Leonard Kleinrock Personal Biography
The Birth of the Internet

IMP1: The first node of the ARPANET

It all began with a comic book! At the age of 6, Leonard Kleinrock was reading a Superman comic at his apartment in Manhattan, when, in the centerfold, he found plans for building a crystal radio. To do so, he needed his father's used razor blade, a piece of pencil lead, an empty toilet paper roll, and some wire, all of which he had no trouble obtaining. In addition, he needed an earphone which he promptly appropriated from a public telephone booth. The one remaining part was something called a "variable capacitor". For this, he convinced his mother to take him on the subway down to Canal Street, the center for radio electronics. Upon arrival to one of the shops, he boldly walked up to the clerk and proudly asked to purchase a variable capacitor, whereupon the clerk replied with, "what size do you want?". This blew his cover, and he confessed that he not only had no idea what size, but he also had no idea what the part was for in the first place. After explaining why he wanted one, the clerk sold him just what he needed. Kleinrock built the crystal radio and was totally hooked when "free" music came through the earphones - no batteries, no power, all free! An engineer was born.

Leonard Kleinrock spent the next few years cannibalizing discarded radios as he sharpened his electronics skills. He went to the legendary Bronx High School of Science and appended his studies with courses in Radio Engineering. When the time came to go to college, he found he could not afford to attend, even at the tuition-free City College of New York (CCNY), and so he enrolled in their evening session program while working full time as an electronics technician/engineer and bringing a solid paycheck home to his family. He graduated first in his class after 5 1/2 years of intense work (and was elected student body president of the evening session). His work and college training were invaluable, and led to his winning a full graduate fellowship to attend the Massachusetts Institute of Technology in the Electrical Engineering Department.

At MIT, he found that the vast majority of his classmates were doing their Ph.D. research in the overpopulated area of Information Theory. This was not for him, and instead he chose to break new ground in the virtually unknown area of data networks. Indeed, in 1961, he submitted a Ph.D. proposal to study data networks, thus launching the technology which eventually led to the Internet. He completed his work in 1962 which was later published in 1964 by McGraw-Hill as an MIT book entitled "Communication Nets". In this work, he developed the basic principles of packet switching, thus providing the fundamental underpinnings for that technology. These principles (along with his subsequent research) continue to provide a basis for today's Internet technology. Kleinrock is arguably the world's leading authority and researcher in the field of computer network modeling, analysis and design and a father of the Internet.

But the commercial world was not ready for data networks and his work lay dormant for most of the 1960's as he continued to publish his results on networking technology while at the same time rising rapidly through the professorial ranks at UCLA where he had joined the faculty in 1963. In the mid-1960's, the Advanced Research Projects Agency (ARPA) - which was created in 1958 as the United States' response to Sputnik - became interested in networks. ARPA had been supporting a number of computer scientists around the country and, as new researchers were brought in, they naturally asked ARPA to provide a computer on which they could do their research; however, ARPA reasoned that this community of scientists would be able to share a smaller number of computers if these computers were connected together by means of a data network. Because of his unique expertise in data networking, they called him to Washington to play a key role in preparing a functional specification for the ARPANET - a government-supported data network that would use the technology which by then had come to be known as "packet switching".

The specification for the ARPANET was prepared in 1968, and in January 1969, a Cambridge-based computer company, Bolt, Beranek and Newman (BBN) won the contract to design, implement and deploy the ARPANET. It was their job to take the specification and develop a computer that could act as the switching node for the packet-switched ARPANET. BBN had selected a Honeywell minicomputer as the base on which they would build the switch.

Due to Kleinrock's fundamental role in establishing data networking technology over the preceding decade, ARPA decided that UCLA, under Kleinrock's leadership, would become the first node to join the ARPANET. This meant that the first switch (known as an Interface Message Processor - IMP) would arrive on the Labor Day weekend, 1969, and the UCLA team of 40 people that Kleinrock organized would have to provide the ability to connect the first (host) computer to the IMP. This was a challenging task since no such connection had ever been attempted. (This minicomputer had just been released in 1968 and Honeywell displayed it at the 1968 Fall Joint Computer Conference where Kleinrock saw the machine suspended by its hooks at the conference; while running, there was this brute whacking it with a sledge hammer just to show it was robust. Kleinrock suspects that that particular machine is the one that was delivered by BBN to UCLA.) As it turns out, BBN was running

two weeks late (much to Kleinrock's delight, since he and his team badly needed the extra development time); BBN, however, shipped the IMP on an airplane instead of on a truck, and it arrived on time. Aware of the pending arrival date, Kleinrock and his team worked around the clock to meet the schedule. On the day after the IMP arrived (the Tuesday after Labor Day), the circus began - everyone who had any imaginable excuse to be there, was there. Kleinrock and his team were there; BBN was there; Honeywell was there (the IMP was built out of a Honeywell minicomputer); Scientific Data Systems was there (the UCLA host machine was an SDS machine); AT&T long lines was there (we were attaching to their network); GTE was there (they were the local telephone company); ARPA was there; the UCLA Computer Science Dept. administration was there; the UCLA campus administration was there; plus an army of Computer Science graduate students was there. Expectations and anxieties were high because, everyone was concerned that their piece might fail. Fortunately, the team had done its job well and bits began moving between the UCLA computer and the IMP that same day. By the next day they had messages moving between the machines. THUS WAS BORN THE ARPANET, AND THE COMMUNITY WHICH HAS NOW BECOME THE INTERNET!

