reasoning. Much of the work of automated reasoning is involved with trying to prove or disprove assumptions using techniques such as generating models as counter examples. Each conclusion that is reached must follow inevitably from the facts from which it is drawn. When an automated reasoning program draws a conclusion, as in the spirit of high school geometry, it cites the specific and immediate facts from which it drew the conclusion, enabling one to check its work. Therefore, one advantage of using an automated reasoning program is its ability to reason without error. No implicit assumptions accidentally occur and no conclusions are drawn that fail to follow from the given information. A result obtained with a reasoning program—a proof of a theorem, a design of a circuit, a verification of a computer code—can generally be accepted.

Another advantage of using a reasoning program is its capacity to examine large numbers of paths in search of a solution. Its effectiveness is not decreased even when the information is very complex, as occurs when processing very long formulas from mathematics or very complicated logical expressions from circuit design.

Fewer than 25 years ago, scientists considered remote the possibility of using a computer program to reason about diverse and unrelated fields. The obstacles of representing the problem to the program, of forming sufficiently general ways of reasoning, and of adequately controlling the reasoning were truly formidable. Nevertheless, because of the potential and appeal of such an idea, research began in 1963 at Argonne National Laboratory under the support of the Department's first predecessor, the Atomic Energy Commission. At the time, the field of research was known as "automated theorem proving," because its early inspiration was to develop computer programs that could prove mathematical theorems (claims for which a proof is not yet known or for which a proof may not yet exist—formulas, propositions, or statements deduced from other formulas or propositions). As it became apparent that the techniques and programs being developed could be applied to other fields of work as well, the name of the research was changed to automated reasoning.

The Argonne researchers adopted a three-pronged attack upon the study of automated reasoning. Simultaneously and with equal concentration, they began focusing on the theory and methodology to be used in an automated reasoning program, the writing of the program itself, and the application of the program to different problems in different fields of work.

One of the major contributions of the Argonne research to the theory and methodology of the field was the introduction of the notion of *strategy* to automated reasoning. This notion changed the entire course of direction of this area of computer science. A strategy is an approach to a problem-solving situation that allows one to better manage information and to reach a conclusion without examining all possible alternatives. Humans employ strategies all the time when playing cards or games, such as poker or chess, when solving puzzles, or simply when accomplishing a particular task. Strategy, as applied to automated reasoning, is used to guide the overall attack on a problem by specifying such things as the order in which certain facts are to be examined, how to recognize and simplify equivalent information, what information is to be retained, and what information is to be discarded. Without such strategies, reasoning programs, as would humans, typically wander aimlessly through an enormous set of possible conclusions and may, after far too much time, fail.

Basic Energy Sciences-supported research at Argonne resulted in the development of several key strategies for automated reasoning programs. These strategies have been adopted as fundamental methods by other program developers in this rapidly expanding field. One such strategy, called the *set of support* strategy, directs a reasoning program to focus intensely on the important specific information about a problem under consideration, and to largely ignore extraneous background information of a more general nature. The set of support strategy is regarded by scientists in the field as the most powerful strategy currently available and is heavily in use today by almost all researchers involved with automated reasoning or automated theorem proving. Many problems in abstract mathematics, for example, cannot be solved without employing the set of support strategy. With it, some of these same problems can be solved in seconds. Without the strategy, a program can draw 20,000 conclusions and yet fail to find a solution, but, with it, the program may require drawing only 200 conclusions before solving the problem.

In addition to strategies, the Basic Energy Sciences-funded research developed several key *procedures* to help direct reasoning. One such procedure, *demodulation*, directs the program to re-