

CECS eNEWS

Center for Embedded Computer Systems, University of California, Irvine

Highlights

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CECS—Past, Present, Future

PAST

The Center for Embedded Computer Systems (CECS) at UC Irvine has its roots in the early 90's and developed out of several research efforts in the areas of computer-aided design, computer architecture, system software and optimizing compilers. In the mid-90's, a group of senior faculty had a vision of creating a preeminent research center in the then-emerging area of embedded computer systems. What follows is a brief history of how CECS has evolved:

1990—Established Irvine Research Unit in Computer Design (IRUCSD). Initially faculty members were from ICS and ECE with several large collaborative research efforts with major companies.

1995—Emphasis shifted to embedded systems. Research focus and emphasis shifted to the emerging theory and technology of embedded systems. CECS now had about 40 graduate students and research funding continued to grow to over \$3 million.

1998—CECS proposed. By now, CECS had grown to about 55 graduate students and the total research funding had grown to over \$5 million. The faculty members created a Master of Science in Embedded Systems degree and faculty members had expanded to



CECS Research Facility

include the Department of Mechanical and Aerospace Engineering, and the College of Medicine, plus UCSD and UCR faculty.

2001—CECS officially established. The UCI Academic Senate approved the establishment of the Center for Embedded Computer Systems (CECS) as an official UCI Organized Research Unit (ORU) effective January 1, 2001.

PRESENT

As an ORU at UCI, CECS now operates as an independent research entity within the university and is responsible for its own administration, accounting, graduate student recruitment, research development, and technology and knowledge transfer. UCI Chancellor Ralph Cicerone appointed Professor Daniel D. Gajski as Director of CECS for a 5 year term, reporting to Vice Chancellor for Research Professor William H. Parker.

Professor Gajski has ap-

pointed Robert P. Larsen as Associate Director in charge of Research Relations and Juancho Banaag as Assistant Director in charge of Operations.

CECS is a premier research organization focusing on research and educational aspects related to embedded systems with emphasis on automotive, communications, and medical applications. CECS has 16 faculty members and 65 graduate students from the Department of Information and Computer Science, Department of Electrical and Computer Engineering, Department of Mechanical and Aerospace Engineering, and the College of Medicine.

FUTURE

Our vision is to pioneer novel and innovative research, in all aspects of embedded systems, that will be recognized world-wide as benefiting the individual and society. Dreams! Dreams! Dreams!

Professors Dutt & Nicolau Receive Motorola Research Gift

In January 2001, Professor Nikil D. Dutt and Professor Alexandru Nicolau received the first \$200,000 payment of a \$400,000 research gift authorized by David Mothersole, Vice President, Semiconductor Products Sector, Motorola, Inc., Austin, TX. This research gift will support the EXPRESSION project aimed at developing a re-targetable compiler for application-specific embedded systems architectures.

EXPRESSION is a processor Architecture Description Language (ADL) supporting the modeling and exploration of heterogeneous processor-memory programmable architectures. Using EXPRESSION, a system designer can rapidly evaluate the effects of different microarchitectural styles (e.g., superscalar, VLIW), features (e.g., pipelining), varying instruction sets, and novel memory organizations. EXPRESSION supports the generation of a complete software toolkit to enable end-to-end specification, analysis, exploration and software development. Currently the EXPRESSION framework generates EXPRESS, a highly optimized and truly re-targetable parallelizing compiler, SIMPRESS, a re-targetable, functional and cycle-accurate, structural simulator, and MEMOREX, an early memory exploration environment. Using the EXPRESSION toolkit, SOC designers are able to perform rapid compiler-in-the-loop exploration of different processor and memory IP blocks, allowing for tuning and customization to fit specific design goals.

Professor Gajski to Develop SpecC Reference Compiler

At a recent meeting of the SpecC Technology Open Consortium (STOC) in Japan, CECS was selected to develop an Open Source Reference Compiler for SpecC, an overarching specification and programming language that supports the seamless integration of product development. With the development of this compiler, SpecC will be available in the public domain for the purpose of making the language an industrial standard for the design and production of embedded systems and other electronic products using product-on-demand (PoD) technology.

The SpecC language is designed to support smooth overall integration of product development starting from a C-style product specification. It seamlessly integrates specification and design, leading to significant designer productivity gains. SpecC defines a formal, executable specification that can be simulated early in product development. With this language, system definition can be streamlined by removing misinterpretations and miscommunications being experienced by conventional design practices.

This compiler development will be done under the guidance of Professor Daniel D. Gajski and Dr. Rainer Dömer.

SpecC Book on Japanese "Top 10" Technical Book List

The Japanese edition of the book "SpecC: Specification Language and Methodology", authored by Gajski, Zhu, Dömer, Gerstlauer, and Zhao, has been recently named in the Japanese "Top 10" Technical Book List.



