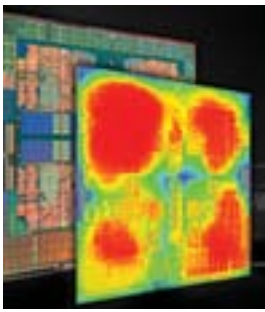
Center for Embedded Systems

An NSF Industry/University Cooperative Research Center



National Science Foundation

SIU Carbondale Southern Illinois University

ASU Ira A. Fulton Schools of Engineering
Arizona State University

“The NSF Center for Embedded Systems provides a unique opportunity to not only bring multiple partners together but also bring different components of system design research under one umbrella. This holistic approach ensures that members and researchers benefit significantly by active collaboration.”

Rathish Jayabharathi
DFX Manager/Senior Staff,
Intel Corporation, Folsom, CA

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“The NSF Center for Embedded Systems has enabled us to integrate network-on-chip synthesis technologies developed by Professor Chatha’s group into Qualcomm Corp R&D design processes. Our interaction has been very good, and we have also had the benefit of attracting technically strong interns.”

Rudy Beraha
Director, Engineering,
Qualcomm Corp., San Diego, CA

About The Center for Embedded Systems

The Center for Embedded Systems (CES) is a research collaboration between academia (Arizona State University and Southern Illinois University Carbondale), industry (leading electronics companies throughout the world) and government (the National Science Foundation). Its purpose is to advance the field of embedded systems in algorithms, applications, and architectures to new levels; thereby, sharing resulting technology advancements and commercializing applications to advance commerce.

CES was founded by the National Science Foundation as an industry/university cooperative research center (I/UCRC) in 2009 as a multi-university center between Arizona State University and Southern Illinois University Carbondale. The center conducts industry-university research projects that are funded by its industry members, the NSF and the two participating Universities. CES sponsors an internship program, provides research support for students and faculty, and administers a relevant embedded systems curriculum.

Millions of dollars have been stimulated in Arizona and Illinois economies based on the Center's research dollars spent to date in areas such as faculty and research assistant salaries. Additionally, more than 50 interns have worked for and many eventually been employed permanently by CES member companies, further broadening the positive economic impact of the Center's research.

Industry Partners:

CATERPILLAR

EMAC, inc.

GENERAL DYNAMICS

Hamilton Sundstrand
A United Technologies Company

intel AZ

intel OR

intel CA

MARVELL

QUALCOMM

Raytheon

Rockwell Collins

TOYOTA

DICKEY-john

member testimonials

"As promised in our first research proposal, we were able to use ASU Professor Fainekos' S-TaLiRo Tool suite prior to physical engine testing to expose performance specification violations in one of our research controller designs. Thus, we conclude that the tool suite can be incorporated to improve our control design process. We look forward to similar success in our second project wherein we will study the effective use of multi-core processors in engine control applications."

Ken Butts, Executive Engineer,
Toyota Motor Engineering & Manufacturing, N.A., Ann Arbor, MI

"The collaborative study of embedded applications, with leading researchers from both SIU and ASU, has a direct and positive impact on all the member companies of this advisory board and further advancements of embedded systems."

Bob Wright, Program Manager, TSI Incorporated, Shoreview, MN

"Our relationship with SIUC enables Hamilton Sundstrand to explore next generation technologies in a cost effective, collaborative environment by augmenting our internal resources with unbiased expert resources. This type of relationship is difficult, if not impossible, with suppliers biased towards particular solutions, or through other types of contracting agreements."

Michael Krenz, Manager, Advanced Technology,
Hamilton Sundstrand, Rockford, IL

"Intel and ASU have enhanced the embedded systems curriculum which enables ASU's faculty members and students with the latest embedded systems technology and industry trends. The internship program, which is part of the Center for Embedded Systems, has been an asset to Intel Corporation in its role as a valuable hiring pipeline for recruiting highly qualified engineers."

Byron Gillespie, Director,
Intel Embedded University Program, Intel Corporation, Chandler, AZ

"Since joining the Center for Embedded Systems this past year, Rockwell Collins is finding that the center provides us with a very cost effective opportunity to pool our resources with other companies to attack difficult technology issues. We have also found great value in leveraging the skills of the researchers to tackle problems specific to our own technology interests."

Scott J. Zogg, Sr. Director, Embedded Info. Systems,
Advanced Technology Center, Engineering and Technology,
Rockwell Collins, Cedar Rapids, IA

"Marvell values the Center's cross-industry discussions and the opportunity to leverage the Center's pooled research efforts."

Bill Reaves, Director of Engineering,
Marvell Semiconductor, Inc., Chandler, AZ

"To date, our relationship with the SIUC technical team and the Center for Embedded Systems has been a good one. Students demonstrate an eagerness to apply what they have learned in school to apply to real life technical problems. Students and faculty alike seriously address technical problems, research new methods, and work toward solutions within an agreed-upon schedule."

David A. Andersen, Senior Associate Engineer,
Research and Development, General Dynamics,
Ordnance and Tactical Systems, Marion, IL

"Intel has always been a firm believer in supporting academic research to advance new ideas in technology. The NSF Center for Embedded Systems is a great example in further facilitating this research by bringing together multiple partners in industry, academia and government to focus research in the area of embedded systems. Research conducted through centers such as this helps ensure a consistent pipeline of both ideas and trained engineering professionals which are crucial to the future success of companies such as Intel."

