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DAC '97

Design Automation Conference

Anaheim, CA
June 9 - 13, 1997

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PROCEEDINGS 1997

DESIGN AUTOMATION CONFERENCE®

Anaheim, CA

Anaheim Convention Center

June 9 - 13, 1997

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EDA CONSORTIUM

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PROCEEDING OF THE 34th DESIGN AUTOMATION CONFERENCE

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General Chair's Welcome

Welcome to the 34th Design Automation Conference!

DAC is the premier forum for exchanging your most exciting ideas and innovations in design automation. At DAC you will hear about the latest research and development in design tools. You will also hear about designers' experiences with design automation, good and bad. They will tell you what their hottest designs are—and how they designed them. Combined with visionary keynote addresses, 170 exhibits, 7 full-day tutorials and numerous other special technical gatherings, the technical program represents the very best of the leading edge technology driving the world's integrated circuit and electronic systems industry.

These proceedings, representing an outstanding expanded technical program were assembled under the very able direction of Technical Program Co-Chairs Giovanni De Micheli (Design Tools) and Jan Rabaey (Design Methods). Nearly 400 papers from North America, Europe, the Middle East, Asia and the South Pacific were submitted to the design tools and design methods tracks, and were reviewed by over 700 professionals. The Technical Program Committee used these reviews, along with their own expert opinions, to select the very best 139 papers in topics ranging from deep submicron design to hardware-software co-design. Nine panel sessions, including EDA company CEOs' views of their industry, challenges in worldwide intellectual property reuse, and financing EDA startups, complement the technical presentations and tutorials embedded in the 5 tracks of the technical program.

I want to thank all of the people who contributed to the success of DAC: the Executive Committee, the Technical Program Committee, the EDA Industry Committee, DAC's sponsors, MP Associates, and especially the exhibitors, authors, speakers, session organizers and session chairs. Their hard work and dedication have made this the world's premier conference for electronic design automation tools and methods. DAC is sponsored by ACM/SIGDA, IEEE Circuits and Systems Society, and EDAC. Their members represent the spectrum of DAC's participants and we are thankful for their continued and active support.

Welcome to Anaheim and the 34th Design Automation Conference. See the challenge and promise of electronic design—it has no boundaries. We wish you a very productive and fun-filled week and trust you will find these proceedings to be a valuable information reference for many years to come.

Ellen J. Yoffa
General Chair, 34th Design Automation Conference

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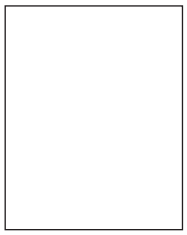

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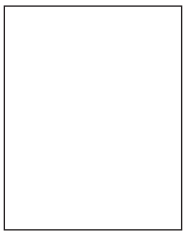

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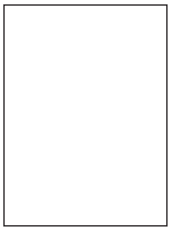

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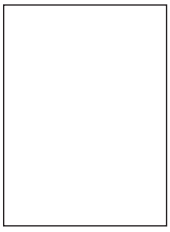

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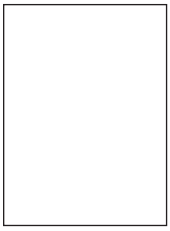

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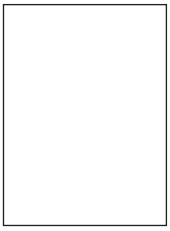

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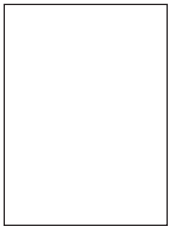

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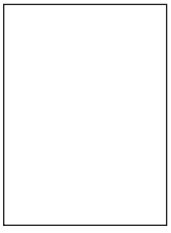

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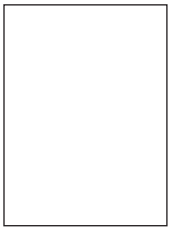

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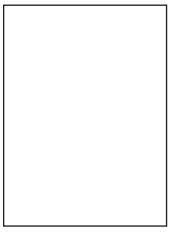

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1997 Best Paper Award

This year, awards are made for the best papers in four categories. Winners are determined from detailed reviews of the accepted papers in the technical sessions. Each award is accompanied by a plaque and a cash award of $400. The awards are given by ACM/SIGDA (Special Interest Group on Design Automation), IEEE/CAS (Institute of Electrical and Electronics Engineers/Circuits and Systems Society) and EDAC (Electronic Design Automation Companies).

