

# FURTHER READING

- Fano, Robert. "Project MAC." In Jack Belzer, Albert G. Holzman, and Allen Kent, eds., *Encyclopedia of Computer Science and Technology*, Vol. 12. New York: Dekker, 1975, pp. 339–360.
- Hauben, Michael, and Ronda Hauben. *Netizens: On the History and Impact of Usenet and the Internet*. Los Alamitos, Calif.: IEEE Computer Society Press, 1997.
- Licklider, J. C. R. "Man-Computer Symbiosis." *IRE Transactions on Human Factors in Electronics*, Vol. HFF 1, Mar. 1960, pp. 4–11.

—Ronda Hauben

# Prolog

Prolog is a programming language that arose from research done by Alain Colmerauer (1941– ) in France and Robert Kowalski (1941– ) at Edinburgh University in the early 1970s. The name *Prolog* (*programmation en logique*) was coined in 1972 by Phillipe Roussel at the University of Marseilles.

Whereas languages such as **Fortran** and **Pascal** are very well suited for numeric processing, they are cumbersome for programs that deal with symbols, such as those used in natural language processing. The language LISP, designed by **John McCarthy** (1927– ) in 1959, was one of the first symbol-oriented languages and remains widely used today. Prolog represents another computational paradigm that has its roots in formal logic.

In Prolog the user does not tell the program directly how to solve a task, but gives it a formal declarative description. The user defines a set of facts that are taken to be true, as if they were axioms. Then he or she can define a set of rules that describe how the facts can be used to answer queries. For example, the fact that Adam is the father of Abel would be coded in Prolog simply as: "father(adam,abel)"; note that lowercase letters are used, because words beginning with uppercase letters are considered variables in Prolog. A rule such as "X is the grandfather of Y, if X is the father of Z and Z is parent of Y" can be written in Prolog as "grandfather(X,Y) :- father(X,Z), parent(Z,Y)". After having given this rule to the system, the user can ask queries about the persons in the set of facts and Prolog will give the correct answer. Prolog implements logical inference using the set of rules and facts defined by the user.

Prolog employs two principal mechanisms: unification and resolution. *Unification* means that every time a query is given to the system, Prolog looks for a matching rule or fact in its database. Only rules or facts that match the input (that can include variables) are considered for further processing. *Resolution* is a mechanism for logical inference that is more powerful than inference rules such as modus ponens. (*Modus ponens* means that if we know that A is true, and that the rule "A implies B" is also true, we can immediately deduce that B is true.) Resolution is more general and includes modus ponens as a special case as well as other inference rules used by human beings. Resolution is easier for the computer to use since it is a single inference rule and can be applied mechanically. If a rule does not match, the system backtracks and looks for another matching rule and another way to prove the query.

Prolog was the main language adopted by the Japanese scientists in the framework of the 10-year Fifth Generation Computer Program started in the early 1980s. The stated objective of the program was building machines capable of executing millions of logical inferences per second. Some Prolog machines were actually built in Japan, the United States, and Europe, but they were never an alternative to conventional computer technology. Prolog lost some ground after the end of the Fifth Generation initiative, but it is still a popular language for artificial intelligence applications.

# FURTHER READING

- Clocksin, W. F., and C. S. Mellish. *Programming in Prolog*. Berlin and New York: Springer-Verlag, 1981; 4th ed., 1994.
- Feigenbaum, Edward A., and Pamela McCorduck. *The Fifth Generation: Artificial Intelligence and Japan's Computer Challenge to the World*. Reading, Mass.: Addison-Wesley, 1983.
- Kowalski, Robert. *Logic for Problem Solving*. New York: Elsevier North Holland, 1979.
- Sterling, Leon, and Ehud Shapiro. *Art of Prolog*. Cambridge, Mass.: MIT Press, 1994.

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# Protocol

A protocol is an agreement between two parties that allows messages to be exchanged following a stan-