Robert E. Kahn

Chairman, CEO and President of the Corporation for National Research Initiatives

Robert E. Kahn is Chairman, CEO and President of the Corporation for National Research Initiatives (CNRI), which he founded in 1986 after a 13-year term at the United States Defense Advanced Research Projects Agency (DARPA). CNRI is a not-for-profit organization for research and development of the National Information Infrastructure.

Following a Bachelor of Electrical Engineering from the City College of New York in 1960, and MA and PhD degrees from Princeton University in 1962 and 1964 respectively, Dr Kahn worked at AT&T and Bell Laboratories before he became Assistant Professor of Electrical Engineering at the Massachusetts Institute of Technology (MIT). He took a leave of absence from MIT to join Bolt Beranek and Newman, where he was responsible for the system design of the Arpanet, the first packet-switched network.

In 1972, Dr Kahn moved to DARPA and subsequently became Director of its Information Processing Techniques Office. There he initiated the United States government’s Strategic Computing Program. Dr Kahn conceived the idea of open-architecture networking. He is a co-inventor of the TCP/IP protocol, and was responsible for originating DARPA’s Internet Program.

More recently, Dr Kahn has developed the concept of a digital object architecture to provide a framework for interoperability of heterogeneous information systems. He is also co-inventor of Knowbot programs, mobile software agents in the network environment. Among his numerous awards, Dr Kahn received the Presidential Medal of Freedom in 2005 and the National Medal of Technology in 1997.

Interview with Dr Robert Kahn, co-inventor of the Internet

Some 40 years ago, you showed the world how to connect different kinds of computers on different types of computer networks. The modern Internet is the direct result of those efforts. How do you feel about this huge success?

Robert Kahn: I used to do white-water canoeing when I was a little younger. You put your canoe into the river and it just keeps going because of the raging rivers. And it feels a little bit like this whole Internet evolution has been like a raging white water stream that we got into some 40 odd years ago, and still going. It’s pretty amazing to see what has happened around the world. In 1973, the initial work on Internet protocol development began, and, by the mid-1970s, a nascent Internet was created within the research community. It was not until 1983 that the Internet protocols were formally adopted for use.

The most eye-opening of all of the events that I’ve witnessed was probably at the 2003 World Summit on the Information Society in Geneva, when for the first time I got to witness all the nations of the world, coming together and publicly discussing what the impact of the Internet was on their country, and how they planned to deal with it, going forward.

Note: Dr Kahn’s full interview is available online at www.itu.int/itunews
Interview

2 There are those who say that the underlying architecture of the Internet may not cope with ever-growing traffic from new, bandwidth-hungry applications. They advocate a clean-slate approach to the future Internet. Are they justified? Or is evolving the Internet the answer?

Robert Kahn: From my perspective, the Internet is a global information system that enables component structures like networks, computers and devices of different kinds to intercommunicate by passing information between them. The essence of the Internet is the protocols and procedures that enable this to happen. The protocols and procedures were designed to be independent of the kinds of networking and computing components that comprise it.

We have to keep evolving the Internet. And the way to evolve it is by integrating with or building on what’s there. I don’t think you need to destroy what exists in order to create a better future. When the original computer networks were developed, they weren’t developed by destroying the telecommunications infrastructure. Where we are today with the Internet, we can do the same thing by leveraging the capabilities that are there to build new and better, more powerful, more relevant applications for the future and more relevant infrastructure to support those applications.

A clean slate is not really practical. Maybe it once was, when there was nothing to begin with. But once you have something that’s widely deployed and in daily use by a large fraction of the world’s population, you have to work with what you have.

3 You developed the digital object architecture concept. What is it exactly and how does it work?

Robert Kahn: The Internet, as originally envisioned by me and others that I worked with, involved moving bits around from place to place on a worldwide basis, without having to know details like what network the party was on, how to route data, and so forth. It was a convenient way to get information (as essentially undifferentiated bits) from one place to another, reliably and rapidly.

What occurred to me, a number of years ago, was that we needed to take an additional step forward, and begin to think about the Internet as a vehicle for managing information, as opposed to just delivery of undifferentiated bits. The problem with much of the technology on the Internet today is that it is a function of other technology that’s available on the Internet. To give you an example, when I first started in computer networking, the way we addressed computers was by the wire that the computer was connected to — on the one and only network in existence. Where we are today with the Internet, we can do the same thing by leveraging the capabilities that are there to build new and better, more powerful, more relevant applications for the future and more relevant infrastructure to support those applications.

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Are we really running out of IP addresses based on the current Internet protocol version 4? And what do you think of the transition to IPv6?

Robert Kahn: IPv4 is a 32-bit addressing protocol. We created the 32-bit protocol back in 1973. At the time, we thought 8 bits would be more than enough to identify each network; and the remaining 24 bits enough to define which machine on that network. The reality was that, with the explosion in local area networks, particularly the Ethernet, it became clear that that was insufficient. That’s what’s put the pressure on IPv4 addresses. Now, depending on how you manage IPv4 addresses, it may or may not be sufficient. But the way it’s being managed today, given the lack of good alternatives for making use of a limited amount of IPv4 addresses, it seems very clear that these addresses will be consumed fairly soon.