PHYSICAL DESIGN AND LOGIC SYNTHESIS

Paper 1.1: "An Improved Algorithm for Minimum-Area Retiming"
Authors: Naresh Maheshwari, Sachin Sapatnekar
Affiliation: Iowa State Univ., Ames, IA

HIGH-LEVEL SYNTHESIS, VERIFICATION AND CODESIGN

Paper 16.2: "Equivalence Checking Using Cuts and Heaps"
Authors: Andreas Kuehlmann, Florian Krohm
Affiliation: IBM Corp., Yorktown Heights, NY

MODELING, SIMULATION AND ESTIMATION

Paper 17.1: "Time-Domain and Mixed Frequency-Time Algorithms for Strongly Nonlinear Circuits with Multi-Tone Excitations"
Author: J.S. Roychowdhury
Affiliation: Lucent Technologies, Bell Labs., Murray Hill, NJ

DESIGN METHODOLOGY

Paper 49.1: "Computer-Aided Design of Free-Space Opto-Electronic Systems"

Authors:	S.P. Levitan, T.P. Kurzweg, M.A. Rempel, D.M. Chiarulli	P.J. Marchand, C. Fan, F.B. McCormick
Affiliation:	Univ. of Pittsburgh, Pittsburgh, PA	Univ. of California, La Jolla, CA

Advancement in Computer Science and Electrical Engineering Undergraduate Scholarships

The objective of the ACSEE Scholarship program is to increase the pool of professionals in Electrical Engineering and Computer Science from under-represented groups (Women, African American, Hispanic, Native American, and Physically Challenged). In 1989, ACM Special Interest Group on Design Automation (SIGDA) began providing the program. Beginning in 1993, the Design Automation Conference provides the funds for the scholarship and SIGDA continues to administer the program for DAC. DAC funds two $4000 scholarships renewable up to 5 years to graduating high school seniors. The former International Daisy User Group funds one $1000 one-time-only scholarship.

The 1997 winners will be announced at the Conference. The 1996 winners were:

1996 DAC/IDUG ACSEE Undergraduate Scholarships

DAC $4K: Ann Nuñez Alejandro, Houston, TX - attending University of Houston

DAC $4K: Ellen Weiss Carvill, Milford, NY - attending Carleton College

IDUG $1K: Shawn P. Koch, Houston, TX - attending Rice University

This year, the graduates of the ACSEE program include Hector Villalobos who will be receiving his BS in Electrical Engineering from Santa Clara University and Sung Jo who will receive his BS in Electrical Engineering from San Jose State University.

For more information about the ACSEE scholarship, please contact Dr. Cherrice Traver, EE/CS Department, Union College, Schenectady, NY 12308 email: traverc@doc.union.edu.

CALL FOR PAPERS

35th DESIGN AUTOMATION CONFERENCE®

MOSCONE CENTER • JUNE 15 - 19, 1998

DAC is the premier conference devoted solely to the field of Design Automation. All aspects of the use of computers as aids to the design process are welcome, from conceptual design to manufacturing. Five types of submissions are invited: regular papers, special topic sessions, panels, tutorials, and design contest entries. All types of submissions should be sent to the Program Chair, postmarked NO later than October 10, 1997.

TOPICS OF INTEREST

Authors are invited to submit original technical papers describing recent and novel research or engineering developments in all areas of design automation. The DESIGN TOOLS TRACK (T) is devoted to contributions to the research and development of design tools and the supporting algorithms. The DESIGN METHODS TRACK (M) deals with contributions to the research and development of design methodologies and applications of design automation tools to designs. Topics of interest include, but are not limited to:

DESIGN TOOLS TRACK:

- T1.1 Electrical-level circuit and timing simulation
- T1.2 Discrete simulation
- T1.3 Critical path analysis and timing verification
- T1.4 Power estimation
- T2.1 Testing, fault modeling and simulation, TPG, test validation and DFT
- T2.2 Design and implementation verification (excluding layout verification)
- T3.1 Floorplanning and placement
- T3.2 Global and detailed routing
- T3.3 Module generation and compaction, transistor sizing and cell library optimization, layout verification
- T4.1 Technology independent, combinational logic synthesis
- T4.2 Technology dependent logic synthesis, library mapping, interactions between logic design and layout
- T4.3 Sequential logic synthesis and optimization
- T4.4 High-level synthesis
- T4.5 Asynchronous logic synthesis
- T5.1 Hardware Description Languages
- T5.2 Hardware/Software co-design, partitioning, system-level specification and design aids
- T5.3 Software synthesis and retargetable compilation
- T5.4 Hardware/Software co-simulation
- T6.1 Interconnect and packaging modeling and extraction
- T6.2 Signal integrity and reliability analysis
- T6.3 Analog and mixed-signal design tools
- T6.4 Microsensor and microactuator design tools
- T6.5 Statistical design and yield maximization
- T7.1 Frameworks, intertool communication, WWW-based tools and databases

