on a murderous killing spree in Los Angeles.

Oh, and by the way, the Internet was born.

Nobody noticed. Even those of us who were putting it together didn't notice in some sense. But in fact, if you look at the impact, it had a greater impact probably than all of those events together.

As we talk about some of the technology we have to understand the key to the success of the Internet was not so much in the technology that was being developed but it was in the environment. For example, it was a golden era where creativity and ideas were flowing all over the place. It is an era not to be repeated unfortunately. It was based on the openness that [the Internet Society] has as its fundamental principles, ethics, open, shared, free, trusted.

Well, it was magnified by the players. The ARPA program managers looked at long-range funding, high-risk/high-payoff, large funding supplies, program managers who were brilliant and had a limited term so they had no agendas that they would bring to the party which could affect long-term. And in fact, they didn't interfere with the studies.

The principal investigators who were responsible for the research took a very relaxed attitude. They allowed their researchers to do what they needed to do. They didn't dominate them. They allowed the graduate students to blossom and show their creativity. And thankfully the graduate students did their thing and they organized themselves into working groups, into cross-university efforts.

The underlying technology itself had the same flavor, a *distributed* controlled technology. Nobody was in charge. It was all, "Bring what you can, think about it well and we will put it together, because we trust each other and we are going to share and it is all going to work together."

That environment was a key issue in bringing about the successful Internet we have today.

That was the magic. That was the magic that's not often talked about but it is back there in the history we are celebrating today.

Let's talk about the future and then we will go back to the detailed history. Everybody knows about the Internet obviously. More than 2 billion that use it. Shucks, my 9-year-old granddaughter knows about it. My 99-year-old mother knew about it. It is penetrating every aspect of our lives, be it commercial, be it education or be it entertainment.

The Internet – in my mind – has only reached its teenage years. And that gives you a kind of condition to see why it is behaving the way it does, because it is behaving very badly. It is mischievous. It is erratic. It is unruly and it is disobedient. Now hopefully it will grow up and get past this stage. But it is not unusual to see this kind of behavior as a technology begins to feel its strength, mature and find its way in life and set its principles. I am optimistic about that.

So let's look at this brief history. I am going to read to you a prediction and wonder if anybody in the room knows who made this prediction.

"It will be possible for a businessman in New York to dictate instructions and have them instantly appear in type at his office in London or elsewhere. And he will be able to call up from his desk and talk to any telephone subscriber on the globe. An inexpensive instrument no bigger than a watch will enable its bearer to hear anywhere on sea or land music or song, the speech of a political leader or the address of an eminent man of science or the sermon of an eloquent clergyman delivered in some other place however distant. In the same manner any picture, character, drawing or print can be transferred from one to the other place."

Who said that? No, it wasn't Vannevar Bush. That man, Nikola Tesla. A giant of his years and it was more than 100 years ago. This man was talking about the Internet if you parse it correctly. It didn't mention video because there was no video. The vision was there. These things were in the air for a century. We had to wait for the technology to reach the right point before we could implement it. There is relatively nothing new under the sun.

Let's look at what happened before the beginning. Well, in 1957 Sputnik was launched. And it caught the United States basically embarrassed. So then President Eisenhower formed the Advanced Research Projects Agency to support science and technology and gain the lead in those domains. The early role of ARPA in creating the Internet that we enjoy today, we are going to trace that a bit right now. Licklider in 1962 became the first head of the information process and techniques office. That was the group that supported the computer science research. Ivan Sutherland became the next director in 1964. He tried to establish a three-node network at UCLA. It failed. It failed not for technical reasons. Political jealousies – something with which we're all familiar. It did stall, but the idea of the network was now present at ARPA. The seeds were being planted. A year later Larry Roberts ran an experiment with Tom Marrow to send a dial-up connection across the United States from Lincoln Laboratory to the Systems Development Corporation. They succeeded but it was a great deal of trouble. There was no protocol. No error control. No signaling. Just a sloppy, difficult job and it convinced everybody that we really needed a technology.

Bob Taylor came in as the next director in 1966 and he recognized that all the groups he was supporting had computers that should be shared, and at the moment they could not share. So he decided let's get a network and put them in a network and let everyone share the resources of those machines. He brought in Larry Roberts in to make it happen as chief scientist. And I am going to stall right now, and pause on the ARPA story to see what else was happening in that time.

What was happening was there was another thread of inquiry taking place. It was basically in the research community. So while ARPA was being developed the research community was developing the underpinnings of the technology to drive the Internet. There were three efforts there. One of them was the MIT effort, my Ph.D. dissertation, and the key work was done in early '61 and early '62. The second effort was at Rand Corporation. Paul Baran. He was looking at survivable communications; his main paper was September of '66. A third effort over here in the UK. Donald Davies. He put together a one-node network early on. He is the one who coined the word "packet." His work is in mid '66. Unfortunately the UK did not support a multi-node

network. And had they done that, the keynoter today would be speaking to you with a British accent. It didn't happen. It is one of those stories worth understanding.

