

科技资料

1991 IEEE COMPCON SPRING

COMPCON SPRING '91

digest of papers

San Francisco, California
February 25 - March 1, 1991



IEEE Computer Society Press
Los Alamitos, California

Washington • Brussels • Tokyo

The papers in this book comprise the proceedings of the meeting mentioned on the cover and title page. They reflect the authors' opinions and are published as presented and without change, in the interests of timely dissemination. Their inclusion in this publication does not necessarily constitute endorsement by the editors, the IEEE Computer Society Press, or The Institute of Electrical and Electronics Engineers, Inc.

Published by



IEEE Computer Society Press
10662 Los Vaqueros Circle
P.O. Box 3014
Los Alamitos, CA 90720-1264

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IEEE Computer Society Press Order Number 2134
Library of Congress Number 90-85549
IEEE Catalog Number 91CH2961-1
ISBN 0-8186-2134-6 (paper)
ISBN 0-8186-6134-8 (microfiche)
ISBN 0-8186-9134-4 (case)
SAN 264-620X

Additional copies can be ordered from:

IEEE Computer Society Press
Customer Service Center
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IEEE Service Center
445 Hoes Lane
P.O. Box 1331
Piscataway, NJ 08855-1331

Lisa O'Conner and Anne Copeland MacCallum, Production Editors
Printed in United States of America by McNaughton & Gunn, Inc.
Cover designed by Jack Ballestero



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General Chairman's Message



Welcome to San Francisco and the Cathedral Hill Hotel for the 36th Annual IEEE International Computer Conference, COMPCON Spring '91. The nature of COMPCON, this year's only broad-based general computer conference sponsored by the IEEE Computer Society, demands a good balance between depth and breadth in coverage of computer-related topics. We continue the conference format started three years ago, offering special featured sessions at the beginning of each day of the technical program to hear personal insights from industry leaders, followed by four parallel tracks, each on a special theme. The conference also has seven tutorial sessions, four on Monday and three on Friday.

The production of COMPCON is made possible by the collective effort of many volunteers, especially the members of the Steering Committee headed by Fred Buelow, and several subcommittees. Many thanks are due to Glen Langdon, Jim Dickie, Bob Fink, Andy Goforth, Rex Rice and Pam Sloan for their enormous and meticulous effort in running the publicity campaign for this year's COMPCON. Special thanks to Bob Fink for his effort and dedication in setting up the local arrangements, and to Roy Lee and Joe Fernandez for organizing the Monday and Friday tutorials. We also thank Dave Hunt, Ross Gaunt, Lori Goerz, Donna Hunt and Jim Rawlings for their administrative support in handling registration and the treasury. Jackie Olila deserves a special recognition for her perseverance and effort in putting together this Digest of Papers. We are also grateful to the members of the IEEE Computer Society's local chapter for their contributions, especially their liaison on our Steering Committee, Ken Majithia. Last, but not least, we thank Ken Miura and Sid Fernbach for their continued advice and guidance to this year's committee.

The heart of COMPCON is the technical program. This is the result of the planning, patience and hard work of our Program Co-Chairs, Michelle Aden and Creve Maples and the contributions of the distinguished members of their Program Committee. We are sure that the result of their effort is an excellent program covering a wide range of topics in the computer field. We also appreciate the effort put forth by the individual session chairpeople and all of the speakers in the conference.

We would like to bring to your attention the two social hours on Tuesday and Wednesday at 5 P.M. There you will have the opportunity to meet your fellow attendees and to meet and discuss the conference with the members of the various COMPCON committees. The entire production committees wish you an enjoyable week at COMPCON under our continued Intellectual Leverage theme!

Roger E. Anderson
General Chairman
COMPCON Spring '91



Program Chairpersons' Message



On behalf of the Program Committee, we wish to welcome you to COMPCON Spring '91, the 36th Annual IEEE International Computer Conference. COMPCON continues its tradition of providing a high-quality forum where computer professionals - engineers, designers, managers, programmers, teachers, users, etc. - can gather to report on and learn about the latest state-of-the-art developments in the broad area of computer science and engineering. In an era with an increasing emphasis on specialization, COMPCON is one of the few remaining broad-based computer conferences. The technical program of the conference is a reflection of what the Program Committee currently perceives as the important topics and significant new developments in the field of computing. The Committee has worked diligently to create a well-balanced program that emphasizes both the breadth of the field and quality of work. Leaders from academia, government, and industry will be presenting their latest results and opinions. All presentations are invited. The program utilizes sessions, tracks, featured speakers and tutorials to achieve both specific focus and breadth of coverage.

