

# Theory and Algorithms of Physical Design

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## ABSTRACT

Prof. T. C. Hu is a pioneer in combinatorial algorithms, mathematical programming and operations research. His works cover multicommodity flows, job scheduling, decomposition for distributed computation, integer programming, tree structures, matrix chain product, knapsack problems, routing, and many other fundamental topics. He also has contributed theory and algorithms to the field of physical design.

## CCS CONCEPTS

• **Hardware** → **Physical design (EDA)**; • **Theory of computation** → *Theory and algorithms for application domains*; • **Mathematics of computing**;

## KEYWORDS

T. C. Hu, ISPD-2018 Lifetime Achievement Award

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## 1 INTRODUCTION

Prof. T. C. Hu is a pioneer in combinatorial algorithms, mathematical programming and operations research. He started his career as a Research Mathematician at IBM Research Center, where he published the Gomory-Hu cut tree on multi-terminal flows. His works cover multicommodity flows, job scheduling, decomposition for distributed computation, integer programming, tree structures, matrix chain product, knapsack problems, routing, and many other fundamental topics. In 1984, he and his Ph.D. student M. T. Shing applied routing to VLSI layout problems. Since then, he has contributed theory and algorithms to the field of physical design.

In 1985, he co-edited with Prof. E. S. Kuh an IEEE book entitled “VLSI Circuit Layout: Theory and Design” to describe the physical design with the perspective of theory and algorithms. The first article of the book raised the question, “Is there an algorithm which can be proved mathematically?” Since many physical design

problems are NP-complete, most of the proposed ingenious algorithms tend to be heuristic. The question was met with a positive, “yes” response using an example of column-generating techniques for global routing. The analogy of traffic congestion was used to formulate the routing problem as a multicommodity network flow problem with duality and shadow price to reflect the cost of the traffic jams on each channel (street). The column generating technique was introduced to derive the error bound of the solution.

Through his career, Prof. Hu’s contributions of mathematical programming and combinatorics have enriched the theory and methods of physical design. His works contribute to the physical design in tree representation, partitioning, and routing. Moreover, he also provided plenty of insight and recipes for successful researches. The shadow price highlights the importance to view problems from different angles. His motto, “always start with the simplest nontrivial cases,” fits well with physical design, where the problem tends to be complex and complicated and at the same time the geometry of the layout provides us with insight into the solution.

## 2 BIOGRAPHY OF T. C. HU

### 2.1 EDUCATION

B.S. (Engineering),	National Taiwan University, 1953
M.S. (Engineering),	University of Illinois, 1956
Ph.D. (Applied Mathematics),	Brown University, 1960

### 2.2 POSITIONS

1954-1956	Programmer, University of Illinois
1964-1965	Visiting Associate Professor, Electrical Engineering and Operations Research Center, University of California, Berkeley (on leave from IBM)
1965-1966	Adjunct Associate Professor, Columbia University (Part-time)
1966-1968	Associate Professor, University of Wisconsin
1968-1974	Professor, Computer Sciences Department and Mathematics Research Center, University of Wisconsin-Madison
1974-1998	Professor, Department of Computer Science and Engineering, University of California, San Diego
1998-2007	Professor, Above-Scale, Department of Computer Science and Engineering, University of California, San Diego (Emeritus)

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### 2.3 OTHER ACTIVITIES

Associate Editor, Journal of SIAM  
Associate Editor, Journal of ORSA  
Consultant, RAND Corporation, Summer 1965  
Consultant, Office of Emergency Preparedness, Executive Office of the President, 1968-1972  
Visiting Professor, Stanford University, (Spring 2004, Summer 2006)  
Editor, IEEE Transactions on Computers  
Advisory Editor, Journal of Heuristics  
Advisory Editor, Journal of Graphs and Applications

### 2.4 INVITED LECTURES AND HONORS

Workshop on VLSI Layout Theory, Dagstuhl, Germany, September 9-11, 1991.  
“Combinatorial Problems in VLSI,” 16'th International Symposium on Operations Research, Trier, Germany, September 9-11, 1991.  
Second ORSA Telecommunications Conference, Boca Raton, Florida, March 9-11, 1992, (90 minute tutorial).  
Plenary lecture, 17'th Symposium on Operations Research, Hamburg, Germany, August 25-28, 1992.  
Mathematische Optimierung, Mathematisches Forschungsinstitut Oberwolfach, Germany, January 8-14, 1995.  
John von Neuman Professorship, University of Bonn, Germany, 1994-1995.  
Senior Professor, Fulbright, 1994-1995.  
Keynote address: “Math, Models and Methods,” Proceedings of 1st International Symposium on Physical Design, April 14-16, 1997, Napa Valley, CA, pp. 207-210.  
IEEE Circuits and Systems Society, Best Paper Award, 1997.