swered, and they will become increasingly pressing in the coming century.

FURTHER READING

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—*Blaise Cronin*

Institute of Electrical and Electronics Engineers

The Institute of Electrical and Electronics Engineers (IEEE) is the main professional society in the field of electronics. It is a nonprofit technical organization with more than 350,000 members in 150 countries. The IEEE resulted from the fusion in 1963 of the American Institute of Electrical Engineers (AIEE) and the Institute of Radio Engineers (IRE). The AIEE was established to unite those involved in the "art of producing and utilizing electricity" during the International Electrical Exhibition of 1884 in Philadelphia.

The IEEE Computer Society is a suborganization within the IEEE; its roots go back to the beginning of the computer era. In 1946, the Subcommittee on Large Scale Computing was formed within the AIEE, which

JOURNALS AND MAGAZINES PUBLISHED BY THE IEEE (SELECTED)

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Computer Magazine
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Computing in Science and Engineering Magazine
Consumer Electronics
Control Systems Technology, IEEE Transactions on
Education, IEEE Transactions on
Electrical and Computer Engineering, Canadian Journal of
Fuzzy Systems, IEEE Transactions on
IEEE Annals of the History of Computing
IEEE Circuits and Devices Magazine
IEEE Communications Letters
IEEE Communications Magazine
IEEE Computer Applications in Power Magazine
IEEE Computer Graphics and Applications Magazine
IEEE Concurrency Magazine
IEEE Control Systems Magazine
IEEE Design and Test of Computers Magazine
IEEE Instrumentation and Measurement Magazine
IEEE Intelligent Systems Magazine
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IEEE Micro Magazine
IEEE MultiMedia Magazine
IEEE Network: The Magazine of Global Information Exchange
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fused later with the Professional Group on Electronic Computers of the IRE. The **Association for Computing Machinery** (ACM) was formed at around the same time as the subcommittee within the AIEE.

The IEEE organizes hundreds of technical conferences every year and publishes proceedings volumes and many high-quality journals. Eight of the most important journals in electrical and electronic engineering are from the IEEE, as are seven of the most important journals in telecommunications, and seven more in computer hardware and architecture. IEEE journals are now available online, so that researchers all over the world have ready access to them; past issues are sold scanned in **CD-ROM**. In fact, the IEEE produces 30 percent of the technical literature about electronics and computers published in the world.

The IEEE is governed by a board of directors and an executive committee. The president is elected for one year and presides over 10 regions and 36 technical societies (the Computer Society being only one of them). The board of directors decides on the recipients of annual awards given to distinguished scientists. Included are the Internet Award, the Andrew Grove Award, and the Undergraduate Teaching Award, established to promote high-quality teaching standards at U.S. universities.

Education is a major concern of the IEEE, which has always fostered the establishment of student chapters at universities. Students can take part in the main conferences and organize many special activities for other students. For a low fee, students can have an electronic subscription to all IEEE journals in a certain field, for example computing.

The IEEE logo shows an arrow within a rhombus, representing the direction of an electric field, with the circle around the arrow representing the magnetic field. The rhombus, taken from the logo of the AIEE, represents Benjamin Franklin's kite, used in his famous experiment on the electric nature of thunderstorms.

—Raúl Rojas

Instruction Set

The collection of basic commands that can be executed directly by the processor of a computer is called the *instruction set.* It can consist of just a few basic commands or hundreds of instructions. The instruction set delimits the capabilities of the machine; from the viewpoint of the programmer, it represents the machine.

The first programmable computer, the **Z1** built by **Konrad Zuse** (1910–95) from 1936 to 1938, had an instruction set of just eight instructions: addition, subtraction, multiplication, and division of two numbers, load from memory and store to memory, as well as reading a decimal number from the keyboard and displaying a decimal result in a panel. Curiously, the first large-scale electronic computer, the **ENIAC**, which was officially presented in 1945, had no instruction set; the ENIAC was programmed by running wires from one unit to another, replicating in this way the **data flow** of the computation.

Modern **microprocessors** are produced in families that are downward compatible at the object code level—that is, the programs compiled for one member of the family can be run by a newer processor. This means that the instruction set can only be expanded, not reduced. One current example is the **Pentium** family of microprocessors, which have added some instructions from generation to generation while preserving compatibility with old programs.

Sometimes a distinction is made between complex instruction set computers (CISC) and **reduced instruction set computers** (RISC). CISCs were produced in the 1970s and 1980s. The CISC instruction sets was optimized in relation to the size of the code, and this favored complex and powerful primitive instructions. RISC machines, in contrast, use simpler instructions but more of them in a single program. Since the individual instructions are simpler, they can be executed in parallel or overlapped, saving time and resources.

An important question in computer architecture is: Which minimal instruction set will still allow the programmer to write any conceivable program? **Alan Turing** (1912–54) designed a computer in the late 1940s that could actually work using a single command: The MOVE A B instruction would only transport a number from memory register A to register B. But every register (and there were several of them) performed a different computation on arrival of each number: One