Every day begins with Featured Speakers presentations. This year our Featured Speakers will focus on the trends and technology which will shape the direction of computing into the 21st Century. These include "Towards 10¹⁵ MIPS", by Eric Drexler, president of the Foresight Institute; "America's Answer To Foreign Competition: The Entrepreneur And Inventor" by Gil Hyatt, an inventor recently awarded the patent for the microprocessor; "Virtual Reality: A Computer Science Perspective" by Jaron Lanier, founder and CEO of VPL Research; "Televisions of Tomorrow: Signals With A Sense Of Themselves" by Andy Lipman, associate director of the MIT Media Lab; and "GaAs Digital ICs: The Future Is Now" by Lou Tomasetto, president of Vitesse Semiconductor Corp.

Through the years COMPCON has managed to preserve its excellent technical quality through the hard work of its volunteers in both the Program and Steering Committees. We wish to thank the members of the Program Committee - Roger Anderson, Richard Belgard, Alan G. Bell, Chuck Clanton, Dave Ditzel, Mohammad Ketabchi, Robert Keller, Cary Kornfeld, Ted Laliotis, Glen Langdon, Stan Mazor, Kenichi Miura, Yale Patt, Ken Stevens, and John Wharton - for their effort. We would also like to thank the Session Chairpeople for volunteering to organize and run a session, and of course the speakers who really provide the heart of the conference. A special thanks is also extended to the Steering Committee for their support, to Roy Lee for organizing the tutorials, and to Bob Fink for handling the local arrangements and publicity. Jacquelyn Olila deserves a very special thanks for her tireless efforts in collecting the author's contributions and getting this Digest prepared on time. We also wish thank Carol Lujan for assisting us with the administrative task of putting the conference together. Finally we would like to acknowledge the cooperation and support of Sun Microsystems and Sandia National Laboratories in providing us the time and resources to bring the program together.

Creve Maples
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COMPCON Spring '91

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COMPCON SPRING 91

Table of Contents

General Chairman's Message	v
Program CoChairmans' Message	vi
Committee Lists	vii

MICROPROCESSOR HARDWARE Track

100 MIPS and Counting
Chair: John Wharton

Performance Enhancements in the Superscalar i960MM Embedded Microprocessor	4
<i>S. McGeedy, R. Steck, G. Hinton, and A. Bajwa</i>	
A Superpipeline Approach to the MIPS Architecture	8
<i>A. Bashueen, I. Lui, and J. Mullan</i>	
The Metaflow Lightning Chipset	13
<i>B. D. Lightner and G. Hill</i>	

Towards the Single Chip PC
Chair: John Wharton

The AMD Am286 TM ZX Microprocessor	20
<i>A. R. Khan</i>	

Desktop SPARC-Compliant Systems
Chair: Phil Huelson

Put a SPARC into Your PC	28
<i>T. Lacey</i>	
A Marriage of PC and Workstation Technologies	34
<i>B. Rosen</i>	
Trends in Building a SPARC-Compatible System: A Case Study in Methods and Tools	37
<i>P. Afshar</i>	

PARALLEL COMPUTING Track

LLNL Parallel Computing
Chair: Eugene D. Brooks, III

BBN TC2000 Architecture and Programming Models	46
<i>E.D. Brooks III, B.C. Gorda, K.H. Warren, and T.S. Welcome</i>	
A Killer Micro Attack On 3D Neutron Transport	51
<i>M.R. Dorr and J.M. Ferguson</i>	
Gauss Elimination: A Case Study On Parallel Machines	57
<i>K.H. Warren and E.D. Brooks III</i>	