Howard Wilson, Engineering Manager,
Intel Labs, Intel Corporation, Hillsboro, OR

Embedded Systems Unveiled

At the heart of all personal technology, healthcare, homeland security, education, transportation and space applications is a computing system that performs the essential functions of sensing, computing, control and communication. Such computing systems that are immersed in their application domains are known as embedded systems.

Design technologies for embedded systems in the nanoscale era face both silicon and system complexities, and the cross-cutting issue of increased power consumption. Given the infusion of embedded systems into all types of safety-critical applications, another extraordinary set of challenges arises from verification and validation of hybrid systems.

Embedded system design in nanoscale technologies presents a significant challenge to industry and government, as it requires a cross-disciplinary approach to problem solving, which cuts across traditional areas of electrical engineering and computer science. We believe that cohesive industry/university teams with expertise in design of circuits, hardware architecture, system software and applications are ideal for undertaking innovative research projects.

The mission of CES encompasses fundamental, industry-relevant research, education, and training for undergraduate and graduate students. The Center accomplishes this by implementing research projects, industry-sponsored internships, and technology transfer made possible by shared intellectual property arrangements and student employment.

Center for Embedded Systems
Research Areas of Expertise

Power, Energy and Thermal Aware Design

- Low power circuit architectures and design tools
- Dynamic peformance, power, energy and thermal management for multicore embedded systems
- Statistical variation aware design of digital systems
- Energy efficient architectures and code optimization for embedded systems

Electronic System-level Design (ESL) and Technologies

- Modeling and simulation
- Hardware/software co-design and optimization
- Trusted, reliable, and secure design

Embedded Multicore Architectures and Programming

- Network-on-Chip design and optimization
- Compilation of stream applications on multicore processors
- Highly power-efficient programmable accelerators
- Soft error resilient system design
- Design and programming of low power embedded systems
- Embedded GPU computing
- Temperature- and variations-aware architectures and programming

Embedded Software System

- Real-time scheduling
- Embedded systems for smart grids
- Middleware and VM for embedded systems
- Embedded software instrumentation and tools

Cyber-Physical Systems

- Modeling and simulation
- Model based formal verification and semi-formal testing
- Model based synthesis from high-level specifications

Integrated Circuit Technologies, Design, and Test

- Semiconductors for hostile environments
- Device physics and modeling
- Microelectronic device and sensor design and manufacturing
- Analog/RF/mixed signal circuit design and test
- Testing and silicon debug of digital circuits

Benefits of Membership

Industry-Relevant Research Projects

1. Participate in research in timely focus areas:
   - Power, Energy and Thermal-Aware Design
   - Electronic System-level (ESL) Design and Technologies
   - Embedded Multicore Architectures and Programming
   - Embedded Software Systems
   - Cyber-Physical Systems
   - Integrated Circuit Technologies, Design, and Test
2. Conduct pre-competitive or exploratory research in an efficient, cost-effective way
3. Access the minds and work of more than a dozen faculty members with laboratory and computing facilities
4. Chart your own course, as base membership enables a member-directed research project

Intellectual Property Arrangement

1. Results of shared research projects available to all
2. Royalty-free non-exclusive IP rights on shared research projects

Leverage of Industry/University Partnership

1. Direct university projects at significantly reduced overhead
2. Realize greater return on investment due to the pooling effect of memberships
3. Maximize your research dollars with federal matching funds for I/UCRC

Internship Program

1. Access academically outstanding engineering students - undergraduate and graduate levels
2. Gain a recruiting advantage by developing relationships with interns, prepped with coursework in embedded systems
3. Hire the best, through your opportunity to select experienced interns for permanent employment

photos on pages 6,9 and 10 by Jessica Slater - Arizona State University

Membership Structure and Operations

Industry Advisory Board (IAB)

- Base membership provides one seat on the IAB
- Recommends research initiatives
- Evaluates research projects and votes on them for funding
- Advises on short-and long-term needs of industry members
- Collaborates during in-person Center meetings twice per year

Project proposals

- 1-year research proposals, with an option to extend through IAB vote
- IAB recommends research priorities for each member company
- Proposals submitted by faculty; evaluated and voted upon by IAB

Research Phase

- Ongoing collaboration between interested industry members and researchers
- Mid-term updates on all proposals via interactive poster sessions
- Final research reports published and presented to IAB

CES Annual Timeline / Project Cycle

JAN	**IAB Progress Report Meeting** at ASU, Tempe, AZ
FEB	Topics of Interest Due - industry to academia
MAR	RFP Sent to Faculty Membership Fees Billed
APR	Proposals Due to directors Proposals Due to IAB
MAY	"Soft" Vote/Evaluations Complete Final Proposals Due Proposals Posted on CES website
JUN	**IAB Annual Meeting** at SIUC, East Metro St. Louis Present final & progress reports Review and rank proposals Announce new projects Present center update & expenditures
JUL	
AUG	**New Projects Begin**
SEP	
OCT	
NOV	
DEC	Results of Final Projects Published

ON-GOING RESEARCH PROJECTS

ON-GOING RESEARCH PROJECTS

“The Center for Embedded Systems allows Caterpillar to explore research topics which have general benefits for all members, while supporting the particular needs of the company. We also benefit from the research performed for other member companies, as they conduct their respective projects and share results with all members. This is a growing consortium that has not yet realized its full potential.”

Stephen Phelps
Research Team Lead, Product Development & Global Technology,
Electronics and Components Research, Caterpillar Inc., Peoria, IL

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