I: The Conception

Paul Baran, an electrical engineer, conceived one of the Internet’s building blocks—packet switching—while working at the Rand Corporation around 1960. Packet switching breaks data into chunks, or “packets,” and lets each one take its own path to a destination, where they are re-assembled (rather than sending everything along the same path, as a traditional telephone circuit does). A similar idea was proposed independently in Britain by Donald Davies. Later in his career, Baran would pioneer the airport metal detector.

Paul Baran: It was necessary to have a strategic system that could withstand a first attack and then be able to return the favor in kind. The problem was that we didn’t have a survivable communications system, and so Soviet missiles aimed at U.S. missiles would take out the entire telephone-communication system. At that time the Strategic Air Command had just two forms of communication. One was the U.S. telephone system, or an overlay of that, and the other was high-frequency or shortwave radio.

So that left us with the interesting situation of saying, Well, why do the communications fail when the bombs were aimed, not at the cities, but just at the strategic forces? And the answer was that the collateral damage was sufficient to knock out a telephone system that was highly centralized. Well, then, let’s not make it centralized. Let’s spread it out so that we can have other paths to get around the damage.

I get credit for a lot of things I didn’t do. I just did a little piece on packet switching and I get blamed for the whole goddamned Internet, you know? Technology reaches a certain ripeness and the pieces are available and the need is there and the economics look good—it’s going to get invented by somebody.

Leonard Kleinrock, a professor of computer science at U.C.L.A., was instrumental in creating the earliest computer networks, in the 1960s. J. C. R. Licklider, one of the fathers of computer science and information technology, was the first director of ARPA’s computer-science division.

Leonard Kleinrock: Licklider was a strong, driving visionary, and he set the stage. He foresaw two aspects of what we now have. His early work—he was a psychologist by training—was in what he called man-computer symbiosis. When you put a computer in the hands of a human, the interaction between them becomes much greater than the individual parts. And he also foresaw a great change in the way activity would take place: education, creativity, commerce, just general information access. He foresaw a connected world of information.

The culture was one of: You find a good scientist. Fund him. Leave him alone. Don’t over-manage. Don’t tell him how to do something. You may tell him what you’re interested in: I want artificial intelligence. I want a network. I want time-sharing. Don’t tell him how to do it.
Robert Taylor left NASA and became the third director of ARPA's computer-science division. Taylor's chief scientist was Larry Roberts, who oversaw development of the Arpanet. ARPA's director was Charles Herzfeld.

Bob Taylor: Sputnik in 1957 surprised a lot of people, and Eisenhower asked the Defense Department to set up a special agency, so that we would not get caught with our pants down again.

ARPA was a go-for-broke kind of culture. First of all, it had a lot of carte blanche. If ARPA asked some cooperation from the air force or the navy or the army, they got it instantly and automatically. There was no interagency bickering. It had a lot of clout and little or no red tape. To get something going was very easy.

Leonard Kleinrock: Bob Taylor, who was funding many research computer scientists around the country, recognized that accessing each of the computers was a pain in the neck.

Bob Taylor: There were individual instances of interactive computing through time-sharing, sponsored by ARPA, scattered around the country. In my office in the Pentagon I had one terminal that connected to a time-sharing system at M.I.T. I had another one that connected to a time-sharing system at U.C. Berkeley. I had one that connected to a time-sharing system at the System Development Corporation, in Santa Monica. There was another terminal that connected to the Rand Corporation.

And for me to use any of these systems, I would have to move from one terminal to the other. So the obvious idea came to me: Wait a minute. Why not just have one terminal, and it connects to anything you want it to be connected to? And, hence, the Arpanet was born.

When I had this idea about building a network—this was in 1966—it was kind of an “Aha” idea, a “Eureka!” idea. I went over to Charlie Herzfeld’s office and told him about it. And he pretty much instantly made a budget change within his agency and took a million dollars away from one of his other offices and gave it to me to get started. It took about 20 minutes.

Paul Baran: The one hurdle packet switching faced was AT&T. They fought it tooth and nail at the beginning. They tried all sorts of things to stop it. They pretty much had a monopoly in all communications. And somebody from outside saying that there’s a better way to do it of course doesn’t make sense. They automatically assumed that we didn’t know what we were doing.