Parallel Computing at Caltech
Chair: Paul Messina

Parallel and Distributed Supercomputing at Caltech	64
<i>P. Messina</i>	
DIME: Portable Software for Irregular Meshes for Parallel or Sequential Computers	68
<i>R. Williams</i>	
Parallel N-Log N N-body Algorithms and Applications to Astrophysics	73
<i>J. Salmon</i>	

New Parallel Computer Architectures

Chair: Roger Anderson

Integrated Heterogeneous Processing	80
<i>N.E. Aneshansley</i>	
The Star 910/VP as a Scientific Computer in Sun Networks	86
<i>G.J. Culler</i>	
The DN10000TX: A New High-Performance <i>PRISM</i> Processor	90
<i>R. Bahr, S. Ciavaglia, B. Flahive, M. Kline, P. Mageau, and D. Nickel</i>	

DATABASE TECHNOLOGY Track

Parallel DataBase Implementation

Chair: Mike Pong

Moving Data in Parallel	100
<i>C. Pearson</i>	
Optimizing Parallel Query Plans and Execution	105
<i>H. Leslie</i>	
Load Balancing Batch and Interactive Queries in a Highly Parallel Environment	110
<i>S. Englert</i>	

SQL Access: Heterogeneous Data-Base Interoperability

Chair: Rao Yendluri

SQL Access Overview	114
<i>J.H. Balboni</i>	
SQL Access and ANSI/ISO SQL and X/Open	120
<i>P. Perkovic</i>	
SQL Access and ISO/RDA	123
<i>H.S. Sabharwal</i>	

Heterogeneous MultiDatabase Interoperability

Chair: Witold Litwin

Pegasus: A System for Seamless Integration of Heterogeneous Information Sources	128
<i>R. Ahmed, P. DeSmedt, W. Kent, M. Ketabchi, W. Litwin, A. Rafii, and M.-C. Shan</i>	
Multidatabase Transactions: Impediments and Opportunities	137
<i>M. Rusinkiewicz and D. Georgakopoulos</i>	
Deadlock Problems in a Multidatabase Environment	145
<i>Y. Breitbart, W. Litwin, and A. Silberschatz</i>	
Maintaining Transaction Consistency in Multidatabases Using Quasi Serializable Executions	152
<i>W. Du, A.K. Elmagarmid, and W. Kim</i>	

COMPUTING & SOCIETY Track

Computer Security: Towards Deployed Systems

Chair: Karl Levitt

Towards a Testbed for Malicious Code Detection	160
<i>R. Lo, P. Kerchen, R. Crawford, W. Ho, J. Crossley, G. Fink, K. Levitt, R. Olsson, and M. Archer</i>	
Password Management	167
<i>M. Bishop</i>	
A System for Distributed Intrusion Detection	170
<i>S.R. Snapp, J. Brentano, G.V. Dias, T.L. Goan, T. Grance, L.T. Heberlein, C.-L. Ho, K.N. Levitt, B. Mukherjee, D.L. Mansur, K.L. Pon, and S.E. Smaha</i>	
The Verification of Secure Distributed Systems	177
<i>J. Alves-Foss and K. Levitt</i>	

Protections AGAINST the Information Age
Chair: Jim Warren

Computers and Privacy in the Pivotal Decade	186
<i>E. Hendricks</i>	
Threats to Privacy and Public Keys for Protection	189
<i>J. Bidzos</i>	

Protections FOR the Information Age
Chair: Jim Warren

Freedom of the Press for the Press of the Future	196
<i>K.E Drexler</i>	

WORKSTATIONS Track

Hewlett Packard/Apollo Next Generation RISC Workstations
Chair: Mark Forsyth

CMOS PA-RISC Processor for A New Family of Workstations	202
<i>M. Forsyth, S. Mangelsdorf, E. DeLano, C. Gleason, J. Yetter, and D. Steiss</i>	
System Design for a Low Cost PA-RISC Desktop Workstation	208
<i>R. Horning, L. Johnson, L. Thayer, D. Li, V. Meier, C. Dowdell, and D. Roberts</i>	
Architecture and Compiler Enhancements for PA-RISC Workstations	214
<i>D. Odnert, R. Hansen, M. Dadoo, and M. Laventhal</i>	