When the World Wide Web was created, the idea there was that you could essentially simplify procedures that we had been using for decades. The idea was to turn procedural methods, like having to log in somewhere and having to know exactly what keys to type, into a clickable version, based on a URL, where the protocols behind the scenes would do essentially the same things for you. But that tied it to the way it was implemented: specific machine names which were resolvable through the DNS and then to specific files on those machines. The half-life of these URLs is not very long, and probably within five years the vast majority of them will either no longer work, or will produce different information. So the notion that we had was to literally identify the information represented in the form of a persistently identifiable data structure we called those data structures digital objects, and, by giving each a separate identifier, every digital object is uniquely identifiable.
That was the motivation for creating IPv6, which uses 128-bit addresses. It has been asserted that this is enough to identify every atom in the universe. The conversion to IPv6 has been anything but straightforward and simple. And getting adoption everywhere in the world still seems a challenge in many respects. But let’s assume that the transition to IPv6 is going to happen as it seems almost inevitable.

The real question is: are we going to cavalierly use IPv6 to identify absolutely everything in the Internet, or are we going to find some other, more prudent, long-term strategy to do that? For example, if I run a system that contains a number of these digital objects I was talking about, suppose it’s got a trillion digital objects in one of these systems, one possibility is to give every one of those objects an IPv6 address. But to me, that’s a very foolish use of these addresses, because IPv6 is also used for routing purposes, in part. It makes for a much more complex system than if you just say, this particular item that I’m looking for, this digital object, is at a system that’s got a given IPv6 address, and then once you get to that system, give me the object that’s got this unique identifier, which has nothing to do necessarily with IPv6. And now if that object moves, you simply say, well, the object is over here now, or it’s in several places, and please give me the object with the same identifier.

Will IPv6 bring us the “Internet of things”, where for example, refrigerators will be able to exchange information with supermarket shelves, where one can be in one’s office kilometres away and switch on and off a microwave oven?

Robert Kahn: I don’t know that history gives us any good guidance as to what to expect in these cases. Usually, initial views of what a technological future will look like are wrong. For example, in the history of telephony, there’s quite a bit of text that’s been written about Alexander Graham Bell, who is credited with the discovery or the invention of telephony in the United States, thinking that it would be a very good means for getting concerts into the home. Well, do you know anybody that listens to concerts over the telephone today? History is replete with examples where the initial view of people as to what might happen turned out to be wrong, and in time more socially effective means of using the technology emerged.
In the context of IPv6, ultimately, whether we are talking about the Internet of things or identity management for individuals, the bottom line is that we are talking about information about those entities or individuals. All these questions revolve around the same set of issues: How do you get to the information? What do you do with the information? Is it accurate? Can you trust it?

In the early 1990s, instead of proceeding down the knowbot path, I decided to focus on the case where the mobile component was removed from the picture. The digital object architecture is what resulted. It was assumed that these digital objects would be stored in accessible locations on the Internet called repositories, and that you could access information in these repositories solely by virtue of knowing the

Tell us more about Knowbots and the “handle system” that you created.

Robert Kahn: One of the people I worked with for a long time in the networking area is Vint Cerf, who’s also gotten a lot of publicity for the work he and I did with the Internet. Vint worked with me at DARPA for many years, he left briefly to go to MCI, and then he joined me again, back as employee number two when I started CNRI; he was at CNRI for another eight years or so after that.

During that period, we got quite interested in the idea of finding and managing information on the Internet by virtue of sending out mobile programs that could execute in different places — you could task them to carry out various objectives for you. One major concern we had was that organizations would not want a mobile program that somebody else had written to just show up on their computers and execute. I suppose it seemed like an open invitation for viruses to show up, or worse.

We were thinking of using “knowbot service stations”, which (among other things) would be responsible for injecting mobile programs into the Internet, and for accepting mobile programs originated elsewhere and running them. So multiple programs could show up and interact with each other, and these programs could somehow, all together, figure out the answer to a question, or carry out a task. It’s still pretty much waiting to happen on a larger scale.
identifier of the object. So you didn’t have to worry about what technology base it was on now or at any point in the future because presumably, if implemented properly, it could all support this kind of a notion.

A way was needed to resolve identifiers to locations and other useful information, like the ability to validate information including identity. This latter ability translates to getting public keys for an individual, who could then verify information with a private key, or authenticate information, or access the object’s terms and conditions. So, the whole notion of the digital object architecture was based on a more static view of these mobile programs. While it was anticipated that it could be used in a mobile environment, this was not the initial focus of this work.

Privacy becomes important in this context. There are search engines on the Internet today that allow you to locate things that are publicly accessible, for example on the web. But that’s not likely to help you find your medical or financial records. The question of privacy is a small part of the larger issue that I really think the digital object architecture was intended to address: How do you get different kinds of information systems that have reasons to interoperate, to be able to interoperate without having somebody specifically figure out ahead of time, for every possible interaction, how they should do it?

Your final thoughts?

Robert Kahn: The world is increasingly connected. The coming decades are going to be as exciting as the past decades have been, probably in dimensions that we don’t really know how to predict or envision. It is ultimately the creativity of the human spirit that is going to drive and fuel this, and anything that we can do to essentially stimulate that, and invigorate it, and enhance it, will probably help to come up with new and better ways of dealing with our societal needs going forward.