Professor Vahid Wins DATE 2000 Best Paper Award



Novel Applications Studied in ECE145

During the Winter Quarter 2001, about 70 senior computer engineering students enrolled in ECE145, Senior Design Project, developed various embedded systems involving the Palm PDA. This undergraduate course was organized by Professor Pai H. Chou. 16 Palm PDA's, 2 Palm modems, and 4 copies of CodeWarrior IDE software were donated by Endeavors Technology, Inc., Irvine, CA.

Professor Chou decided that the students should do projects involving the Palm PDA. This steered the students away from the traditional PC or workstation paradigm. The Palm PDA is an ideal device for students to explore a variety of hardware and software issues; including limited memory, small-screen user interface, infrared/wireless communication, hardware/software interfaces, and internet protocols.

One group of students is collaborating with Professor Bruce J. Tromberg aimed at transforming the Palm PDA into a device for detecting breast cancer using near-infrared spectrum detection technology.

Another group of students is collaborating with Dr. Gregory Bolcer, CTO of Endeavors Technology, Inc., Irvine, CA, to explore MAGI and Python applications on the Palm PDA.

All students were excited and extremely interested in their projects.

Courses Offered

The following Spring Quarter 2001 (March 28 to June 16) graduate level courses are being offered by CECS faculty members:

- N. Dutt ICS53 "Embedded Systems Computing" Tu Th 9:30-10:50 AM Room IERF B105
- R. Gupta ICS252 "Introduction to Computer Design" Tu Th 5:00-6:20 PM Room ICS209
- A. Nicolau ICS249 "Seminar in Network Systems" F 2:00-4:50 PM Room ICF102
- N. Dutt ICS251 "Digital System Verification and Testing" W 2:00-4:50 PM Room IERF 127
- D. Gajski ICS257 "System Tools" F 3:00-5:50 PM Room IERF 127
- N. Dutt ICS259 "Seminar in Design Science" Th 2:00-3:20 PM Room IERF127



2 SRC Awards

The Semiconductor Research Corporation (SRC) recently named one CECS graduate student as an SRC Fellow and one CECS graduate student as an SRC Master's Scholar.

Graduate student Frederic Doucet, studying under Professor Rajesh K. Gupta, was named an SRC Fellow in the SRC Graduate Fellowship Program. This fellowship award is for up to three years of study and provides tuition and fees, a generous monthly stipend, and an annual unrestricted gift of \$2,000 to the ICS department.

Graduate student Shannon Tauro, studying under Professor Nikil D. Dutt, was named an SRC Master's Scholar in the SRC Master's Scholarship Program. This scholarship award is for up to two years of study and provides tuition and fees, a generous monthly stipend, and an annual unrestricted gift of \$2,000 to the ICS department.

CECS is honored and privileged to have these two outstanding graduate students and congratulates Shannon and Frederic on receiving these prestigious SRC research awards.

DATE 2001 Appearances

CECS was well represented at the Design, Automation, and Test in Europe Conference (DATE 2001) held in Munich, Germany on March 13–16, 2001.

Professor Frank Vahid was honored by receiving the DATE 2000 Best Paper Award in the Design Methods category for the following paper:

- “Techniques for Reducing Read Latency of Core Bus Wrappers,” R. Lysecky, F. Vahid, T. Givargis, DATE 2000 Proceedings, pp. 84–91, March 2000

The following faculty members served on committees or made presentations:

- N. D. Dutt served on the Executive Committee
- R. K. Gupta served on the Technical Program Committee
- D. D. Gajski organized a tutorial titled “SpecC Language and Methodology”
- T. Ishii, A. Gerstlauer, J. Zhu presented a tutorial titled “SpecC Language and Design Methodology”
- D. D. Gajski was the organizer and panelist at a session titled “C/C++: Progress or Deadlock in SLD Specification”

SRC Review Meeting

On February 27-28, 2001 the Semiconductor Research Corporation (SRC) Integrated Circuit and System Sciences (ICSS) Area Coordinating Committee conducted a Review of System Design Projects. Researchers from the following universities made presentations: Princeton University, University of Illinois, University of Wisconsin, Virginia Technical University, Carnegie Mellon University, Massachusetts Institute of Technology, and University of California, Berkeley. The following UCI and CECS faculty made presentations related to their research programs:

- Vice Chancellor for Research William H. Parker delivered a welcoming address to the university and industrial attendees
- R. K. Gupta made a presentation titled “A Parallelizing Compiler Framework for Integrated System Design”
- D. D. Gajski made a presentation titled “SoC Abstraction Algebra”

Visiting Researchers

Associate Professor Slim Ben Sauod, National Institute of Applied Science and Technology, Tunisia, will be studying and performing research with Professor Daniel D. Gajski as a Fulbright Scholar for the period March–September 2001.