The DECStation 5100
Chair: Dileep Bhandharkar

DECStation 5000 Model 200	220
<i>M.J.K. Nielsen</i>	
TURBOchannel	226
<i>M.J.K. Nielsen</i>	
PixelStamp Graphics Subsystems for the DECStation 5000	234
<i>Z. Hussain and B. Kelleher</i>	

The Intergragh Clipper C400 Processor
Chair: Bob Moeller

Future Directions in CLIPPER Processors	240
<i>H. Sachs and H. McGhan</i>	
The C400 Clipper Superscaler/Superpipelined RISC Design	247
<i>L. Hanson and N. Brookwood</i>	
Code Restructuring for Enhanced Performance on a Pipelined Processor	252
<i>W. Baxter and R. Arnold</i>	

HIGH PERFORMANCE COMPUTING Track

New SIMD Architectures
Chair: Roger Anderson

The Data Transport Computer TM : A 3-Dimensional Massively Parallel SIMD Computer	264
<i>J.H. Jackson</i>	
The Coherent Processor TM : An Associative Processor Architecture and Applications	270
<i>C.D. Stormon</i>	

Parallel Processors
Chair: Kenichi Miura

Applications of the MasPar MP-1 at NASA/Goddard	278
<i>J.R. Fischer and J. Dorband</i>	

One Year with an iPSC/860	283
<i>E. Barszcz</i>	
An ECL RISC Multiprocessor	289
<i>B. Foster, C. Alexander, A. Roberts, and D. Roberts</i>	

High-Performance Computer Systems

Chair: Ken Stevens

VP2000 Series Dual Scalar and Quadruple Scalar Models Supercomputing Systems - A New Concept in Vector Processing	294
<i>K. Miura, H. Nagakura, and H. Tamura</i>	
The NEC SX-3 Supercomputer System	303
<i>T. Watanabe</i>	
IBM ES/9000 Model 320 Air-Cooled Computer Technology	309
<i>V. Gani, M. Graf, K. Mathews, and E. Eichelberger</i>	

MULTIMEDIA Track

Video Processors and Multi-Media

Chair: John Wharton

The C-Cube CL550 JPEG Image Compression Processor	318
<i>S.C. Purcell</i>	
Intel's i750 (R) Video Processor - The Programmable Solution	324
<i>R. Manepally and D. Sprague</i>	
A Flexible Chip Set for Intra Frame Video Compression	330
<i>D. Auld</i>	

Video Compression Standards

Chair: Theodore A. Laliotis

The MPEG Video Compression Standard	334
<i>D.J. Le Gall</i>	
MPEG-Audio Draft, Description as of December 10, 1990: ISO/IEC JTC1/SC2/WG11	336
<i>J.D. Johnston</i>	
MPEG Systems Committee Draft: ISO/IEC JTC1/SC2/WG11	338
<i>A.G. MacInnis</i>	
An Overview of the Fluent Video System Architecture	340
<i>P. Uppaluru</i>	

Advances in Data Compression - Lets Get Small

Chair: Glen G. Langdon

General Purpose Data Compression ICs	344
<i>D.R. Helman</i>	
JPEG ⁺⁺ : Selective Compression for High Quality Color Desktop Publishing	349
<i>A. Ligtenberg</i>	
Adaptive Binary Arithmetic Coding for Multi-media Applications	354
<i>G.G. Langdon, Jr.</i>	

SOFTWARE Track

Trends in UNIX Software

Chair: Jeffrey Haemer

PANEL SESSION

UNIX Software Next	362
<i>P.H. Salus</i>	
Trends in UNIX Software	365
<i>J.S. Haemer, S.P. McCarron, and P.H. Salus</i>	
A Look at Computing in the 1990s	369
<i>M. Burch</i>	

Constraint Programming Languages

Chair: Joxan Jaffar

The CLP(R) Language and System: An Overview	376
<i>J. Jaffar, S. Michaylov, P.J. Stuckey, and R.H.C. Yap</i>	
The CLP Language CHIP: Constraint Solving and Applications	382
<i>P. Van Hentenryck</i>	
Constraint Hierarchies and Their Applications	388
<i>A. Borning, B. Freeman-Benson, J. Maloney, and M. Wilson</i>	

