Present at the creation

Vinton Cerf was one of the founding fathers of the internet and has continued to take an active role in its development

IT WAS as a teenager in the late 1950s that Vinton Cerf first encountered a computer—an experience he still vividly recalls. The machine in question was a SAGE AN/FSQ-7 computer in Santa Monica, California, one of a national network of military machines, linked together by telephone lines, that was being built to monitor American airspace. "I was brought on a tour and got totally excited by it," he says. "It was a tube-based machine, so big you physically walked inside it." The SAGE machines—each of which contained 55,000 vacuum tubes, weighed 275 tonnes and occupied half an acre of floorspace—were in fact the largest computers ever built. Awestruck, the young Mr Cerf was soon "totally hooked" on computers. "I went to Stanford and took every computer course I could find," he says.

After graduating in mathematics, Mr Cerf worked briefly at IBM, but soon returned to academia, eventually receiving a PhD in computer science from the University of California, Los Angeles, in 1972. During this time he helped to design and develop the protocol (called NCP) for the ARPANET, the first modern "packet switched" network, which linked together several different kinds of computer using a common protocol. In 1972 Robert Kahn, one of the architects of the ARPANET, began to think about how to take this idea one step further, and to link together packet networks (rather than just individual computers) of different kinds, a concept he called "internetting". In 1973 he invited Dr Cerf, by now a professor at Stanford, to help with the design of a new protocol to make such inter-network links possible.

In May 1974 the two men published a paper, "A Protocol for Packet Network Intercommunication", laying out their proposals. It refers to "internetwork packets" and "internetwork addressing". By December 1974, when the full specifications for the new proposal were published in a document called RFC 675, the term "internetwork" had begun to be abbreviated to "internet". The protocol that Dr Cerf and Dr Kahn designed, initially called "internet TCP", was subsequently developed into TCP/IP, the protocol that still underpins the internet today.

As a result, Dr Cerf and Dr Kahn are often referred to as the fathers of the internet. They have received many awards over the years in recognition of the importance of their work, including the National Medal of Technology, the Presidential Medal of Freedom, and a Turing Award (the computer-science equivalent of a Nobel prize). Even so, Dr Cerf is keen to point out that many people were involved in the creation of the internet. "There were many of us," he says. "As a father, I've learned you don't want to take too much

credit for what your kids do, because when they screw up you don't want to take too much blame."

Keep it simple

From its origins as an experimental network in the 1970s, the internet has since grown to become a global network with around 1 billion users and a dazzling range of applications, from Amazon and eBay to Napster and Skype. This growth and flexibility was possible because rather than prejudging the kinds of uses to which the internet might be put and favouring some at the expense of others, Dr Cerf and Dr Kahn opted to make it as simple as possible. "We deliberately did not try to tailor the network to particular applications, because we believed there would be applications we couldn't predict," says Dr Cerf. "We hoped that having a very general packet-switched capability would support almost anything. So far, it has been true."

Of all the various new applications that the internet has enabled, Dr Cerf says he has been most surprised by the emergence of the web, and particularly by the ensuing "avalanche of content" published by hundreds of millions of ordinary users. Another surprise, he says, was the widespread adoption of peer-to-peer (P2P) applications such as Napster and Skype. The internet was originally designed for machine-to-machine communication (rather than, say, publishing information from a central source) so the emergence of P2P is entirely in keeping with the internet's original philosophy. Looking to the future, predicts Dr Cerf, "the thing that is going to surprise me will be the applications that come up in the mobile environment, where the utility of geographically based information is much greater."

Is there anything he would change about the design he and Dr Kahn cooked up for the internet? Dr Cerf admits that with hindsight, there are two things he regrets not including: authentication, to ensure that internet packets really do come from where they claim to have originated, and support for mobile devices.

Since his pioneering studies in the 1970s, Dr Cerf has held a succession of jobs that mirror the development of the internet. After Stanford he continued his work on the internet's architecture at the Defence Advanced Research Projects Agency, the military research body that funded the network's original development. He then moved to MCI, a telecoms firm, where he developed MCIMail, the first commercial e-mail service to connect to the internet. After another spell in research, he returned to MCI in 1994 and remained there as the company became closely identified (now as part of WorldCom) with both the hysteria of the internet bubble and the subsequent telecoms crash.

