successful commercial networking ventures. He is currently the Chairman of Com21, Inc. which develops switching and cable modem technology to deliver Internet services to home users.

Today's distributed, packet-switched Internet represents an ongoing tribute to Paul Baran's networking ideas. It is a rather wonderful irony that Baran's Cold War–inspired work now serves as the basis for a network that allows so many nations to communicate.

BIOGRAPHY
Paul Baran. Born 29 April 1926 in Poland. B.S. in electrical engineering from Drexel Institute of Technology, 1949; M.S. in engineering from University of California, Los Angeles, 1959. Began work at Eckert-Mauchly Computer Corporation, 1949. Joined the RAND computer science department, 1959. Developed the idea of a distributed, packet-switched network, 1960–62. Published *On Distributed Communications*, 1964. Became an informal advisor to the ARPANET development team, and left RAND to cofound the Institute for the Future to develop better methods for long-range forecasting and planning, 1968. Established Cable Data Associates, 1974. Cofounded packet radio company Metricom, 1985. Currently chairman of cable networking developer Com21. Recipient of numerous awards, including IEEE Edwin H. Armstrong award, 1987; and the Electronic Frontier Foundation Pioneer Award, 1993.

SELECTED WRITINGS
Baran, Paul, et al. "On Distributed Communications." Vols. I–XI, *RAND Corporation Research Documents*. Santa Monica, Calif.: RAND Corporation, August 1964.
    http://www.rand.org/publications/RM/baran.list.html

FURTHER READING
Abbate, Janet. *Inventing the Internet*. Cambridge, Mass.: MIT Press, 2000.
Gilder, George. "Inventing the Internet Again." *Forbes ASAP*, 2 June 1997.
Hafner, Katie, and Matthew Lyon. *Where Wizards Stay Up Late: The Origins of the Internet*. New York: Simon and Schuster, 1996.
Leiner, Barry M., et al. *A Brief History of the Internet*. Internet Society, 2000.
    http://www.isoc.org/internet-history/brief.html
Mattis, Michael. "Fathers of Invention." *Business 2.0*, October 1999.
Moschovitis, Christos J. P., Hilary Poole, Tami Schuyler, and Theresa M. Senft. *History of the Internet: A Chronology, 1843 to the Present*. Santa Barbara, Calif.: ABC-CLIO, 1999.
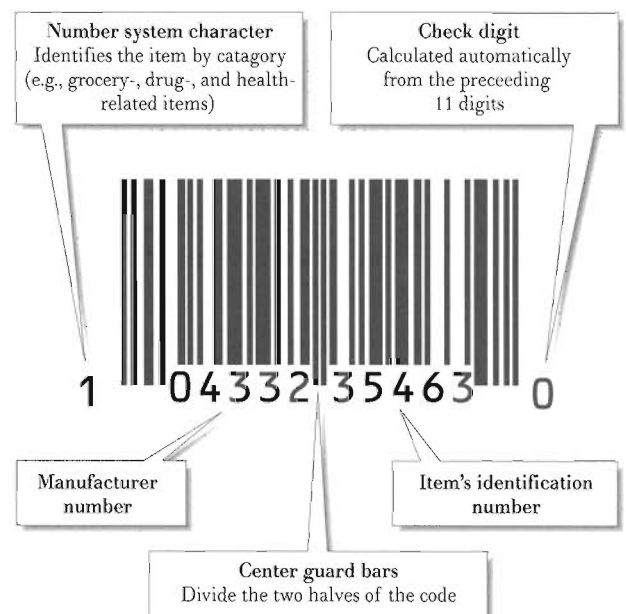
Understanding the Internet. PBS Online, 2000.
    http://www.pbs.org/uti/transcripts.html
Zakon, Robert H. *Hobbes' Internet Timeline v5.1*. 2000.
    http://www.isoc.org/guest/zakon/Internet/History/HIT.html
                                    —*Christopher D. Hunter*

Bar Code Scanner

A bar code scanner is a device that reads bar codes, which are chains of black and white stripes printed on packages. Bar codescanners are used at supermarket checkouts and in portable devices: for example, to encode address information on packages sent by express mail. The nearly ubiquitous black-and-white codes and the computerized devices that scan them have become icons of the digital age.