A month later the second node was added (at Stanford Research Institute) and the first Host-to-Host message ever to be sent on the Internet was launched from UCLA. This occurred in early October when Kleinrock and one of his programmers proceeded to "logon" to the SRI Host from the UCLA Host. The procedure was to type in "log" and the system at SRI was set up to be clever enough to fill out the rest of the command, namely to add "in" thus creating the word "login". A telephone headset was mounted on the programmers at both ends so they could communicate by voice as the message was transmitted. At the UCLA end, they typed in the "l" and asked SRI if they received it; "got the l" came the voice reply. UCLA typed in the "o", asked if they got it, and received "got the o". UCLA then typed in the "g" and the darned system CRASHED! Quite a beginning. On the second attempt, it worked fine!

Little did those pioneers realize what they had created. Indeed, most of the ARPA-supported researchers were opposed to joining the network for fear that it would enable outsiders to load down their "private" computers. Kleinrock had to convince them that joining would be a win-win situation for all concerned, and managed to get reluctant agreement in the community. By December 1969, four sites were connected (UCLA, Stanford Research Institute, UC Santa Barbara, and the University of Utah) and UCLA was already conducting a series of extensive tests to debug the network. Indeed, under Kleinrock's supervision, UCLA served for many years as the ARPANET Measurement Center (in one interesting experiment in the mid-1970's, UCLA managed to control a geosynchronous satellite hovering over the Atlantic Ocean by sending messages through the ARPANET from California to an East Coast satellite dish). As head of the Center, it was Kleinrock's mission to stress the network to its limits and, if possible, expose its faults by "crashing" the net; in those early days, Kleinrock could bring the net down at will, each time identifying and repairing a serious network fault. Some of the faults he uncovered were given descriptive names like Christmas Lockup and Piggyback Lockup. By mid-1970, ten nodes were connected, spanning the USA. BBN designed the IMP to accommodate no more than 64 computers and only one network. Today, the Internet has millions of computers and hundreds of thousands of networks! Electronic mail (email) was an ad-hoc add-on to the network in those early days and it immediately began to dominate network traffic; indeed, the network was already demonstrating its most attractive characteristic, namely, its ability to promote "people- to-people" interaction. The ARPANET evolved into the Internet in the 1980's and was discovered by the commercial world in the late `80's; today, the majority of the traffic on the Internet is from the commercial sector, whereas it had earlier been dominated by the scientific research community. Indeed, no one in those early days predicted how enormously successful data networking would become.

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In the ensuing years since those pioneering days that led to the birth of the Internet, Kleinrock has continued as a prime mover at the frontier of the Internet and its growth and development. He has provided an international brain trust of Ph.D. graduates (39 to date) who populate major laboratories, universities and commercial organizations and who continue to advance the state of the art in networking. As one of the youngest members elected to the National Academy of Engineering, he was a founding member of the National Research Council's elite Computer Science and Telecommunications Board (CSTB). He chaired the committee that produced this Board's first report, "Towards a National Research Network"; in presenting the findings of this landmark report, he testified for then Senator Al Gore, which precipitated the Gigabit Networking component of the US Government's High Performance Computing and Communications Initiative.

Today, four events have juxtaposed to create a crucial juncture. First, the Internet has exploded in use and reach (and no one controls the Internet, no one owns it, no one can "shut it off"). Second, the US Administration has vigorously promoted a vision of the Information Superhighway (the National Information Infrastructure - NII). Third, the entertainment industry, along with the telephone and cable TV industries, have recognized that there is a massive business opportunity in network-based entertainment. Fourth, the telecommunications networks have been deregulated. Indeed, the Internet and the World Wide Web are household words. The result is that huge sums of money are about to be expended by the private sector to wire up the USA. In the face of this, there are some basic questions as to what is the proper vision of future networking, what is the technology framework needed to realize that vision, who will design and deploy it, whom will it serve and how, what kinds of applications and services will it support, what is the role of government and of the private sector, etc. Once again, Leonard Kleinrock is leading the effort here by way of a National Research Council CSTB committee that he chaired, and that produced the widely circulated 1994 report "Realizing the Information Future; The Internet and Beyond". This report took the country by storm, and he briefed many government and industry groups regarding its recommendations. Kleinrock's goal this time is to help formulate the guidance needed to bring the networking technology that he pioneered to society and industry for the greater good of this country and of the world.

More recently, Kleinrock has taken the leading role in the new technology of Nomadic Computing and Communications; the idea is to create a technology that will support the nomadic user in his computing and communication needs as he travels from place to place.

The potential impact of a ubiquitous information infrastructure is unbounded. The nature of the services and styles it can produce is limited only by the imagination of its practitioners. Kleinrock has always worked at the frontier of new technology. He chooses not to follow, fill-in, patch-up or catch-up. Rather, he takes the lead and opens up vast new technologies that have impact and excitement. Kleinrock has provided the leadership and vision to help bring this about .

From a comic book to cyberspace; an interesting journey indeed!