Parallel Languages

Chair: Bob Keller

Vectorization of an Applicative Language: Current Results and Future Directions	396
<i>D.C. Cann</i>	
Portable Programs for Parallel Computers Using STRAND ⁸⁸	403
<i>T.G. Mattson</i>	
Parallelism, Distribution, and Synchronization in SR	407
<i>R.A. Olsson</i>	
Parallel Programming In Ada: Experience and Results	413
<i>A. Goforth, P. Collard, and M. Marquardt</i>	

FUTURE DIRECTIONS Track

EDA Environments in 1995 - What Will They Be Like

Chair: Jeff Lewis

EDA Environments in 1995: Specification, Not Implementation	424
<i>J. Lewis</i>	
EDA 1995: Challenges for ASIC Vendors	428
<i>M.S. O'Brien and J. Lipman</i>	
EDA Environments in 1995 for Systems Development	434
<i>S. Hulsoor</i>	

Computing Systems Based On Optical Logic

Chair: Joe Goodman

A Digital Optical Implementation of RISC	436
<i>R. S. Rudokas and P. S. Guilfoyle</i>	
Optical Disks in Optical Computing	442
<i>M.A. Neifeld, A.A. Yamamura, S. Rakshit, S. Kobayashi, and D. Psaltis</i>	

Formal Methods in Hardware Design

Chair: Phil Windley

From Formal Verification To Silicon Compilation	450
<i>J. Joyce, E. Liu, J. Rushby, N. Shanker, R. Suaya, and F. von Henke</i>	
Bridging the Formal Methods Gap: A Computer-Aided Verification Tool for Hardware Designs	456
<i>M. Srivas</i>	
The Practical Verification of Microprocessor Designs	462
<i>P.J. Windley</i>	

APPLIED COMPUTING - STATE-OF-THE-ART Track

Rapid Commercialization of Handwriting and Text Recognition

Chair: Larry Spitz

Neural Network Approach To Handprint Character Recognition	472
<i>L. D. Jackel, C. E. Stenard, H. S. Baird, B. Boser, J. Bromley, C. J. C. Burges, J. S. Denker, H. P. Graf, D. Henderson, R. E. Howard, W. Hubbard, Y. LeCun, O. Matan, E. Pednault, W. Satterfield, E. Säckinger, and T. Thompson</i>	

Automated Recognition of Embossed Characters Using Artificial Neural Systems	476
<i>C.M. Anderson</i>	
Handwriting Recognition in the GO Operating System	483
<i>R.M. Carr</i>	
Multiple Neural Net Architectures for Character Recognition	487
<i>C.L. Scofield, L. Kenion, and J.-C. Chang</i>	

What is Software Design: Why Isn't It Software Engineering?
Chair: Terry Winograd

The Relation of Design to Human Concerns	494
<i>B. Hartfield</i>	
Conceptual Models and Metaphor in Software Design	498
<i>P. Heckel</i>	
Interacting With Users in the Design Process	500
<i>L. De Young</i>	

OBJECT AND DATABASE TECHNOLOGY Track

Intelligent Database Technology
Chair: Mohammad Ketabchi

Intelligent Object-Oriented Features in Distributed Databases	504
<i>A. Chan, S. Khoshafian, R. Abnous, and R. Blumer</i>	
Remote-Exchange: An Approach to Controlled Sharing Among Autonomous, Heterogeneous Database Systems	510
<i>D. Fang, J. Hammer, D. McLeod, and A. Si</i>	
Declarative Reasoning Extensions to Commercial SQL Database Management Systems	516
<i>S. Khoshafian and L. Thieme</i>	
A Pattern-Based Constraint Specification Language for Object-Oriented Databases	522
<i>S.Y.W. Su and A.M. Alashqur</i>	

Object Technology: Present and Future
Chair: Dr. Rao Mikkilineni

Issues in the Adoption of Object-Oriented Paradigm	534
<i>P. Goyal</i>	
Current State of Object Technology in Japan	540
<i>M. Aoyama</i>	
A Perspective on Object-Oriented Technology	546
<i>J. Zhu, R. Nassif, P. Goyal, and R. Mikkilineni</i>	
Foundations of Concurrency Among Objects	553
<i>S. Das, B. Gopinath, and D. Kurshan</i>	