Bob Taylor: Working with AT&T would be like working with Cro-Magnon man. I asked them if they wanted to be early members so they could learn technology as we went along. They said no. I said, Well, why not? And they said, Because packet switching won’t work. They were adamant. As a result, AT&T missed out on the whole early networking experience.

Robert Kahn worked on the technical staff at Bell Laboratories before joining the electrical-engineering faculty at M.I.T. In 1966 he left to become a networking theorist at Bolt, Beranek & Newman, in Cambridge, Massachusetts—where he worked until 1972, when he was named head of ARPA's computer branch. He teamed with Vint Cerf to devise the TCP and IP networking protocols in the 1970s.
Bob Kahn: Let me put it into perspective. So here we are when there are very few time-sharing systems anywhere in the world. AT&T probably said, Look, maybe we would have 50 or a hundred organizations, maybe a few hundred organizations, that could possibly partake of this in any reasonable time frame. Remember, the personal computer hadn’t been invented yet. So, you had to have these big expensive mainframes in order to do anything. They said, There’s no business there, and why should we waste our time until we can see that there’s a business opportunity? That’s why a place like ARPA is so important.

Best known for founding, editing, and publishing the Whole Earth Catalog, Stewart Brand is a techie anthropologist and a co-founder of the Global Business Network and the Long Now Foundation.

Stewart Brand: This was a time which was pretty much ARPA-derived, in the sense that the money for computers and for networking computers was coming from the government, and from pretty enlightened leadership there. The idea of Arpanet was that it was going to basically join up computational resources. It was not set up primarily to do e-mail—but the computational-resource connection turned out to be not so important, and the e-mail turned out to be the killer app. These were people who were just trying those two experiments, one to try to make the computational resources blend, and the other to stay in touch with each other conveniently. You were inventing in all directions, with no particular certainty what was going to play out.

Anyway, we were all engineers of both ilks, the narrow-tie, nine-to-five serious engineers and the stay-up-all-night long-haired hackers who had earned their way into the respect of the engineers. And pretty much everybody was male.

II: The Creation

In 1969, ARPA gave the job of building “interface message processors” (I.M.P.’s), otherwise known as “nodes” or “packet switches”—the crucial hardware for sending and receiving bursts of data—to Bolt, Beranek & Newman. In a congratulatory telegram to the company, Senator Edward M. Kennedy referred to I.M.P.’s as “interfaith” message processors.

Bob Kahn: They said, We want a network. This would be like a bid for a rocket to the moon—you know, handle a thousand pounds of payload, launch from a vertical liftoff in Florida, bring back something safely.

Larry Roberts: There were two competing bids that were particularly close, BBN and Raytheon. And I chose between them based on the team structure and the people. I just felt that the BBN team was less structured. There wouldn’t be as many middle managers and so on.

Bob Kahn: Larry Roberts was an engineer. In fact, Larry probably could have built the Arpanet himself, would be my guess, except there would have been nobody at ARPA to run the program who was capable. When Larry contracted with us at BBN to do it, you know, in some sense he kept his fingers in the pie right through that whole period.
On an eight-month deadline, the BBN team delivered their prototype I.M.P. to U.C.L.A. on August 30, 1969.

Leonard Kleinrock: September 2, 1969, is when the first I.M.P. was connected to the first host, and that happened at U.C.L.A. We didn’t even have a camera or a tape recorder or a written record of that event. I mean, who noticed? Nobody did. Nineteen sixty-nine was quite a year. Man on the moon. Woodstock. Mets won the World Series. Charles Manson starts killing these people here in Los Angeles. And the Internet was born. Well, the first four everybody knew about. Nobody knew about the Internet.

So the switch arrives. Nobody notices. However, a month later, Stanford Research Institute gets their I.M.P., and they connect their host to their switch. Think of a square box, our computer, connected to a circle, which is the I.M.P., 5, 10 feet away. There’s another I.M.P. 400 miles north of us in Menlo Park, basically at Stanford Research Institute. And there’s a high-speed line connecting those two. We are now prepared to connect two hosts together over this fledgling network.