Bar codes were invented by Norman Joseph Woodland and Bernard Silver at Drexel University in the late 1940s. They filed for a patent on 20 October 1949. Woodland used binary stripes of two different colors in an attempt to create something like the Morse code. In order to be able to scan the code in any direction, the prototype used circular patterns. The first bar codereader was built by both inventors in 1951, but it was bulky and consumed too much power. Unable to develop the bar code into a product, they sold the patent

Number system character
Identifies the item by catagory (e.g., grocery-, drug-, and health-related items)

Check digit
Calculated automatically from the preceeding 11 digits

Manufacturer number

Item's identification number

Center guard bars
Divide the two halves of the code

Example of a bar code.

to Philco in 1962, and Philco later sold it to RCA, a cash register and computer company.

The first working bar code scanner was built by Computer Identics, a company cofounded by David Collins, a former employee at Sylvania. Collins originally proposed the idea of developing bar code readers to Sylvania, but they refused and Collins decided to start Computer Identics. Using low-power lasers, he was able to use light sensors to read bar code strips. The first industrial scanners were installed in 1969.

Meanwhile, in the same year, members of the Grocery Manufacturers of America and the National Association of Food Chain met to discuss an "interindustry product code." RCA started working with representatives from the grocery industry to solve the problem of reading merchandise labels at checkout. At the time RCA was the main producer of cash register machines, so bar code scanners were a natural extension of its product line. In 1971, RCA demonstrated a version of Woodland and Silver's bar codes, again using the circular patterns. However, **IBM**, which had hired Woodland a few years before, asked him to develop a better system, and under his leadership, the Universal Product Code (UPC) was born. In 1973, IBM's UPC was selected by the grocery industry as the standard for product labeling, and the following year the UPC Council was formed.

The UPC code consists of a set of decimal digits coded using seven bits. A one is represented by a black stripe, a zero by a white stripe. The stripes are printed one after the other, without spacing. What to the eye look like wide black stripes, in the bar code actually correspond to several black bars printed together. The UPC-Symbol A code is shown in the accompanying table.

A UPC frame contains the code for "101" at each end of the frame and the code for "01010" exactly in the center. Digits coded to the left of center use the left binary code, and decimal digits coded to the right use the right binary code (see the figure for an example). One code is the complement of the other: The left code uses an odd number of ones, the right code an even number. By checking this, it is easy for the scanner's software to interpret the bar code in the proper direction and thus obtain the correct product number. One of the decimal digits encoded is a check

UPC-Symbol A Code		
Digit	Left binary code	Right binary code
0	0001101	1110010
1	0011001	1100110
2	0010011	1101100
3	0111101	1000010
4	0100011	1011100
5	0110001	1001110
6	0101111	1010000
7	0111011	1000100
8	0110111	1001000
9	0001011	1110100

The UPC-Symbol-A code.

digit, which is used to test the consistency of the information obtained.

Simple bar code scanners consist of a light pen, which is moved across the black and white stripes. The reflected light is converted into an electrical signal that is the binary equivalent of the stripes. Supermarket bar code scanners, on the other hand, work with low-power lasers. Laser rays are sent through a rotating mirror, working in conjunction with fixed mirrors, and hit the code bar from different angles. The reflected light, along the same path of the laser ray, is captured by photo sensors and analyzed. The black stripes do not reflect light, the white stripes do. An embedded microprocessor does the decoding and delivers the final reading.

John Woodland was awarded the National Medal of Technology in 1992 by U.S. President George Bush (1924–). Today, many different types of bar codes have been developed for diverse applications. They have even been used to tag insects in the wild.

FURTHER READING

Brigham, Eugene F. *The Bar Code Manual.* Fort Worth, Tex.: Harcourt Brace College Publishers, 1995.

Palmer, Roger C. *The Bar Code Book: Reading, Printing, and Specification of Bar Code Symbols.* Peterborough, N.H.: Helmers Publishing, 1995.

Pearce, Stephen. *The Bar Code Implementation Guide.* Doylestown, Pa.: Tower Hill Press, 1997.

Uniform Code Council. *UPC Symbol Specification Manual,* Dayton, Ohio: UCC, Jan. 1995.

—Raúl Rojas