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Back to the Future

First, allow me to congratulate all the ACM honorees that receive their well-deserved awards this month at the ACM Awards Gala in San Francisco. For an account of the awards this year, please read ACM President Cherri Pancake's summary on p. 5 of this issue.

I want to take you back to the mid-1800s, as the telegraph emerged as a nearly fast-as-light communication technology. You can imagine the excitement when in 1844 Samuel Morse sent his first message between Washington, D.C., and Baltimore, MD. Now you could send messages faster than even a speeding train. If the bad guy robbed a bank and jumped on a train to escape, you could signal the next station to have the police ready to nab the miscreant before the train arrived. The successful laying of a trans-Atlantic cable in 1866 (earlier trials failed in short order) was another major milestone. Then, in 1901, Guglielmo Marconi came along and did it without wires!

These systems worked by "store and forward" since telegrams were sent from station to station, being manually copied and retransmitted "hop by hop." Eventually there were paper tape teletypes that would punch out a tape with the message characters encoded with 5-bit Baudot codes for each letter. The transmitting teletype read the tape and sent the characters to a receiving teletype that would punch out a duplicate tape. The operator would hang the tape on a peg next to the machine that would be used to forward this message to the next hop.[a] There is a wonderful book entitled *The Victorian Internet* by Tom Standage[b] that outlines the history of the telegraph.

Eventually, circuit-switching systems derived from the telephone network could be used to connect the source and destination teletypes directly to each other without the need for intermediate hops, just as voice calls are made. A circuit was set up and the sending teletype would transmit its paper tape and the receiving teletype would punch it out at the other end.

Ironically, the packet switching of the Arpanet reintroduced the store-and-forward method for intercomputer communication. Dedicated circuits connected the packet switches just as the old telegraph sets were connected. When a packet was received, the receiving packet switch examined it and if the packet was not destined for a locally connected computer, it was stored briefly until it reached the head of the line in a queue whereupon it was then forwarded to the next hop (packet switch) along a path to the destination.

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This was a much faster process than the old manual telegraph method and the forwarding of the packets allowed the concurrent sharing/multiplexing of the dedicated telephone circuit between the packet switches. There was no waiting to set up a dialed circuit. The same circuit could carry many packets going to many destinations without setting up and tearing down circuits. Because all the traffic was split into packets, long files would be easily mixed in with other traffic, reducing the latency for access to the common communication network. With increasingly fast dedicated circuits, the latencies end-to-end dropped and capacity went up leading to the streaming audio, video, and interactive videoconferencing and gaming so prevalent today.

In March 2019 issue of *Communications* there is an important article by Pamela Zave and Jennifer Rexford[c] that reenvisioned the current Internet as a recursively layered network of networks of networks (so to speak) that captures the evolved architecture now manifest. We have come a long way since the 1844 introduction of the telegraph and the 1983 activation of the Internet and there is strong evidence that further evolution is to be expected as new technologies arrive to spark imagination and challenge engineers to improve on the past. C

a This was sometimes called "torn tape" telecommunication because you would tear the tape off the receiving teletype.

b Standage, T. *The Victorian Internet*. Walker and Company, 1998.

c Zave, P.A. and Rexford, J. The compositional architecture of the Internet. *Commun. ACM 62*, 3 (Mar. 2019), 78–87.

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