DESIGN METHODS TRACK:

The Design Methods track deals with innovative methodologies for the design of electronic circuits and systems, as well as creative experiences with design automation in state-of-the-art designs. Submissions for this track will be judged especially on their design application contents.

M1 Design methodologies and case studies for specific design tasks
- M1.1 Design entry and specification
- M1.2 Simulation, analysis, modeling and estimation
- M1.3 Verification, test and debugging
- M1.4 Physical design, module generation, design for manufacturing
- M1.5 Logic and high-level synthesis
- M1.6 System-level design, embedded-system design and co-design
- M1.7 Other

M2 Design flows and case studies for specific application domains and platforms
- M2.1 Board and MCM
- M2.2 FPGA, rapid prototyping and reconfigurable computing
- M2.3 ASIC
- M2.4 Microprocessor, multiprocessor and networking
- M2.5 Multimedia and consumer
- M2.6 DSP, communications and wireless
- M2.7 Other (automative, medical, optical, ...)

M3 Design technologies and technology drivers
- M3.1 Deep sub-micron: signal integrity, interconnect
- M3.2 High-performance design: timing, clocking and power distribution
- M3.3 Low power design
- M3.4 Mixed-signal, analog, and RF
- M3.5 New devices, sensors, MEMS
- M3.6 Other

M4 Integration and management of DA systems
- M4.1 Management of DA systems, design interfaces
- M4.2 Standardization issues
- M4.3 Distributed, networked, and collaborative design
- M4.4 Intellectual property, design reuse and design libraries

Watch the WWW for updates! (http://www.dac.com)

REQUIREMENTS FOR SUBMISSION OF PAPERS

Previously published papers, including workshop proceedings, will not be considered. Each submission should include one cover page and eleven (11) stapled copies of the complete manuscript.

The one cover page should include:

- Name, affiliation, and complete address for each author
- A designated contact person including his/her telephone number, fax number, and email address
- A designated presenter, should the paper be accepted
- A list of topic numbers preceded by the letter T (Tools Track) or M (Methods Track), **ordered by relevancy**, most clearly matching the content of the paper
- The following signed statement: "All appropriate organizational approvals for the publication of this paper have been obtained. If accepted, the author(s) will prepare the final manuscript in time for inclusion in the Conference Proceedings and will present the paper at the Conference."

To permit a blind review, do not include name(s) or affiliation(s) of the author(s) on the manuscript. Include:

- Title of paper
- 60-word abstract indicating significance of contribution.
- The complete text of the paper in English, including all illustrations and references, not exceeding 4000 words. The papers will be reviewed as finished papers. Preliminary submissions will be at a disadvantage.

Notice of acceptance will be mailed to the contact person by February 23, 1998. Authors of accepted papers must sign a copyright release form.

PANELS, TUTORIALS, SPECIAL TOPIC SESSIONS

Proposals should not exceed two pages in length and should describe the topic and intended audience. They must include a list of all participants, including the moderator for Panels. **For proposal instructions, send a one-line email message to proposals@dac.com.**

Special Topic Sessions may be either independent papers with a common theme or a set of closely related papers describing an overall system. In both cases, independent reviews of each paper and evaluation of the session as a whole will be used to select sessions. Proposals for Special Topic Sessions should be submitted **along with the list of papers to be included in the session** and should describe the session's theme. These proposals and paper submissions must be postmarked no later than October 10, 1997.

UNIVERSITY DESIGN CONTEST

Submissions of original electronic designs (circuit or system), developed at universities and research organizations after June 1996 and resulting in operational implementations are invited. Submissions should contain the title of the project, a 60-word abstract and a complete description of the design, not exceeding 4000 words in text. The submission should clarify the originality, distinguishing features, and the measured performance metrics of the design. Proof - of-implementation in the form of die or board photographs and measurement data is a must. Submitted designs should not have received awards in other contests. Submissions will be reviewed by a special committee of experts. Selected designs will be presented and exhibited at the conference.