Advanced Transaction Models
Chair: Andreas Reuter

Advanced Rule Driven Transaction Management	562
<i>J. Klein</i>	
Coordinating Activities Through Extended Sagas: A Summary	568
<i>H. Garcia-Molina, D. Gawlick, J. Klein, K. Kleissner, and K. Salem</i>	
ConTracts: A Means for Improving Reliability in Distributed Computing	574
<i>H. Wächter</i>	

COOPERATION AND COMPUTERS Track

Industrial Partnerships for Commercialization of U.S. Government Technology
Chair: Joseph Allen

Licensing Government Funded Technologies at the University of California	582
<i>C.L. Voelker</i>	

Commercializing Federal Technology	588
<i>J. Allen</i>	
Opportunities for Accelerating Commercial Development Via Effective Partnering	590
<i>R.E. Barks</i>	
Experience with Joint US/JAPAN Computing Ventures	
Chair: M.A. Harrison	
PANEL SESSION	
A Lawyer's Perspective On Joint U.S./Japan Computing Ventures	594
<i>M.R. Moyle</i>	
Author Index	597

MICROPROCESSOR HARDWARE TRACK



100 MIPS and Counting

Performance Enhancements in the Superscalar i960MM Embedded Microprocessor

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Intel Corporation, Hillsboro, OR

Abstract

Continued research into Intel's i960 architecture has resulted in the development of performance improvements beyond those implemented in the i960CA microprocessor. These improvements allow additional superscalar dispatch opportunities, reduce memory access delays and enhance the performance of specific instructions. The i960MM microprocessor is an implementation of these performance enhancements. Additionally, the i960MM includes an implementation of a full-function floating-point unit. Performance of 27 MFLOPS (single precision) and 16 MFLOPS (double precision) is achieved on the Linpack benchmarks at 40 MHz. This paper describes both the micro-architectural enhancements to the i960 and the new floating-point unit.

1. Introduction

In 1989 Intel introduced the i960CA, the first microprocessor capable of decoding, dispatching, executing, and returning results from more than one instruction per basic clock cycle. Evolutionary enhancements have been made to a version of the i960CA core that allow more opportunities to dispatch and execute instructions in parallel.

2. The i960 Architecture

This section provides a brief overview of the i960 architecture. More detail may be found in [McG89] and [Myers88], and reference manuals are available [960KB] and [960CA].

2.1. Instruction Set. The i960 architecture presents a simple reduced instruction set to the user. It is a three-operand load/store architecture, and most instructions operate on three register operands, two source operands and a destination, and that the only specific memory load and store instructions explicitly access memory. The architecture defines 24 basic instructions, including the normal arithmetic, logical, and memory access

instructions, and 16 extended instructions, including a combined compare-and-branch instruction, subroutine call and return instructions, and atomic and synchronous memory access operations.

All i960 instructions fall into one of four main categories: Register (REG) format instructions, Memory (MEM) instructions, Control (CTRL), and Compare-and-Branch (COBR) instructions. Most general instructions are of the REG type, such as add, subtract, boolean, and bit manipulation instructions. Compare instructions are also of REG type, and are the only general-purpose instructions which set the condition codes. The COBR instructions are a variant of the REG-style compare instructions that combine a comparison operation with a conditional branch. These instructions are useful to reduce code size when a useful instruction cannot be placed in the delay slot after a comparison and prior to a branch instruction. The load, store, and load address instructions are of the MEM type, and may access byte, half-word, word, double-word, triple-word, or quad-word data. Conditional and unconditional branches as well as the call and return instructions are of the CTRL type.

2.2. Register Architecture. The i960 architecture defines a register file consisting of 32 general-purpose registers that are divided into two sets: *global* registers and *local* registers. The local registers r0 through r15 represent the currently visible portion of a *local register cache*, where local registers from previous subroutine invocations are retained. Management of the local register cache is fully transparent to the user program, as the processor automatically flushes frames out to memory when the cache becomes full. The 16 global registers are not affected by procedure calls and returns, and are used for parameter passing and, within a procedure, as temporary value registers.