So on October 29, 1969, at 10:30 in the evening, you will find in a log, a notebook log that I have in my office at U.C.L.A., an entry which says, “Talked to SRI host to host.” If you want to be, shall I say, poetic about it, the September event was when the infant Internet took its first breath.

Bob Kahn: More than a year and a half later there were really no fully operational sites. And the reason was that, in order to get on, you had to implement interfaces, you had to build protocols, you had to connect it to your operating systems, you had to connect it to your applications. It was a job for wizards. My conclusion was that we needed to do something to stimulate people. So I talked to ARPA about doing a demonstration, and they made arrangements with the organizers of the very first International Conference on Computer Communication. It was very exciting. People would come in to see what was going on. If you had to pick an analogy, I’d almost liken it to Kitty Hawk.

Vint Cerf, who worked with Leonard Kleinrock at U.C.L.A., is the co-designer (with Bob Kahn) of the TCP and IP protocols that provide the basic linking structure of the Internet. He is now an executive at Google, where his title is “chief Internet evangelist.”

Vint Cerf: One of the features of this Arpanet is that the machines that were connected to it were time-shared. The idea of leaving files for each other was pretty common in the time-sharing world. A guy named Ray Tomlinson, at Bolt, Beranek & Newman, figured out a way to cause a file to be transferred from one machine through the Net to another machine and left in a particular location for someone to pick up. He said, I need some symbol that separates the name of the recipient from the machine that the guy’s files are on. And so he looked around for what symbols on the keyboard were not already in use, and found the “@” sign. It was a tremendous invention.

Robert Metcalfe, who worked on the Arpanet at M.I.T., went on to invent Ethernet and to found 3Com. He is also the progenitor of Metcalfe’s Law: as the number of users on a network grows, the value of that network increases exponentially. Metcalfe was given the job of demonstrating the Arpanet system at its coming-out party, at the I.C.C.C. meeting at the Washington Hilton, in 1972.
**Bob Metcalfe:** Imagine a bearded grad student being handed a dozen AT&T executives, all in pin-stripped suits and quite a bit older and cooler. And I’m giving them a tour. And when I say a tour, they’re standing behind me while I’m typing on one of these terminals. I’m traveling around the Arpanet showing them: Ooh, look. You can do this. And I’m in U.C.L.A. in Los Angeles now. And now I’m in San Francisco. And now I’m in Chicago. And now I’m in Cambridge, Massachusetts—isn’t this cool? And as I’m giving my demo, the damned thing crashed.

And I turned around to look at these 10, 12 AT&T suits, and they were all laughing. And it was in that moment that AT&T became my bête noire, because I realized in that moment that these sons of bitches were rooting against me.

To this day, I still cringe at the mention of AT&T. That’s why my cell phone is a T-Mobile. The rest of my family uses AT&T, but I refuse.

*As networking grew, so did the number of distinct networks. Across the Atlantic, French computer scientist Louis Pouzin was building his own Arpanet, called Cyclades. A packet-switched satellite network (Satnet) was developed. Foreseeing the chaos of multiple networks that could not communicate, Bob Kahn and Vint Cerf designed the Transmission Control Protocol (TCP), in 1973. The term “Internet” has its roots in TCP, which is a way of interconnecting networks.*

**Larry Roberts:** After we built the Arpanet, lots of people built networks. Everybody was competing. Everyone had their own thing that they wanted to do. So it became very important that the world have one protocol, so they could all talk to each other. And Bob Kahn really pushed that process. And Vint. And it wasn’t licensed. They proved to the world that making something free as a driver would make a huge difference in making it a standard.

**Vint Cerf:** The Arpanet demonstrated the effectiveness of packet switching. And it demonstrated that it was possible to get heterogeneous computers to talk to each other through a single common packet-switched net. What Bob Kahn and I did was to demonstrate that with a different set of protocols you could get an infinite number of—well, infinite is not true, but an arbitrarily large number of—different heterogeneous packet-switched nets to interconnect with each other as if it was all one big giant network. TCP is the thing that makes the Internet the Internet.

We absolutely knew what could happen if our work was successful. We knew about the mobile possibilities. We knew about satellite. We had some idea of how powerful this was. What we didn’t know was the economics of it.

*In the decade after TCP was introduced, the Internet was embraced by university researchers and other early adopters.*