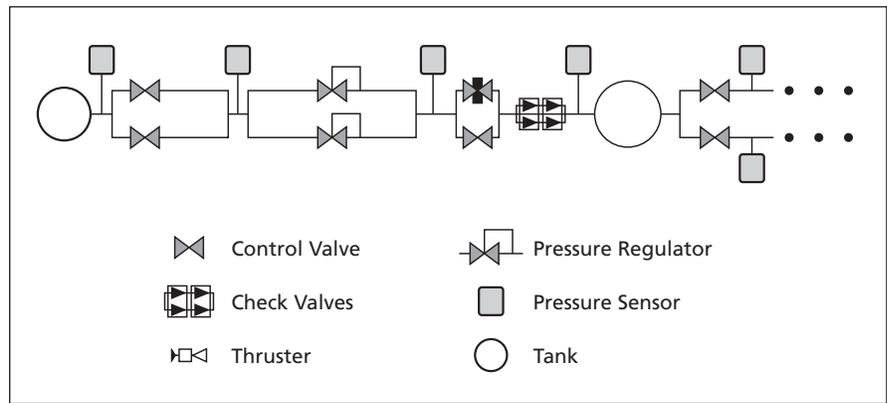


ancies are found, but when failures occur, multiple incompatible assumption sets appear. This process continues to determine new incompatible sets until the causal simulation is completed.

The second-mentioned limitation of the GDE is overcome by a combination of two methods, embodied in algorithms that, relative to prior algorithms used for the same purpose, require less computation to arrive at a minimal diagnosis. These methods and algorithms were described in “Fast Algorithms for Model-Based Diagnosis” (NPO-30582) and “Two Methods of Efficient Solution of the Hitting-Set Problem” (NPO-30584), both published in *NASA Tech Briefs*, Vol. 29, No. 3, March 2005, pages 69 and 74, respectively. To recapitulate: One of the two improved methods is based on mapping of the diagnosis problem onto the Boolean satisfiability problem. This mapping makes it possible to utilize Boolean function theory to reduce the diagnosis problem to the prime-implicant problem (one of the problems in the theory). This, in turn, makes it possible to utilize very efficient algorithms, developed previously for the satisfiability problem, to compute the minimal diagnosis. The algorithm thus developed to solve the diagnosis problem requires an amount of computation proportional to a superpolynomial function of n (meaning that the computation time is proportional to $n^{ln(n)}$), where n is the number of components of the engineering system.

The other improved method is based on the mapping of the diagnosis prob-



A Relatively Simple Engineering System of tanks, valves, pipes, and pressure sensors serves to illustrate the basic diagnostic principle. This system would be diagnosed by comparing actual and expected values of pressure-sensor readings as correlated with commanded openings and closings of the valves.

lem onto the integer-programming problem. This mapping makes it possible to utilize a variety of algorithms developed previously for integer programming to solve the diagnosis problem. In the integer-programming approach, the diagnosis problem can be formulated as a linear integer optimization problem, which can be solved by use of well-developed integer-programming algorithms. Some of these algorithms, modified to make them suitable for solving the diagnosis problem, can efficiently diagnose a system that contains as many as several thousand components.

The development of this efficient model-based diagnosis engine has been accompanied by the derivation of a deep matrix analysis of the integer programming problem that makes it possible to extract bounds for the sizes of the solutions of the optimization problem, without solving the problem explicitly. This

analysis could be helpful in the development of algorithms that would be much more efficient for solving specific problems.

This work was done by Amir Fijany, Farrokh Vatan, Anthony Barrett, Mark James, Ryan Mackey, and Colin Williams of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to NPO-40544, volume and number of this NASA Tech Briefs issue, and the page number.

DSN Simulator

NASA's Jet Propulsion Laboratory, Pasadena, California

The DSN Simulator (wherein “DSN” signifies NASA’s Deep Space Network) is an updated version of the software described in “DSN Array Simulator” (NPO-44506), *Software Tech Briefs* (Special supplement to *NASA Tech Briefs*), Vol. 32, No. 9 (September 2008), page 26. To recapitulate: This software is used for computational modeling of proposed DSN facilities comprising arrays of antennas and transmitting and receiving equipment for microwave communication with spacecraft on interplanetary missions. Such modeling is performed to estimate facility performance, evaluate require-

ments that govern facility design, and evaluate proposed improvements in hardware and/or software. The software includes a Monte Carlo simulation component that enables rapid generation of key mission-set metrics (e.g., numbers of links, data rates, and data volumes), and statistical distributions thereof as functions of time.

The prior version of the software could model only one DSN facility at a time and included hard-coded, unconfigurable metrics. The present updated version is capable of modeling the entire DSN and provides for configurable met-

rics, making it possible to perform loading analyses for alternative future DSN architectures and mission-set scenarios. The present version also features an improved user interface and interfaces for exchange of data with other DSN software and with a DSN mission model database.

This program was written by Ryan M. Mackey and Raffi P. Tikidjian of Caltech for NASA's Jet Propulsion Laboratory.

This software is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-45513.