So we have this technology, data networks. Highly efficient, a new technology, a new market. We spread it around to the carriers of the world.

Nobody cared. In fact, they said it wouldn't work. And they said, "Even if it does work we want nothing to do with it." That was the mentality we had to face.

However ARPA was poised in the background with the need for a network and there the technology was available. So if we summarize what happens: Licklider had described a galactic network vision in 1960 and 1962; I had laid out the mathematical theory of this technology; Ivan had basically tried a network; Taylor said we need it; Larry was there to make it happen, and son of a gun this thing began to flow.

Let's look at the beginning again. In 1967 – just around that period – ARPA gathered a bunch of people and said, "Let's create a request for proposal." [RFP] That request for proposal went out. Part of the specification was through Wes Clark. He said, "Don't put the communications load on the host. Put it in a separate machine." We now call those things routers and packet switches. That was a major contribution. And, by the way, you are going to see pictures [in my slideshow] of many of the personalities who are sitting around this room, here at this gathering. I am going to flash them up very quickly. Hopefully you will bump in to them along the way.

RFP went out to deliver a network in September 1969. BBN won the contract and Frank Heart led the effort and Bob Kahn did the system design in 1968. It was also decided that UCLA would be the first node on this network. In '69 we put out a press release – another vision was put forward, a vision that is *still* not realized. It was to be ubiquitous, it was to be always on, it was to provide, basically, web-based IP services and to be invisible. Well, the Internet is anything but invisible today.

On August 29th [1969] the first switch arrived at UCLA. That was Labor Day weekend. On the Tuesday following Labor Day, September 2nd, the first computer was connected, the first piece of Internet equipment ever.

What did it look like in '69? [shows a photo of original Internet equipment at UCLA] That little thing there was the host computer running a time-shared system at UCLA before September. In September that switch arrived and called an interface message processor, the packet switch, the router if you will. It looks like a large refrigerator. We still have that machine. It is the first piece of Internet equipment ever. It is a very sophisticated machine with a great front panel. If you look inside, this machine it is *so ugly* that you have to love it. It is beautiful. It *smells* good. It has its own odor.

Now the next month, in October of '69, SRI's host received its switch and there you see the first piece of the Internet backbone ever. Running at a blazing speed of 50,000 bits per second and in those days that was fast. Very fast.

We decided to keep a log. That's what it looks like. That is probably the most important document about the Internet. It records something as you see in just a moment. You see it is an

engineer's log. It doesn't look like a Madison Avenue log, it is a real engineer's log. We took an old log and adapted it. Who promoted us to keep a log of our activities? The famous Jon Postel. There he is [showing a photo of Postel]. We miss you, Jon.

The most important entry in that log, which makes it the most important document of the Internet in my mind, is the following: On October 29, 1969 at 10:30 at night there is an entry there that says we talked to SRI host-to-host. Essentially, that is a record of the first message ever on the Internet. It connected UCLA through its switch to the high-speed line to the switch at SRI, to the host at SRI.

So the question is what was that first message? Was it something good like "What hath God wrought," basically from Samuel Morse more than a century ago? "Watson, come here, I need you," the first telephone message? Or, more recently, "One giant leap for mankind," Neil Armstrong as he stepped on the moon? Those guys were smart. They understood media. They understood how to get the message out and get known. And every one of us knows those messages a century and a half later.

We had no clue. All we wanted to do was to log in from our machine to theirs. To log in, all you have to type is L-O-G, and the I-N the remote machine will type because it is smart enough to know what you are doing. So we got all ready – here's the setup again – we have essentially Charley Klein down at my machine typing in and Bill Duvall up at the SRI machine and we had a telephone connection just in case. So we started. We had to type L-O-G. So we typed the L and said, "Did you get the L?" Said, "Yup, got the L." Typed the O. "You get the O?" "Got the O." Typed the G. "You get the G?" Crash!

(Laughter, and someone drops something in the audience that makes a clanging noise.)

Good. So what was the first message ever on the Internet? "Lo," as in "lo and behold."

We couldn't have asked for a more succinct, prophetic message than that – by accident – but it is the best one ever, and hopefully no one will ever forget that.

[To see the log of the 1969 UCLA to SRI log-in message go to this Web page:
http://www.lk.cs.ucla.edu/internet_first_words.html]

Let's watch the Internet grow. We have 40 years of history to catch up. [Shows a timeline.]