Meanwhile, Dr Cerf also took an active role in internet governance. He and Dr Kahn founded the Internet Society in 1992, and Dr Cerf currently spends around 25% of his time serving as the chairman of ICANN, the body that regulates domain names and addresses on the internet. He describes this as "a form of penal servitude"—a reflection of the controversy and criticism that has surrounded ICANN from its inception.

In 2005 Dr Cerf was appointed "chief internet evangelist" at Google, the latest firm to embody the internet Zeitgeist, where he is once again in his element—shaping the future of the internet. "I am surrounded by some of the smartest people I've ever met," he says. "It's an amazing experience—everyone is about 25, running at 900 miles per hour."

At Google, Dr Cerf plays several roles. "I'm playing intellectual bumble-bee, visiting engineering offices, interacting with engineers, trying to find out what problems they have, helping them find solutions," he says. He also evaluates new companies or technologies that Google "should be engaged with or even acquiring", and represents Google on policy issues. In February he appeared before the Senate Commerce Committee in Washington, DC, where internet regulation and the question of "network neutrality" have recently become hot topics. This is because large telecoms firms, such as AT&T and Verizon, are proposing to build internet "fast lanes", which would allow them to charge users and content providers for speedy, guaranteed delivery of data. This has prompted a wave of protest from those, including Dr Cerf, who worry that this violates the fundamental non-discriminatory basis of the internet, and could thus hamper its innovative culture.

What particularly offends Dr Cerf about the telecoms operators' plans is that "they are trying to force us back into a 19th-century model in a 21st-century world," he says. Under the old 19th-century model, telephone calls (like letters and parcels before them) are delivered from A to B, and the caller (or sender) pays the operator (or delivery firm) accordingly. The internet, however, operates on a completely different principle: users, whether giant corporations or individuals, simply pay for access to the network—the faster it is, the more it costs—and there are then no carriage or delivery fees. But Dr Cerf warns that although this simple approach has made possible all kinds of new services, the operators are now trying to move back towards the old model. "If we follow their logic, every time I send you an e-mail I will have to pay," he says. Operators should simply recover their costs through access fees, he insists.

To infinity and beyond

Plans for internet "fast lanes" are also a personal affront to Dr Cerf, since they could undermine the open architecture that he has spent his career developing, and still continues to promote. In recent years Dr Cerf has been working with researchers at America's space agency, NASA, to develop an interplanetary internet (IPN). (The existing protocol is unsuitable for interplanetary use, because of the long time delays associated with communication over such long distances, and also because the topology of the network is in constant flux as planets and spacecraft move around.) This is not as crazy, or hypothetical, as it sounds. Some of the results of this work have already found their way into the *Mars Reconnaissance Orbiter*, a NASA probe that recently went into orbit around the red planet. And the IPN research turns out to have uses on earth as well, says Dr Cerf. Its "delay-and-disruption-tolerant networking" protocol is now being tested by America's defence department for use in

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mobile communications on the battlefield, and by researchers at UCLA who are working on wireless sensor networks.

But it is building networks in space that really appeals to Dr Cerf—a science-fiction fan who describes himself as a "frustrated thespian" and once had a brief walk-on part in "Earth: Final Conflict", a sci-fi television series. "The NASA folks finally started doing a long-term space-communications architecture study, and it looks like we are now about to adopt these concepts as part of their 40-year plan for the further deployment of space platforms," he says. The idea is that future space probes will be IPN-capable, so that a network will gradually be built up, one spacecraft at a time. "The backbone will accrete over time as we launch new missions, so I won't see the fruition of all this, as it will take decades," says Dr Cerf. But it is a logical culmination of his work on ARPANET (connecting individual machines) and the internet (connecting networks), since the interplanetary internet will eventually consist of interconnected planetary internets.

"It's so much fun to be part of all this," says Dr Cerf, as he looks back at his remarkable career. "You feel as though you are having some impact on future generations when you are involved in this kind of thing." Most people would probably be quite happy to retire after having helped to create the communications network for a single planet, but not Dr Cerf. At 62, he still feels he has work to do. "I don't know if I'm going to retire," he says. "Being Vint Cerf is fun. I still can't quite believe I get paid for doing this stuff."