ASP-DAC 2001 Appearances

CECS was well represented at the Asia and South Pacific Design Automation Conference 2001 (ASP-DAC 2001) held in Yokohama, Japan on January 30–February 2, 2001. The following CECS faculty members made presentations:

- N. Dutt, A. Nicolau, H. Tomiyama, A. Halambi presented a tutorial titled “New Directions in Compiler Technology for Embedded Systems”
- P. H. Chou served on the Embedded Systems and Software Subcommittee
- R. K. Gupta served on the System Design Methodology Subcommittee
- D. D. Gajski and J. Zhu presented a paper “Compiling SpecC for Simulation”
- D. D. Gajski organized a tutorial titled “SpecC: Specification Language and Design Methodology”
- R. K. Gupta organized a tutorial titled “Design and Tools for Networked System-on-Chip”

Visitations

On January 4, 2001, Daniel D. Skilken, President and CEO, and Dr. Mark Hartoog, Chief Product Architect, C Level Design, Campbell, CA visited Professor Daniel D. Gajski.

Professor Profile

CECS is proud to profile Assistant Professor Pai H. Chou, Department of Electrical and Computer Engineering, The Henry Samueli School of Engineering, as an outstanding research affiliate.



Professor Chou was born in Taipei, Taiwan and received an AB in 1990 from the University of California, Berkeley, a MS in 1993 and a PhD in 1998 from the University of Washington.

His paramount research project is IMPACCT. IMPACCT is striving to develop a system-level design tool for power-aware systems design that integrates the best power management strategies into one tool framework.

Professor Chou serves on the Program Committee for ISSS and ASP-DAC and is an Associate Editor for the Journal of System Architecture and the IEEE Transactions on VLSI Systems.

The following are some of Professor Chou most recent publications:

- "Power-Aware Scheduling under Timing Constraints for Mission-Critical Embedded Systems," J. Liu, P. Chou, N. Bagherzadeh, F. Kurdahi, Proceedings of the 38th Design Automation Conference, 2001
- "A Constraint-Based Application Model and Scheduling Techniques for Power-Aware Systems," Proceedings of the Codesign Symposium, 2001
- "Synthesis and Optimization of Coordination Controllers for Distributed Embedded Systems," P. Chou, G. Borriello, Proceedings of the 37th Design Automation Conference, 2000
- "IPChinook: an Integrated IP-based Design Framefor Distributed Embedded Systems," P. Chou, R. Ortega, K. Hines, K. Partridge, G. Borriello, Proceedings of the 36th Design Automation Conference, 1999
- "Control Generation for Embedded Systems Based on Composition of Modal Processes," P. Chou, K. Hines, K. Partridge, G. Borriello, Proceedings of the 35th Design Automation Conference, 1998

Graduate Student Profile

CECS has selected Peter G. Grun to be profiled as an outstanding graduate student. Peter was born in Deva, Romania and received his secondary education there. He received a BS in 1994 and a MS in 1995 from the Technical University of Timisoara, Romania. He received a MS in 1997 from University of California, Irvine.



Since then he has been performing research under the guidance of Professor Nikil D. Dutt. During the summer of 1997 he was an intern at Conexant Systems, Inc., Newport Beach, CA. He received a Motorola Research Fellowship for the 2000/2001 academic year. He is currently nearing completion of his PhD thesis which is titled "Hardware/Software Memory Customization for Embedded Systems." The goal of this research is to perform hardware customization of the memory architecture, coupled with software transformations of the input application and memory-aware compiler optimizations to significantly improve the memory system power and performance for programmable embedded systems. He has coauthored the following papers:

- "Access Pattern Based Local Memory Customization for Low Power Embedded Systems," P. Grun, N. Dutt, A. Nicolau, DATE 2001
- "Processor-Memory Co-Exploration Driven by a Memory-Aware Architecture Description Language," P. Mishra, P. Grun, N. Dutt, A. Nicolau, 14th International Conference on VLSI Design, 2001
- "MIST: An Algorithm for Memory Miss Traffic Management," P. Grun, N. Dutt, A. Nicolau, ICCAD, 2000
- "Memory-Aware Compilation Through Accurate Timing Extraction," P. Grun, N. Dutt, Nicolau, DAC, 2000
- "RTGEN: An Algorithm for Automatic Generation of Reservation Tables from Architectural Descriptions," P. Grun, A. Halambi, N. Dutt, A. Nicolau, ISSS, 1999
- "VSAT: A Visual Specification and Analysis Tool For System-on-Chip Exploration," A. Khare, N. Savoiu, A. Halambi, P. Grun, V. Ganesh, N. Dutt, A. Nicolau, EUROMICRO, 1999