Steve Crocker, who is here [at the Internet Society 20th anniversary events] as well, put out the first RFC – Number 1 – describing the host-to-host protocol and also set up the Network Working Group. Vint [Cerf] was in that same group, so was Jon Postel and a few others, Charley Klein. A year later that team produced the Network Control Program, which was the first host-to-host protocol. That same year Norm Abramson developed the first packet radio network, Alohanet. Ray Tomlinson came out two years later [1972] with email on the Internet, it was well-known in time-sharing systems, made a big splash on the Internet. The first public demonstration that same year of the ARPANET. [1983] We deployed a satellite network connection across the ocean. The first international connection was made in '73. Bob [Kahn] and Vint developed and published the concept of TCP in '73. Metcalf develops Ethernet the same year.

Basically the management of the ARPANET was transferred to the Defense Communications Agency. We at UCLA had been measuring *the heck* out of it and stressing it and testing it. DC I don't think ever made another measurement. *Nobody* knows how the Internet works today. They stopped looking at what's going on.

In 1977, TCP connects three networks – a *very significant* connection, across the ocean and back – for some simple communications, and this showed the power of Internetting. In '78 we split TCP in to TCP and IP and this basically allowed UDP to come along, thanks to Danny Cohen, Dave Reed and John Shoch. [In 1979] CSNET was conceived to allow any university to connect in – Larry Landweber, David Farber, Tony Hearn, Peter Denning. [In 1983] ARPANET standardizes on TCP/IP and no machine can now connect to the Internet without using TCP/IP as its protocol. Split in to MILNET and ARPANET in '83. In '84, the Domain Name System developed – Paul Mockapetris, he's here. [1986] NSFNET comes online, Steve Wolff and Dave Mills.

[In 1988] Robert Morris unleashes the first Internet worm. Uh-oh! Suddenly something funny happens. For 20 years this is a well-behaved network. What is that? We said, “Ah, don't worry about it.” What a mistake. We should have *really* been alert at that point. We said, “It's an aberration, no problem.” But that was prophetic in showing us signs of things to come. '88 National Research Council puts out a report that I chaired a conference on talking about the National Research Network. Al Gore basically supported that. From that we led to the gigabit networks under first President Bush. ARPANET was replaced by NSFNET. In '91 the World Wide Web was suddenly made available. [The Internet Society] is formed in '92. Happy 20th anniversary. There were a million hosts on the Internet by 1992. The Mosaic browser was released, 1993.

Canter and Siegel introduced spam in 1994, uh-oh, and this time, ouch! This one hurt. These two folks, Canter and Siegel, they actually used *our* Internet to send out a commercial advertisement. You ever hear of something like that? It was the first mass mailing on purpose to a large piece of the community and there, by the way, [points to the screen] is the first spam ever. It was April 12, 1994. They were promoting their service to help you get access to a lottery for a green card. Well, we really got upset when we saw that, so we sent an e-mail back to them saying, “No, don't do that; shame on you. Stop. Bad!” We sent so much e-mail back to them we took down their server. And so an unintended consequence of the first spam was the creation of the first denial of server attack. Such is life.

But now it was out of the bag. From then on until now, and into the future we have these kinds of things causing problems.

So what are the enablers of the Internet? It allows anyone to reach hundreds of millions, billions of people. How? Easily, quickly, with no basic cost and anonymously. What better formula for the dark side of the Internet? And so the enablers that made the network so popular, so successful in its first 20 years now in the 25th year were essentially creating the dark side, and the dark side, I don't have to elaborate on all the lovely bits of it, but it is causing consternation all over the world.

[Kleinrock puts up a slide that has an image of a computer screen with a dialogue box that reads “Do you want to install a virus now?” with two button choices, “Yes” and “Yes”] *Here* is an

example of the dark side. Suppose you saw a message like that and look at the choices you get. (Laughter) I can thank Bill Cheswick for that one. This is an example of what we face every day.

Continuing on the growth of the Internet, in 1995 Netscape comes out, starts the new dot.com boom. A new model: eyeballs matter, cash does not. Bill Gates launches Windows 95 and says hmmm, there is something called the Internet out there. And he steers that battleship around and he points it directly at the Internet and he targets Netscape. Of course, Netscape didn't survive very long after that. Deregulation of the data networks in '96. More email than postal mail in the United States that same year. WiFi standard comes out in 1997. Barry Leiner puts out a paper ["The Past and Future History of the Internet"
<http://groups.csail.mit.edu/ana/Publications/PubPDFs/The%20past%20and%20future%20history%20of%20the%20internet.pdf>] with a number of the early pioneers as joint authors. Classic paper. Blogs begin to appear in '98. Napster rolls out – Sean Fanning and Sean Parker – in '99. Dot.com bubble begins to burst and now things begin to unravel a bit in 2000. English is no longer the major language of the Internet in 2001 and Wikipedia is launched. We are going to hear about that in a minute from Jimmy, Jimmy Wales. Half a billion users in 2001.