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Design Automation Conference Graduate Scholarships

Each year the Design Automation Conference sponsors several $12,000 scholarships to support graduate research and study in Design Automation (DA), with emphasis in "design and test automation of electronic and computer systems". Each scholarship is awarded directly to a university for the Faculty Investigator to expend in direct support of one or more DA graduate students.

The criteria for granting such a scholarship expanded in 1996 to include financial need. The criteria are: the academic credentials of the student(s); the quality and applicability of the proposed research; the impact of the award on the DA program at the institution; and financial need. Preference is given to institutions that are trying to establish new DA research programs.

Information on next year's DAC scholarship award program will be available on the DAC World Wide Web page at: http://www.dac.com/scholarship.html.

Design Automation Conference Graduate Scholarship Awards

- Prof. R. Iris Bahar of the Brown University, Providence, RI, for Qian Cui. Their project is entitled, "Using Implications to Drive Low-Power Optimization of Technology-Dependent Circuits".
- Prof. David Kaeli of the Northeastern University, Boston, MA, for Ying Liu. Their project is entitled, "Designing in the 3rd Dimension".
- Prof. Miodrag Potkonjak of the University of California, Los Angeles, CA, for Inki Hong. Their project is entitled, "Design Methodology for Synthesis of Real-Time Systems on Silicon".
- Prof. Shambhu J. Upadhyaya of the State University of New York, Buffalo, NY, for Kamran Zarrineh. Their project is entitled, "A Design for Test Perspective on Memory Synthesis".

The Lucent Technologies supported DAC Graduate Scholarship is awarded to:

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OPENING KEYNOTE ADDRESS

Scott G. McNealy
President/Chairman of the Board/CEO
Sun Microsystems, Inc.
Mountain View, CA

Under the leadership of co-founder Scott McNealy, Sun Microsystems, Inc. has become one of America's fastest-growing companies, according to *Fortune* magazine. The 41-year-old chief executive leads "the most efficient company in the industry," writes *Business Week*.

Mr. McNealy serves as Chairman of the Board, President and CEO of Sun, the parent company of all Sun subsidiaries and operating companies. With more than $6 billion in annual revenues, Sun Microsystems ranks 222 on the Fortune 500. The company is the world's leading provider of powerful UNIX® workstations, servers and related software. Java™, its platform-independent programming language, provides a comprehensive solution to the challenge of programming for complex networks, including the Internet.

Mr. McNealy has become an industry spokesman for open computer systems and a chief proponent of client-server, peer computing. He serves as Co-vice Chairman for the security encryption and export controls committee of the Computer Systems Policy Project, a consortium of 13 of the largest U.S. computer companies that address public policy issues affecting the industry and the nation. He is also on the Board of Directors of the Santa Clara County Manufacturers Board.

Mr. McNealy was Vice President of Operations at Sun before his appointment to President in February 1984. Prior to Sun, he was Director of Operations at Onyx Systems, a manufacturer of microcomputer systems, and a member of FMC's corporate manufacturing staff. He also held various operations and sales positions at Rockwell International.

Mr. McNealy was awarded a degree in economics from Harvard University and an M.B.A. from Stanford University.

THURSDAY KEYNOTE ADDRESS

Michael A. Aymar
Vice-President/General Manager
Intel Corp.
Santa Clara, CA

A VISION OF THE FUTURE OF COMPUTING

The pace of technology advancement in computing continues to accelerate. Mr. Aymar will offer a glimpse into the future of EDA design environment. The continued evolution will provide new capabilities which are based on standards, innovation, value and choice. Technologies such as video, audio, imaging, animation and the internet provide the foundation. These capabilities will improve your productivity at work and on the road, and provide new entertainment experiences at home.

Michael Aymar is Vice President and General Manager of Intel Corp.'s Desktop Products Group.

Mr. Aymar, who joined Intel in 1976, has extensive experience in micro- and mini-computer systems. Prior to his current assignment, he held positions in system and software engineering, microprocessor marketing, VLSI design automation, and general management assignments in development systems and mobile personal computers. Before coming to Intel, Mr. Aymar was employed by Hewlett-Packard.

A graduate of Stanford University, Mr. Aymar received both his B.S. and M.S. degrees, cum laude, in electrical engineering in 1970.

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