The following were published by CECS faculty during the period of January 1, 2001 to March 31, 2001:

| Main Focus | Title, Authors, Publications |
|-------------------------------|--|
| <i>Co-Exploration</i> | “Processor-Memory Co-Exploration Driven by a Memory-Aware Architecture Description Language,” P. Mishra, P. Grun, N. Dutt, A. Nicolau, Proceedings of the 14th International Conference on VLSI Design, 2001 |
| <i>Power Evaluation</i> | “Trace-Driven System-Level Power Evaluation of System-on-Chip Peripheral Cores,” T. Givargis, F. Vahid, J. Henkel, Proceedings of the Asia-South Pacific Design Automation Conference (ASP-DAC), Yokohama, Japan, January 2001 |
| <i>Functional Abstraction</i> | “Functional Abstraction of Programmable Embedded Systems,” P. Mishra, J. Astrom, N. Dutt, A. Nicolau, ICS Technical Report #01-04, January 2001 |
| <i>Compiling SpecC</i> | “Compiling SpecC for Simulation,” J. Zhu, D. Gajski, Proceedings of the Asia-South Pacific Design Automation Conference (ASP-DAC), Yokohama, Japan, January 2001. |
| <i>Compiler Technology</i> | “New Directions in Compiler Technology for Embedded Systems,” N. Dutt, A. Nicolau, H. Tomiyama, A. Halambi, Proceedings of the Asia South-Pacific Design Automation Conference (ASP-DAC), Yokohama, Japan, January 2001 |
| <i>FSM Modeling</i> | “Efficient FSM Modeling for RTL Synthesis,” R. Satapathy, S. Pal, R. Gupta, ICS Technical Report #01-10, February 2001 |
| <i>Transducer Design</i> | “Design of A Transducer for Parity Encoder,” Haobo Yu, Qiang Xie, Daniel D. Gajski, ICS Technical Report #01-08, February 14, 2001 |
| <i>Interface Synthesis</i> | “Interface Synthesis at Behavioral RTL,” Dongwan Shin, Pei Zhang, Daniel D. Gajski, ICS Technical Report #01-07, February 15, 2001 |
| <i>Memory Customization</i> | “Access Pattern Based Local Memory Customization for Low Power Embedded Systems,” P. Grun, N. Dutt, A. Nicolau, Proceedings of the Design Automation and Test in Europe Conference (DATE 2001), Munich, Germany, March 2001 |
| <i>Diagnosis for BIST</i> | “Diagnosis for Scan-Based BIST: Reaching Deep into the Signatures,” I. Bayraktaroglu, A. Orailoglu, Proceedings of the Design Automation and Test in Europe Conference (DATE 2001), Munich, Germany, March 2001 |
| <i>Power-Aware Scheduling</i> | “Power-Aware Scheduling Under Timing Constraints for Mission-Critical Embedded Systems,” J. Liu, P. Chou, N. Bagherzadeh, F. Kurdahi, Proceedings of the 38th Design Automation Conference, June 2001 |
| <i>Speculation Techniques</i> | “Speculation Techniques for High Level Synthesis of Control Intensive Designs,” S. Gupta, N. Savoiu, S. Kim, N. Dutt, R. Gupta, A. Nicolau, Proceedings of the 38th Design Automation Conference, June 2001 |
| <i>Test Volume Reduction</i> | “Test Volume and Application Time Reduction Through Scan Chain Concealment,” I. Bayraktaroglu, A. Orailoglu, Proceedings of the 38th Design Automation Conference, June 2001 |

Center for Embedded Computer Systems, University of California, Irvine

CECS Mission Statement:

To conduct leading-edge interdisciplinary research in embedded systems, emphasizing automotive, communications, and medical applications, and to promote technology and knowledge transfer for the benefit of the individual and society.

WE'RE ON THE WEB!
WWW.CECS.UCI.EDU

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Editor's Byline



At CECS, we value our extensive synergy with industry, because it enriches us with challenging problems. These technical interchanges help us disseminate ideas, algorithms, and experimental results that benefit our

partners with a longer term technology view and prospects of novel future products.

Our present research paradigm in embedded systems consists of a core research program and a domain research program. If you are interested in any aspect of CECS's educational and research programs, please feel free to contact me as listed above. We are always open to explore new collaborative research opportunities that result in "win-win" situation. CECS is committed to research excellence and our graduate students are outstanding. We are continuously monitoring tech-

nology trends world-wide and our research staff is pioneering innovative technologies and applications in all areas of embedded systems.

We hope to hear from you concerning any of your research needs or interests in CECS. It's your interest and support that helps us drive and shape our collaborative research programs. Let's communicate!

Bob Larsen