Report on the Sixth International Symposium on
MULTIPLE-VALUED LOGIC

Stephen Y. H. Su and Richard Spillman
Utah State University

The Sixth International Symposium on Multiple-Valued Logic was held at Utah State University, Logan, Utah, May 25-28, 1976, under the co-sponsorship of the IEEE Computer Society, the ACM, the Office of Naval Research, and Utah State University.

Professor Stephen Y. H. Su of Utah State University served as the symposium chairman and Professor Zvonko Vranesic of the University of Toronto was the technical program chairman. The symposium included two invited talks, eight parallel technical sessions, five tutorial sessions, and a panel discussion. Five tutorial papers and 40 technical papers were presented. The last session reported recent results and ideas that have not as yet been fully developed.

In his opening remarks to the 79 participants from nine countries, Dr. Su outlined some of the reasons why interest in multiple-valued logic has been growing for several years. He pointed out that multiple-valued logic offers a means of overcoming the pin limitation problem of MSI and LSI, since it allows each input pin to accept and each output pin to deliver more information. In addition, he indicated that the wide range of applications of the concepts of multiple-valued logic in the areas of digital systems, software, artificial intelligence, plant disease diagnostic rules, and human movement control were represented by some of the papers presented at the symposium. Su noted that when a 10-valued logic system is eventually developed the conversion from decimal to binary and back again will be eliminated. He also noted the increased reliability and reduced cost of multiple-valued circuit elements.

Dr. David Rine, formerly at West Virginia University, now at the University of Texas, presented the first tutorial paper entitled, "A Survey of Multiple-Valued Algorithmic Logics: From a Practical Point of View."

Rine noted several basic differences between theoretical and actual programming models. He then suggested a number of changes in the current models utilizing multiple-valued logic that would reduce these differences.

In the second tutorial session, Dr. I. Rosenberg of the University of Montreal discussed the algebraic and combinatorial aspects of multiple-valued circuits. He outlined the results of the last five symposia dealing with the mathematical development of multiple-valued logics. Among the topics which Rosenberg briefly covered were discrete functions, Post algebras, and threshold logic.

In the third tutorial session, Su and Peter Cheung of Packard Instrument Company reviewed the development of a cubical notation for multiple-valued switching functions and pointed out that compact notation is easily stored and processed by a digital computer. They defined a number of basic operators and their algebraic properties that could be used to manipulate the cubes to detect symmetrical functions and to minimize switching functions. Su and Cheung defined a general "don't care" condition and indicated that the diagnosis of colon cancer is one of the

Invited speaker Dr. Yoh-Han Pao (middle) involved in informal discussion with overseas participants.

Dr. Stephen Y. H. Su, symposium chairman, proposes that multiple-valued logic is a way to solve the pin limitation problem of the integrated circuit chip.

Dr. David Rine presents a survey of multiple-valued algorithmic logics. First row from left: Dr. W. J. Poppelbaum and Joel Trimble.
several possible applications of such a new definition.

Dr. K. C. Smith of the University of Toronto outlined the development of circuits for multiple-valued logic in the fourth tutorial session. He suggested that more development of multiple-valued circuits for practical applications will be seen in the near future. Smith developed a notation for drawing multiple-valued circuits and then offered several examples of multiple-valued logic elements, such as a ternary NAND using T^L and a current-mode five-valued storage element.

The final tutorial paper was given by Dr. U. Strasilla of Reticon Corporation who described discrete-time analog devices. He demonstrated how such devices could be used to implement multi-level logic operations.

The panel discussion centered on possible future applications of multiple-valued logic. In addition to hardware applications, several unique areas of application, such as social systems, medical systems, and philosophical systems were discussed. Specifically, among the many examples mentioned were time series multiple-valued logic, systems modeling of interpersonal interaction, diagnosis of disease, programming systems, and proving the independence of axioms. The general conclusion of the panel discussion was that the concept of multiple-valued logic has a broad range of applications in a number of diverse disciplines.

While the 40 papers presented in the technical sessions reflected the theme of the panel discussion with their wide range of interest, the majority of the papers addressed the issue of the design, construction, and analysis of digital multiple-valued systems. In technical session 1A, four papers dealing with multiple-valued networks and arrays were presented. Parallel session 1B presented four papers developing the algebraic properties of various multiple-valued logics.

Session 2 consisted of an invited paper by Dr. Y. H. Pao and J. Altman of Case Western Reserve University entitled, "Use of Associative Memory Techniques in Implementation of Multiple-Valued Logic Systems." They outlined a pattern recognition technique closely related to a fuzzy logic recognition system.

A paper developing techniques of fault detection in multiple-valued systems was presented in session 3A. A modified form of the D-algorithm for fault detection was suggested which would handle the problems of fault detection introduced by the multiple-valued nature of the circuit. In parallel session 3B, two papers on the philosophical applications of multiple-valued logic were discussed.

Session 4A consisted of three papers on the applications of three-valued logic to digital systems. In this session a COS/MOS implementation of three-valued logic was proposed, as well as a static hazard-free three-valued T-gate and a three-valued positional control system. In session 4B, three related papers were presented. One applied Venn diagrams to multiple-valued systems. The second paper developed a many-valued propositional calculus. The final paper in this session applied multiple-valued logic to hypothesis generation and medical diagnosis.

The mathematical aspects of multiple-valued circuit implementation were discussed in the four papers of session 5A. The synthesis of multiple-valued circuits, the development of multiple-valued codes, a discussion of noise margins in multiple-valued circuits, and an analysis of circuit complexity were among the specific topics presented. Session 5B included four papers on fuzzy logic and its applications. Fuzzy maps and applications of fuzzy logic to linguistics and to a logic of uncertainty were developed.

The second invited paper, "Seman
tic Influence from Fuzzy-Premises," was presented in session 6 by Dr. L. A. Zadeh of the University of California at Berkeley. Dr. Zadeh translated fuzzy statements into relational assignment equations and illustrated their solution with several examples.

The various applications of multiple-valued logic was illustrated by the three papers of session 7A. In this session, multiple-valued logic was applied to universal decision elements, human movement control, and plant disease diagnostic rules. In session 7B, three papers developing multiple-valued minimization techniques and procedures for the generation of multiple-valued prime implicants were presented.

The final session reported the results of recent research efforts. The subject matter of this session ranged from fuzzy logic and network theory to circuit realization of three-valued systems.

Two general principles may be derived from this symposium: (1) multiple-valued logic presents some real advantages in the future development of digital systems; and (2) the concepts of multiple-valued logic may be used to solve some important problems in computer science, engineering, medical diagnostics, and mathematics, etc. The overall conclusion of the symposium is that multiple-valued logic offers an exciting new frontier which is clearly worthy of a concentrated research effort.

The conference proceedings may be ordered from The Bookshelf, p. 87.