

BACK TO BASICS

The stored program concept

The ability of a calculating machine to store its instructions in its internal memory and process them in its arithmetic unit, so that in the course of a computation they may be not just executed but also modified at electronic speeds, makes general-purpose computers practical

Almost every one of the computers produced in the past 40 years has employed von Neumann architecture. This architecture, which introduced the stored program concept, involves the passage of a single information stream through a central processing unit. Though new designs hold great promise for high-end computing, it seems likely for years to come that the von Neumann architecture will prevail for most uses.

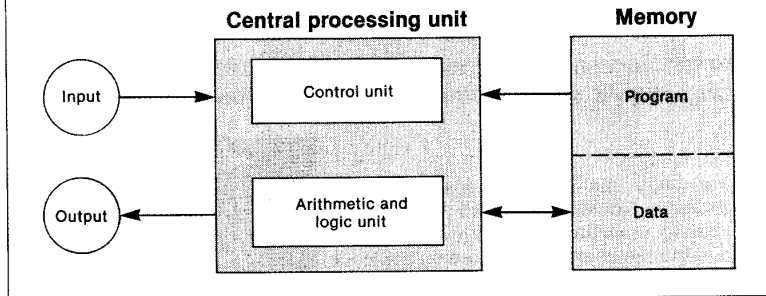
Who deserves credit for the stored program concept depends in large part on one's attitudes about science versus technology, commercial versus academic interests, and theory versus implementation. John von Neumann, a faculty member of the Institute for Advanced Study in Princeton, N.J., participated in the discussions in which the idea was elaborated, wrote the first report of the concept, placed it in a theoretical context, and built his own computer, which was the early model for a number of others, including the important commercially manufactured IBM 701.

J. Presper Eckert and John Mauchly perhaps first conceived of the stored program concept and developed most of the plans for implementing it in the Edvac, and later incorporated it in the Univac and other computers produced by their company. Several British computer scientists, notably Maurice Wilkes, were the first to implement the idea in machines initially designed to embody this feature.

The context for the development of the stored program concept was the Moore School of Electrical Engineering at the University of Pennsylvania in Philadelphia,

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Von Neumann described how a computer comprises five units—input, output, arithmetic processor, control unit, and memory—and how, at the discretion of the control unit, the instructions can be stored in the same internal memory unit as data and be processed in the same way as data by the arithmetic unit.



where during World War II a team of engineers led by Eckert and Mauchly built an automatic electronic calculating machine, the Eniac, to calculate ballistic tables for the Army's Ballistic Research Laboratory (BRL).

Since January 1944, von Neumann had been investigating high-speed computing equipment that he could use for carrying out some mathematical computations associated with the implosion design for the first atomic bomb. That summer, he heard about the Eniac project and became a regular visitor to the Moore School that fall. He participated actively in the design discussions about the successor to the Eniac, eventually known as the Edvac, and was probably influential in obtaining BRL financing for the project.

Von Neumann's 1945 *First Draft of a Report on the EDVAC* set out in approximately 100 pages the stored program concept and also the architecture known today by his name. Interestingly, the stored program computer was not described in the report as being built from mechanical switches, electromechanical relays, or even electronic vacuum tubes, but instead from theoretical neurons introduced in a 1943 paper by Warren McCulloch and Walter Pitts. Von Neumann's reasons for this approach were to emphasize the similarities between the computer and the brain and to isolate the logical structure (computer architecture) from the engineering implementation.

The British were quicker than the U.S. groups to develop working prototypes. Versions were completed in England at Cambridge and Manchester universities and at the National Physical Laboratory between 1948 and 1950. In the United States, von Neumann organized a computer project for scientific research purposes at the Institute for Advanced Study after the war, and his computer began effective operation in late 1951.

Other prototypes were completed in the early 1950s at the National Bureau of Standards, at Government laboratories, and at universities around the country. Meanwhile, Eckert and Mauchly left the Moore School to establish their own computer company, which later became part of

Remington Rand (then Sperry, now Unisys).

In one sense, the credit for making stored programming a significant contribution should go to the computer manufacturers who implemented it in their products. The one-of-a-kind calculating machines built in the late 1940s and early 1950s were important pioneering devices, but they did not have the maintainability, reliability, price-performance, and ease of use needed to make them attractive to a wide range of scientific and commercial users. Rather, it was the continuing improvements in hardware and software introduced by industry that made possible the spread of the computer into our factories, offices, and homes.

Interestingly, it was von Neumann himself who initiated examining "non-von Neumann architectures" in the first study of cellular automata, a theoretical computing device with a parallel architecture.

To probe further

Four sources provide additional background information on stored programming and the history of computers using that concept:

- *Papers of John von Neumann on Computing and Computer Theory*, eds. William Aspray and Arthur Burks, MIT Press, Cambridge, Mass., and London; and Tomash Publishers, Los Angeles and San Francisco, 1987.
- "From ENIAC to the Stored Program Computer: Two Revolutions in Computers," by Arthur Burks, in *A History of Computing in the Twentieth Century*, eds. Nicholas Metropolis, Jack Howlett, and Gian-Carlo Rota, Academic Press, New York, 1980, pp. 311-44.
- *From ENIAC to UNIVAC* by Nancy Stern, Digital Press, Bedford, Mass., 1981.
- *A History of Computing Technology* by Michael R. Williams, Prentice Hall, Englewood Cliffs, N.J., 1985.

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