SoC Design Skills: Collaboration Builds a Stronger SoC Design Team

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Abstract

The success of new System-on-a-Chip (SoC) initiatives depends on the availability of well-trained SoC designers who are able to bridge the gap between software centric system specification and hardware-software implementation in novel architectures. The Pittsburgh Digital Greenhouse is working with its member Universities to facilitate the education of such designers – those capable of bridging all the key competence areas required to bring about this integration. We are cooperating in the creation of an MS Certificate program in SoC Design that will be collaboratively developed and jointly coordinated. This paper briefly describes our educational initiative, and the resulting collaboratively defined SoC Skill set.

Overview and Objectives

Through the cooperative development of an SoC Education program, we plan to increase the number of graduates who are well equipped for the design of the next generation of Integrated Circuits [1]. Very few graduating engineers have either the point skills or the systems' level perspective to prepare them for the challenges of embedded systems and SoC design. These skills include engineering fundamentals, significant depth in one field, and adequate breadth to work in a multi-disciplinary team. Current curricula at the Greenhouse member schools (Carnegie Mellon, Penn State, and University of Pittsburgh) cover both fundamentals and advanced SoC topics. The proposed SoC Master's certificate program will enhance the breadth and depth of the existing curriculum by building on the strengths of each of the participating schools.

The primary reasons that students are not graduating with state-of-the-art skills and systems level perspectives are two-fold: i.) the cost of developing relevant curriculum, and ii.) the cost of keeping the curriculum up to date with fast moving industrial practices. For example, the installation and upgrading of the set of commercial software tools necessary to teach state-of-the-art chip design can require a full time technical support staff member. The testing of these tools, as well as the construction of design libraries and tutorials for student use requires many additional hours that must be contributed by graduate students and/or faculty. This effort must currently be duplicated at each university, and it represents time better spent on research, student interaction, and development of new curricula. Greenhouse sponsored collaboration between the three Universities will allow us to achieve the necessary economies of scale to more efficiently educate students in the SoC state of the art through:

i. shared infrastructure for design and development,
ii. distributed course development and teaching, and
iii. leverage of extensive existing academic programs.

Educational Goals

The success of SoC technology will depend critically on the availability of trained SoC architects, designers and engineers. Our proposed Master's-level program will encompass courses in all the key areas of knowledge and skills vital for integrated system design and design management. In September 2000, the Greenhouse sponsored a University/Industry workshop to get industrial input into the SoC taskforce plans [2]. During this workshop key skills were reviewed including complex circuit design, SoC architectures, integrated software issues, and reusability and Intellectual Property (IP) management [3,4]. The key organizational form for future system integration projects is the small core competence team. Hence, a work effort of this type requires the ability to co-operate with engineers from other cultures and with differing backgrounds. Students in our program will have an opportunity to gain this skill while working on team projects, on inter-university teams, and as interns with local industry and Greenhouse member companies.

SoC Skill Set

Mastery of the complexity and heterogeneity of next generation Integrated Circuit design requires profound interdisciplinary understanding of the key design issues. This will be ensured in the proposed program by our course mix, from designing deep sub-micron circuits to system-level modeling and optimization, with the *System-on-a-Chip* concept as a unifying thread. Table 1 lists the core SoC skills which are essential to our collaborative curriculum.

The member universities will develop and initially offer several new SoC-related courses, with additional courses being identified and introduced as increased teaching resources and expertise becomes available in the member universities. Further, some existing courses are targeted for enhancement to address specialized SoC skills topics (e.g. VLSI Design, Reconfigurable Computing, Communication / Wireless Systems, Image Processing). These courses already offer significant background essential for future SoC designers, and will be augmented to enhance student skills in system integration and embedded system design.

Additionally, a "capstone-design" course that offers a significant SoC design experience is planned under this program. This course will require students to work in teams to complete a large-scale system design project. The teaming arrangements may include intra- and inter-university groups, with the goal of a Greenhouse-supported student design facility for team use. Project topics for this course will be selected with close interaction between local industries and major System-on-Chip industries, in each of the development, implementation, and evaluation phases of the project.

Summary and Status

The Greenhouse SoC curriculum project offers a unique opportunity to enhance our region's academic and economic SoC design infrastructure. Through the establishment of cross registration agreements between the three universities, students in this program can take advantage of unique courses that will be developed and taught at each institution. The intended outcomes of this collaborative degree program are to:

1. Create a larger and better-trained workforce coming from both full-time graduate students and part time students (company employees) who have knowledge and skills to work in SoC and related technologies.
2. Build academic infrastructure, both people and resources, to support teaching and research at the three universities in SoC and related technologies.
3. Attract business to relocate (or stay) in Western PA to do business in SoC related technology, by enhancing the relationships between industry and the universities, with a more open flow of people (both students and instructors) and technology (both IP and methodologies) between academia and industry.

References

[1] T. Cain, M. Irwin, P. Khosla, et.al. "SoC Curriculum Development & Educational Collaboration", Greenhouse SoC Taskforce report to the Pennsylvania Technology Investment Authority, Nov. 14, 2000

[2] D. Landis, et.al., *Proc. University/Industry SoC Curriculum Workshop*, Pgh. Digital Greenhouse, Sept. 27, 2000.

[3] M. Keating and P. Bricaud, Reuse Methodology Manual, Kluwer Academic Publishers, Norwell MA, 2nd edition, 1999

[4] D. Bouldin, "Enhancing System Level Education with Reusable Designs", *Proc. European Workshop on Microelectronic Education*, France, May 2000

Table 1. SoC Core Skills (by subject area)

I. SoC System Design and Development:
- Requirements Definition and Evaluation
- System Specification
- System level Behavioral modeling & analysis
- Architectural Analysis
- IP Evaluation, Selection & Mapping
- Performance Estimation
- Hardware/Software Partitioning
- System Level Optimization

II. Hardware Architecture:
- Hardware Architectural Analysis
- Embedded, DSP, GP Processor architectures
- Reconfigurable Hardware
- Memory System Organization (hierarchy)
- Design for X (power efficiency, testability, manufacturability, reliability, etc.)
- I/O system Architecture

III. Hardware IP Authoring & Delivery
- Interface Standards-Based Design
- Design for Multiple Use and Re-Use
- Logic and Mixed-Signal Design
- Analog and RF Design
- Design for X (power efficiency, testability, manufacturability, reliability, etc.)
- IP Qualification/Compliance
- Formal Verification
- Interface Design; Interface-Driven Integration
- Functional and Timing Verification
- Synthesis (for Soft and Firm VCs)

IV. Software Architecture:
- Software Architecture Design
- Real-Time Operating Systems
- Networking Layered Architecture
- Constraint-Aware Compilation
- Interfacing & Device Drivers

V. Support Skills for SOC applications
- Human/Computer Interaction
- Control & Communication
- Computing / Digital Signal Processing
- Algorithm Development
- Network Protocol Development
- Image/Voice Processing
- Multi-/Concurrent Processing; Real-Time Programming

VI. Non-Technical Skills:
- IP Licensing; legal and business issues
- Multi-Disciplinary Design Teams
- Verbal and Written Communication
- Entrepreneurship