MySpace launched. Facebook launched, Mark Zuckerberg, 2004. Google is now the darling of the Internet. What could be better, more benign, "Do no evil." Wonderful system. Grokster closes down 2005 due to a Supreme Court decision. YouTube launched, not too long ago. AT&T disappears. AT&T reappears. SBC took over the name. You can't keep these things down. Google Maps and Google Earth appear. MySpace exceeds Google views, bit of a shock to Google. The next year, 2006, [people are asking] "Is Google evil?" and YouTube is purchased by Google for almost \$2 billion.

[By 2007] AT&T is now the largest U.S. carrier again. By the way AT&T went down because they had some of the best scientists in the world and some of the worst managers and they died of stupidity, but that's another story. 2007 Apple launches the iPhone and Microsoft buys Facebook at a \$15 billion valuation. Google announces Android in 2007. A billion cell phones sold in 2007 – that number seems small now. Twitter comes along in 2007.

[By 2008] GPS everywhere, in your phones and all around. Apple opens an app store 2008. Facebook overtakes MySpace. More Chinese on the Internet than Americans, 2008. Financial crisis, things again begin to unravel in a different way now. [By 2009] Cloud computing takes over.

[In 2010] iPad is introduced. AT&T phases out unlimited data usage, a major change in the way that people use their mobile phones with significant economic impact. Wikileaks leaks. Facebook is the most visited website.

The [2011] livestreaming of the royal couple Will and Kates' wedding was the biggest event ever to be watched on the Web, and yet the younger generation didn't think it was such a great thing. [Kleinrock shows a photo of the royal couple kissing on a balcony with a little flower girl in the foreground of the picture grimacing and covering her ears, he then shows the same photo, which had been edited by the royal family to eliminate the unhappy child and only show the couple kissing.] You can't find that picture on the Web anymore. That's the power of censorship.

Same year at UCLA we do a similar kind of thing. We announce an Internet history center and

that younger generation is still there doing their thing, understanding it the way they do. [Shows a photo of himself at the 2011 unveiling event for the history center, with a child in the foreground]. And that happens to be the original IMP sitting in its original location. How many revolutions do you know where you can point to the exact spot where it occurred? We got the exact four square feet where that switch started the Internet. So that's worth looking at.

[More history from 2011, 2012] The Arab Spring, basically connectivity helped fuel it. Microsoft buys Skype for billions of dollars. Google buys patents for over \$10 billion. Intel is buying patents. Facebook is buying companies that you wonder about. Billion dollars. [Referring to Instagram] Microsoft is buying patents. Everyone is buying patents these days. So it is beginning to become a legal protection and legal attack world.

So, were those events, any one of them critical to the growth of the Internet? The Web? Facebook? E-mail? No. The Internet has been growing exponentially ever since Day One in the number of attached devices and it continues to grow. It has been the sequence of important events that have allowed it to grow to the 2 billion and beyond. So who brought all of this to us? I have shown you the pictures and here are the early pioneers. And then we get the implementers. Then we get the value adders. Then we get the launchers. And then we get the billionaires. Time goes down the page. [Shows a large set of photos arrayed on the screen and keeps adding rows].

It took many years for those technologies to blossom in to the basically financial giants that we have today.

So, what are the next phases of the Internet?

One phase, nomadic computing, wherever you go you can get attached. Well, that's already happened. Nomadic computing is a reality now. Embedded technology, we are going to take cyberspace out from behind the screen of your laptops and machines and smartphones into the physical space. Ubiquitous computing, wherever you go it will be available to you. Smart space everywhere. And software agents will support you. But all of that is infrastructure. There is a whole other world of applications and services. The infrastructure is easy to predict, the application services almost impossible. We constantly have been surprised by them. A long sequence of applications have come to us out of the blue. We didn't see them coming.

What are the examples? Email early on. World Wide Web, peer-to-peer, file sharing, social networking, blogs, user-generated content.

It is safe to predict that we will be *unable* to predict those applications in the future. They will continue to come out of the blue and hit us in the side of the head and grow. That's the beauty and the opportunity of the Internet. It is all out there for all of us in this room and the younger generations to continue to produce creative works.

So where do we go from here? Well, the obvious things are the infrastructure. Everything is going to be converged – content, functions, app services. We are going to be able to see significant changes in the way you do everything. It is going to be a world of extreme mobility, that's already become apparent. Mass personalization – that's not an oxymoron. Basically [we will see] video addiction. Location-based services. Social networking. Applications: we can't

predict them; they will surprise us.

[We will see] change in the way we do everything in our world, society, the way they organize. The infrastructure, to summarize, we are going to have, basically, a pervasive global nervous system on this planet. In terms of applications and services, no one is in charge. It is the Wild West. Surprising apps create opportunity and open the world.

We have come a long way. We have come along as we progressed. And as technologies come online, you can wonder. So thank you very much. Appreciate it.